UNESCO-IHE
Institute for Water Education

Decentralized sanitation in informal settlements

Linking technology to planning and management practices – Study case in Brasília (Brazil)

Viviane Virgolim

MSc Thesis USW-SE 2017-11

Student Number 49610

March 2017

Decentralized sanitation in informal settlements: Linking technology to planning and management practices - Study case in Brasília (Brazil)

Master of Science Thesis

by

Viviane Virgolim

Supervisors

Prof. Damir Brdjanovic, PhD

Mentors

Martin Mulenga, PhD

Raquel dos Santos, MSc

Examination committee

Prof. Damir Brdjanovic, PhD

Maarten Blokland, Msc

Martin Mulenga, PhD

Raquel dos Santos, MSc

This research is done for the partial fulfilment of requirements for the Master of Science degree at the UNESCO-IHE Institute for Water Education, Delft, the Netherlands

Delft

March 2017

Abstract

Although sanitation is a human right, 2.4 billion people on the world do not have access to it. Great efforts are being made worldwide to provide access to improved sanitation for all by year 2030, which is one of the targets of the Sustainable Development Goals (SDG) established by the United Nations. In Brazil, 30.2% of the population lack access to improved sanitation. If all promised government investments are made as planned, access to centralised conventional systems and septic tanks are projected to increase to 92% by year 2033. As improving as this is for Brazilian standards, it still fails in achieving the global SDG target 6.2. The biggest problem lies in informal settlements, where formal services are not provided due to the illegal nature of the settlements. As a result, decentralized sanitation methods come as an alternative to conventional centralized systems and have a better chance of reaching more people.

This research is a study case in Brasília, capital of Brazil, and aimed to investigate how decentralised systems can successfully be implemented in informal settlements to achieve universal coverage for Brazil's urban poor. It considers and identifies factors that affect development, delivery and uptake of decentralized sanitation in informal settlements of Brasília. The study investigated authorities' decisions concerning planning, management and technical feasibility, and their actions in the implementation process. It also explored why and how informal settlements have managed to flourish in a planned city, such as Brasília. Data were collected mainly through semi-structured interviews with nineteen relevant stakeholders at institutional and community levels in Brasília and Vila Cauhy, an informal settlement where a total of 53 households were surveyed.

Results indicate that although informal settlements are home to huge numbers of people, formal sanitation services are not provided due to the unplanned nature of these settlements. The procedure adopted by the government is either to legalize the settlements or to relocate families to another planned and formal neighbourhood although this has clearly not solved the problem. Results further show that although informal settlements rely on decentralized technologies, there are no planned mechanisms in place at the institutional level to support the provision of these services to these low-income neighbourhoods. As a result many low-income communities remain unserved. Even in situations, where governmental organizations can provide some form of support, there are, however, no incentives for communities to seek guidance or resources and this ultimately affects the uptake of decentralized sanitation. The only form of decentralized sanitation recommended by the government is the use of septic tanks but, without proper support, few residents can access that and have to depend on inferior alternatives. Moreover, the sanitation agencies have no interest in operating decentralized systems, which further limits the choice of technologies accessible to the poor people living in informal settlements.

Decentralized sanitation could be an alternative for informal settlements of Brasília and Brazil with the right governmental support, legal and regulatory framework and institutional arrangements are adapted.

Keywords: sanitation; decentralized sanitation; informal settlements; urban poor; decision-making process.

Acknowledgements

I would like to thank my parents for being such strong and inspiring models in my life and for guiding me into pursuing my dreams. Eduardo Virgolim, my father, has inspired me since I was a little girl into following his steps as a sanitary engineer. His confidence in me has always kept me motivated to reach higher academically and professionally. My mother, Angela Virgolim, a distinguished writer and psychology professor at University of Brasília and her achievements of the highest academic levels have inspired me to accomplish my MSc, which concludes with this thesis. None of this would be possible if it was not for my caring and loving husband, Rodolfo Danilow, who accompanied me on this journey and has always been by my side. Thank you for believing in me and keeping me strong to achieve my goals with confidence.

A special thank you to my mentors, Martin Mulenga and Raquel dos Santos, for guiding me and giving me valuable advice. I thank the group of volunteers who believed in my research and helped me to apply the survey used on this thesis. In especial, my sister Michelle Virgolim, who is always keen to help whenever needed. Last, but not least, thank you for all the interviewed, who opened a space in their busy agendas to answer the interviews used in this research.

Table of Contents

List of Figures

List of Tables

List of Graph

Abbreviations

ADASA – Agência Reguladora de Águas, Energia e Saneamento do Distrito Federal [Regulatory Agency of Water, Energy and Sanitation of the Federal District]

AGEFIS – Agência de Fiscalização do Distrito Federal [Inspection agency of the Federal District]

AMOVIC – Associação de Moradores da Vila Cauhy [Association of Community Members of Vila Cauhy]

CAESB – Companhia de Saneamento Ambiental do Distrito Federal [Water and Environmental Sanitation Company of the Federal District]

CODEPLAN – Companhia de Planejamento do Distrito Federal [Planning Company of the Federal District]

CODHAB – Companhia de Desenvolvimento Habitacional do Distrito Federal [Company of Housing Development of the Federal District]

FUNASA – Fundação Nacional de Saúde [National Foundation of Health]

HCES – Household-Centered Environmental Sanitation

IBRAM – Instituto do Meio Ambiente e dos Recursos Hídricos do Distrito Federal [Institute of Environment and Water Resources of the Federal District]

JMP – Joint Monitoring Program – WHO & UNICEF

LAC – Latin America and Caribbean

MPOG – Ministério do Planejamento, Orçamento e Gestão [Ministry of Planning, Budget and Management]

OWP – Open Wastewater Planning

SEGETH – Secretaria de Estado de habitação e Gestão do Território [Secretariat of Housing and Management of the Territory]

SEMA – Secretaria de Estado do Meio Ambiente [Secretariat of Environment of the Federal District]

SFD – Shit Flow Diagram

SINESP - Secretaria de Estado de Infraestrutura e Serviços Públicos [Secretariat of Infrastructure and Public Services

SuSanA – Sustainable Sanitation Alliance

UNICEF – United Nations Children's Fund

WASH – Water, Sanitation and Hygiene

WHO – World Health Organization

Glossary of terms

Decentralized sanitation: Systems that are usually simple, small, easy to operate and maintain locally, low-cost and suitable for a household or a small community. It is composed of collection, treatment and disposal/reuse of wastewater, but with different technologies than a centralized system. The treatment is usually on-site and might enable recovery of resources (Lens, et al., 2001).

Improved sanitation facilities: Defined as flushed or poor-flushed systems to piped sewer system, septic tanks or pit latrines; ventilated improved pit (VIP) latrines; pit latrines with slabs; and composting toilets. Any flushing or poor flushing systems that are disposed elsewhere are not considered improved sanitation. Open pits, buckets or hanging toilets are also unimproved sanitation, as are shared facilities of any type or open defecation (Unicef and WHO, 2015).

Informal settlements: Settlements that emerge illegally in public or private land in a random and irregular manner. They are unplanned and breach governmental rules and consequently lack access to infrastructure – water, sanitation, electricity, garbage collection, paved roads (Ishtiyaq and Kumar, 2011). Informal settlements can also be referred as slums, poor urban areas or favelas (UN-Habitat, 2015). In this research, the term informal settlement refers only to low-income urban areas.

Sanitation: It is the collection, transport, treatment and safe disposal or re-use of human excreta in a hygienic way. Sanitation is declared by the United Nations as a human right and it should be accessible by everyone, without discrimination. To be considered appropriate, sanitation has to be safe, hygienic, physically accessible, affordable and culturally acceptable (United Nations Economic and Social Council, 2010). It is important to highlight that in Brazil, the term "sanitation" is equivalent to the English term "basic sanitation", including wastewater, water supply, solid waste and stormwater drainage systems. In this thesis, it is adopted the English term sanitation, which only refers to wastewater, sludge or human excreta.

Stakeholder: A social entity, person, group or organization that has interest or influence over an organization's actions or decisions (Enserink, et al., 2010). Many stakeholders are involved in the sanitation aspects of a community, which range from the Government to the people directly affected.

Urban poor: Families that "are able to maintain their presence in the formal community" even though with difficulty; "young families that rent or live with relatives while saving up to enter a public subsidized housing program"; or families who live in informal settlements (Solo, et al., 1993, p. 2).

CHAPTER 1

Introduction

1.1. Background

Sanitation is declared by the United Nations as a human right. However, 2.4 billion people in the world still lack access to improved sanitation (Unicef and WHO, 2015). Many efforts are being done worldwide to increase accessibility. From years 2000 to 2015, 189 countries were committed by the Millennium Development Goals (MDGs) in halving the population without access to improved sanitation (SDGF, 2016). Although many countries could not achieve the target, 2.1 billion people gained access to improved sanitation the past years (Unicef and WHO, 2015). Now, the world has the new challenges of Sustainable Development Goals (SDGs) to be achieved by year 2030. As described in chapter 2.2, the main target in sanitation is to ensure "access to adequate and equitable sanitation and hygiene for all and end open defecation paying special attention to the needs of women and girls and those in vulnerable situations" (United Nations, 2015a, p. 18).

To achieve the SDG sanitation target, it is important to understand the meaning of sanitation and its importance to the world's development. Sanitation is the safe and hygienic disposal of human faeces and urine (WHO, 2016). For the United Nations (2010, p. 2), it is the system for the "collection, transport, treatment and disposal or re-use of human excreta and associated hygiene". Not only is it a human right, but should also be accessible to all with no discriminations, be safe, hygienic, physically accessible and culturally acceptable (United Nations Economic and Social Council, 2010). Human health is directly affected by sanitation. The appropriate accessibility along with hygienic behavior can reduce up to 65% percent of human contamination by diarrheal diseases (WHO and UNICEF, 2000). Moreover, sanitation directly impacts labor productivity and school enrolment, which have a straight connection to social and economic development (Mara, et al., 2010).

While the importance of sanitation provision is clear, achieving universalization is not easy. According to JMP[1] (Unicef and WHO, 2015), 70% of the people without sanitation services live in rural areas. However, rural population has increasingly been immigrating to cities over the last decades, and it is predicted that this shifting continues to increase. Over half of the population today live in urban areas and most of the world's population growth will occur in city centers (United Nations, 2015b). The biggest challenge takes place in developing countries, where there are a higher number of people without access to improved sanitation. The trend is

[1] Joint Monitoring Program of the World Health Organization (WHO) & Unicef

for rural emigrants to be added to the number of urban areas being underserviced (Unicef and WHO, 2006b). Moreover, even though most people without access to improved sanitation facilities live in rural areas, the environmental and health conditions are worse in the cities, especially in poor and dense urban settlements (Mulenga, et al., 2004).

One of the biggest challenge in providing sanitation access to informal settlements of developing countries is that governments tend to overlook the problem. The rationale behind this behavior is that by providing services and infrastructure, they will be complacent to the illegal aspect of the settling and attract more people to it (Solo, et al., 1993). When trying to provide sanitation services in these settlements, one might encounter many constraints (physical, technical, economical, financial, institutional or structural) as reasons not to cover the communities (Solo, et al., 1993). Moreover, using the state-of-the-art centralized solution to provide sanitation to poor urban areas of developing countries is, in many cases, not considered a sustainable practice (Lens, et al., 2001, Libralato, et al., 2012).

Decentralized sanitation is an alternative to conventional centralized systems and has a good chance of being the answer to achieve the Sustainable Development Goal target 6.2 (Libralato, et al., 2012). Systems are usually simple, small, easy to operate and maintain, low-cost and suitable for a household or a small community (Lens, et al., 2001). Many decentralized technologies can be selected for different steps of the service chain – user interface, collection, conveyance, treatment and final disposal or reuse. The technology selection in each case will depend on many factors, such as cultural aspects, water availability, financial matters and the possibility of using by-products (Tilley, et al., 2014). The most appropriate technology must be "economically affordable, environmentally sustainable and socially acceptable" (Massoud, et al., 2009, p. 656).

The success in implementing a decentralized sanitation system will depend on the participation of the community and the presence of an enabling environment throughout the process. Engaging the community in the planning process and understanding their needs will have a big impact on the sustainability and effectiveness of the sanitation system (Mulenga, et al., 2004). Having an enabling environment in all phases of the project – planning, implementing and monitoring – will dictate its success. An enabling environment relies on government support, supporting legal and regulatory framework, organized institutional arrangements, technical expertise, provision and access to financing mechanisms, and socio-cultural acceptance (Lüthi, et al., 2011).

Academic contribution can help the sanitation sector to understand problems that emerge when pursuing achievement of the 6th Sustainable Development Goal. Studying how different parts of the world are dealing with the inaccessibility to improved sanitation contributes to the clarification of this problem and of possible solutions that might be adopted by authorities. Through a study case in Brasília, this thesis discusses the use of decentralized sanitation as an alternative to increase accessibility to improved sanitation in informal settlements. It is expected that the outcomes of this research may contribute in increasing accessibility to improved sanitation in similar cases and in meeting the 2030 agenda of the United Nations Sustainable Development Goals in Brazil.

1.2. Problem statement and justification of the study

The socio-economic situation of Brazil is variable throughout different regions of the country and with that, sanitary conditions also varies. According to the latest report of evaluation on the National Plan of Basic Sanitation published by the Ministry of Cities of Brazil (2015), the total accessibility to improved sanitation of the country is 69.8%. The southern region, which is more developed, has 89.4% of accessibility, while in the least developed region (north), only 34.9% of the people have access to sanitation services. There is a big difference when comparing urban and rural areas, in which the last one has lower access to sanitation (19.2%) (Ministério das Cidades, 2015).

For Brazil to achieve the SDG requirements by year 2030, a lot of effort from authorities is required. Although the Brazilian Government has invested in programs to improve the sanitation picture, the evaluation on the National Plan of Basic Sanitation (Ministério das Cidades, 2015, p. 50) points out that with the proposed sanitation plan, by year 2033, 92% of the population in the country will have access to sanitation by sewer collection or septic tanks. While this might be an improvement, this figure still falls below the universal coverage SDG target. Though many people living in rural areas do not have access to improved sanitation, the biggest concerns are towards poor people in urban informal settlements where the environmental conditions have a negative impact on public health.

This research focuses on the factors that can enable universal coverage in urban informal settlements of Brazil's capital, Brasília. It is a planned city that was built from scratch in the 1950's and inaugurated in 1960 as the new capital of Brazil. The city is located within the Federal District, which is an area of 5,780km² located in the central-west part of the country (IBGE, 2016). Although it was planned for 500,000 people, the Federal District has grown into almost 3 million people (Campos and Canes, 2015, Setti, 2005). Together with the satellite cities that emerged surrounding the capital's main plane-shaped area, many low-income informal settlements have evolved illegally on both public and private land. These settlements have remained for years without any infrastructure provided by the government, which is only provided after an area becomes legalized. In contrast with the rest of the District that has proper sewer collection and treatment in one of the sixteen (16) existing wastewater treatment plants (CAESB, N.D.), people living in these informal settlements have to provide their own decentralized solutions or live under hazardous conditions, such as having raw wastewater run down on the streets.

One of the low-income informal settlements of Brasília – Vila Cauhy – was chosen as a study case location to analyze its sanitary situation (Figure 1). Vila Cauhy emerged together with the construction of Brasília. It is located inside the administrative region of Núcleo Bandeirante, one of the first satellite cities of Brasília. Vila Cauhy is a small settlement with 1,468 inhabitants and 432 dwellings over an area of 26.1 hectares (Codhab, 2016b). Due to environmental issues and the real estate value of the area, Vila Cauhy has many problems in becoming a legalized urban settlement (Barbosa, 2015). In this scenario, the government does not provide any sanitation services or infrastructure for the population. Few families could afford systems such as septic tanks to contain household and wastewater. Tired of this situation, the population collectively funded and built a sewer network without government assistance. Unfortunately, due to limited financial resources and lack of technical knowledge, the community's project

failed for two reasons: (1) not all households were connected and (2) detrimental environmental impacts arose from raw wastewater being directly discharged into a nearby stream.

While the technological solution proposed by the Vila Cauhy community has failed, this example indicates significant factors that ought to be taken into account when developing and improving upon the informal settlement's current sanitation situation. The research mainly focuses on the applicability and sustainability of decentralized sanitation services in the study case and what affected its development, delivery and uptake. It further investigates the decision-making process regarding planning and the management of sanitation services in Brasília which enables the identification of bottlenecks that constrain the achievement of improved sanitation access for all. The research findings and recommendations can benefit Brazilian informal settlements with similar decentralized sanitation problems, as the study case outlines general sanitary problems and how populations are affected by the lack of public services. The ultimate purpose of this research was to contribute to the achievement of universal sanitation coverage and the achievement of target 6.2 of the SDGs.

Figure 1 - Location of Vila Cauhy - retrieved from Google Earth (2016)

1.3. Research objectives

The main objective of this research is to increase understanding of the factors that affect the development, delivery and uptake of decentralized urban sanitation in low-income informal settlements of Brazil, through a case study in Brasília. Within this topic, specific objectives are:

- Investigate why informal settlements exist and how they emerged in such a planned city as Brasília;
- Characterize the present sanitary situation and verify the adequacy of sanitary solutions in the study case location;
- Investigate institutional decisions towards sanitary solutions for informal settlements, regarding planning, management and technical feasibility.

1.4. Research questions

The following questions are complementary to the specific objectives and are answered in this research:

- What factors contributed to the development of informal settlements in a planned city such as Brasília?
- To what extent does living in an informal settlement affect accessibility to sanitation in Brasília?
- How is the decision-making process for implementation of sanitation developed and how has planning affected technology choice, implementation and management of decentralized sanitation systems in informal settlements in Brasília?

1.5. Hypothesis

The main hypothesis of this research is that the possible solution of achieving universalization of sanitary services in Brasília relies on the adoption of decentralized solutions for the informal settlements. It is also assumed that Brazilian governmental authorities overlook this option as a reliable and sustainable solution that can be invested in.

1.6. Outline of the thesis

This thesis is structured in six chapters. The first chapter is an introduction to the research, which substantiates the importance of the study, objectives, research questions and hypothesis. The second chapter is a literature review on the global sanitary situation, challenges of the sector and overview of different topics that are essential to the understanding of the studied problem. Chapter 3 brings the methodology used to collect and analyze data. Results from interviews, survey and secondary sources are presented in Chapter 4, analyzed and discussed in Chapter 5. In the final chapter are the conclusion of each research question and overall conclusions based on research findings; it also presents proposed future researches to fill the gaps of this study. Additional materials, such as full survey results, and interview protocols are included as appendices.

1.7. Chapter summary

- Sanitation services in the world have improved from years 2000 to 2015 with the implementation of the MDGs. However, 2.4 billion people in the world still lack access to improved sanitation.

- The world has today the new challenge to implement SDGs, in which one of the targets is to provide access to improved sanitation for all and end open defecation by year 2030.
- Decentralized sanitation has a good chance to be a sustainable solution for the implementation of sanitation services in poor urban areas, overcoming constraints that might exist in centralized solutions.
- According to the latest report of evaluation on the Plan of Basic Sanitation published by the Ministry of Cities of Brazil (2015), the total accessibility to improved sanitation of the country is 69.8%. By year 2033, Brazil plans to achieve 92% accessibility, which does not meet with the global SDG target 6.2.
- Brasília is the capital of Brazil since 1960 and, even though it is a planned city, there are many informal settlements since the construction period. It was chosen as a study case for this research. One of its low-income informal settlements, Vila Cauhy, is approached in this research to complement the study.

CHAPTER 2

Literature Review

This chapter gives a theoretical description and relevant literature discussions related to the topics approached in this research: Overview of global sanitation; Sustainable Development Goals; sanitation in informal settlements; centralized and decentralized sanitation systems, technologies, management and sustainable planning.

2.1. Overview of global sanitation

The world has become very urbanized during the past few decades, which is a big challenge for the universalization of sanitation services. Over half the population today lives in urban centers and it is predicted that most of the world's population growth will take place in these areas (Cohen, 2006, United Nations, 2015b). Keeping pace with the expansion of the cities and providing appropriate infrastructure is a big challenge that governments have to deal with. Recommendations from United Nations (2015b) are that governments should implement policies ahead and prepare for population growth providing sustainable solutions and expand infrastructure to ensure accessibility to services.

While water, sanitation and hygiene (WASH) are essential for human health and welfare, many people still do not have access to these basic human rights (Unicef and WHO, 2014). According to Unicef and WHO (2015), 68 percent of the global population has access to improved sanitation facilities. While the picture has improved over the last 25 years, 2.4 billion people in the world still lack access to improved sanitation. The studies have pointed out that the majority of these people live in developing countries in Africa, Asia and Latin America and Caribbean (LAC) (Unicef and WHO, 2015). Many efforts have been made to increase improved sanitation throughout the world, but there is still a lot to be done.

Sanitation is not only a basic human right, but essential to human development and reduction of poverty. Studies point out that providing improved sanitation, safe water supply and hygiene education will effectively affect the population's health (Mara, et al., 2010, Unicef and WHO, 2014, WHO and UNICEF, 2000). According to WHO and Unicef (2000), 65 percent of diarrheal diseases and related morbidity of 26 percent may be reduced by WASH interventions. This has a strong impact in work productivity and school enrolment, which is directly related to the social and economic development of the world (Mara, et al., 2010).

WHO (2016) defines sanitation as "the provision of facilities and services for the safe disposal of human urine and faeces. […] It is the maintenance of hygienic conditions through services

such as garbage collection and wastewater disposal" (WHO, 2016). For the UN[2], sanitation is also "a system for the collection, transport, treatment and disposal or re-use of human excreta and associated hygiene" (United Nations Economic and Social Council, 2010, p. 2). In other words, it is a "multi-step process in which human excreta and wastewater are managed from the point of generation to the point of use or ultimate disposal" (Tilley, et al., 2014, p. 10). By collecting and disposing human excreta in a hygienic way, the spread of pathogens is tremendously reduced. Improved facilities together with hygienic behaviors work together in a multi-barrier approach to break the cycle of pathogenic diseases (Unicef, 1999). Sanitation is declared by the UN as a human right and it should be accessible by everyone, without discrimination. For the UN, sanitation has to be safe, hygienic, physically accessible, affordable and culturally acceptable (United Nations Economic and Social Council, 2010).

According to Unicef and WHO (2015), 70 percent of the uncovered population and 90 percent of the people who still practice open defecation lives in rural areas. Nonetheless, the environmental and health conditions of the people living in poor urban areas is much worse, due to the density of these settlements and the close human contact with their excreta, which facilitates the break out of contamination by diarrheal diseases (Mulenga, et al., 2004, United Nations, 2015b). However, governments in developing countries have been reluctant to provide sanitation for informal settlements. The rationale behind this attitude is that providing services would mean being complacent with the living situation of these communities. Governments prefer to eradicate the slums than projects to develop them (Solo, et al., 1993).

2.2. Sustainable Development Goals

In the year 2000, most countries of the world signed the United Nations Millennium Declaration, where eight goals were set to be achieved by the year 2015 (SDGF, 2016). The Millennium Development Goals (MDGs) aimed developing the world by achieving targets in different areas of action. Sanitation had a focus within the 7th goal – Ensuring Environmental Sustainability. The target was to halve, by year 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation. The efforts to achieve the target resulted in 2.1 billion people gaining access to improved sanitation (Unicef and WHO, 2015).

Pursuing the same philosophy as the MDGs, the United Nations proposed in 2015 a new document with 17 goals – the Sustainable Developing Goals (SDGs). With sustainability in mind, these goals (Figure 2), which associate 169 integrated targets, are to be achieved by the year 2030 (United Nations, 2015a). The goals have the ambition of transforming the world with a universal development agenda for the global community, leaving no one behind. Even though the SDGs are not legally binding, countries are expected to meet the agenda by creating their own policies and actions to implement the 17 goals. There are global partnerships to support national efforts. Although, the involvement of all level stakeholders is required to implement the agenda (United Nations, N.D.).

[2] United Nations

Figure 2 - Sustainable Development Goals (United Nations, 2016, p. 48)

Goal 6 of the SDGs encompasses clear water and sanitation: "Ensure availability and sustainable management of water and sanitation for all" (United Nations, 2015a, p.18). Sanitation is within this goal, in the specific target 6.2, which aims to "achieve access to adequate and equitable sanitation and hygiene for all and end open defecation paying special attention to the needs of women and girls and those in vulnerable situations" (United Nations, 2015a, p.18). To avoid misinterpretation of the target, the definition of 'adequate' or 'improved sanitation' was established by the Joint Monitoring Program (JMP) for Water Supply and Sanitation, created by WHO and Unicef. An improved sanitation facility "hygienically separates human excreta from human contact" (Unicef and WHO, 2015, p.50) and is defined by: flushed or poor-flushed systems to piped sewer system, septic tanks or pit latrines; ventilated improved pit (VIP) latrines; pit latrines with slabs; and composting toilets. Any flushing or poor flushing systems that are disposed elsewhere are not considered improved sanitation. Open pits, buckets or hanging toilets are also unimproved sanitation, as are shared facilities of any type or open defecation (Unicef and WHO, 2015).

2.3. Sanitation in poor informal settlements

Urbanization is the migration of rural population, from small settlements where the main economic activity is agriculture, to the urban areas, which are dense and mainly focused on industrial and services activities (United Nations, 2015b). Urbanization is inevitable and seen as a positive phenomenon since it enables significant economic development. More than half of the population today lives in urban areas and it is predicted that this number increases to 5 billion people in 2030 (United Nations Population Fund, 2007).

While urbanization facilitates economic and social development, provision of adequate infrastructure for all is impaired by the rapid and unplanned population growth (United Nations, 2015b). This is the situation in developing countries – the population is rapidly increasing, infrastructure is not provided for urban poor and the number of people living in slums is increasing (United Nations Population Fund, 2007). In the year 2012, nearly one third of the

population in developing countries lived in slums and this number is increasing (United Nations, 2015b).

The planned parts of a city, where infrastructure is provided by the government, are considered formal settlements. Many aspects are considered when planning a formal settlement, such as physical, social and economic. Settlements that emerge illegally in public or private land in a random and irregular manner are considered informal settlements. They are unplanned and breach governmental rules and consequently lack access to water, sanitation, electricity, garbage collection, paved roads and all other infrastructure that are implemented by the authorities in the formal settlements. The informal settlements can be composed by permanent or temporary house structures and commonly have inadequate inside facilities (light, air, water, toilet). Even though the dwelling may exist for a very long time, they do not have the right of occupancy. They are typically over crowded areas with highly dense population and usually emerge in the cities' borders, green belts, edging roads, railway tracks or low-lying flood prone areas (Ishtiyaq and Kumar, 2011). UN-Habitat (2015) describes informal settlements as residential areas where inhabitants have no security in their dwellings, usually lack basic services and city infrastructure and the housing does not comply with regulations and are usually located in geographically and environmental hazardous places. Informal settlements exist all around the world in many location, dimensions, forms or typologies and they can be called slums, poor urban areas, "squatter settlements, favelas, poblaciones, shacks, barrios bajos, bidonvilles" (UN-Habitat, 2015, p. 2).

Many governments do not acknowledge the existence of slums or informal settlements, which hinders sustainable development (UN-Habitat, 2015). Governments usually overlook these areas and insist in not providing services not to incentive and attract more people to live in these illegal settlements (Solo, et al., 1993). The people who live in the peri-urban areas or informal settlements are left out of the society, experience constant discrimination and suffer from spatial, social and economic exclusion (Solo, et al., 1993, UN-Habitat, 2015). These are the people who have no access to water or sanitation and "who should be a focus of concern" (Solo, et al., 1993, p. 3). Due to the high density of the population in informal settlements there is a big potential for the spread of diseases. The lack of improved sanitation in these areas limits the options of disposal of human excreta, leading to contamination and spread of diseases (Isunju, et al., 2011).

Poor urban areas experience a hand full of sanitation deficiencies, as described by Tayler, et al. (2003). Most of the times, there are no sanitation facilities, which can happen due to the illegal characteristics of the informal settlement, or also because of the fast population growth that impairs the services provision. When sanitation facilities do exist, many times they are unpleasant or unhygienic and are not used by the population. Other times, they may be inaccessible to the poorest people and are exclusive to the 'slum landlords' or to those who can pay to use the toilets. Sanitation facilities might also have been provided but are not well maintained or operated, which causes a system failure. Finally, in many poor urban areas the facilities may be in place and well-functioning, but the wastewater collected is not treated causing big environmental and health impacts elsewhere.

There are many challenges in providing sanitary solutions for peri-urban areas in low-income countries. Many constraints such as physical/technical, economical/financial, institutional and structural may be a reason not to provide services in these areas, pointing out the need for a

profound reform. The following explanations are exposed by Solo, et al. (1993) in the WASH technical Report nº85:

- Conventional sewerage systems might be limited by physical and technical issues. Poor urban settlements are commonly in an undesirable land to build due to low market values. These places are hardly reached by conventional sewer systems without turning into expensive systems. Moreover, the houses usually do not have adequate space in between to settle conventional sewer pipelines.
- Economic and financial problems are a constraint for both the service provider and the dweller. For the company, the investment for implementing and running a sewer system is very high and not paid back by the poor communities. Upgrading the slums requires a big investment and external financing resources are not always easy to obtain. For the dweller, there is a financial issue to legalize the household to earn sanitation services and to connect to the sewer system for the first time.
- Ineffective public works are known to be complicated and disorganized, which is an institutional constraint for the universalization of sanitation services. Difficulties in developing countries include: discipline to charge and collect payments in poor urban areas; being able to build new systems with the company's resources; corruption and politicization; lack of eager to increase efficiency and expand services to all possible markets.
- Structural constraints are harder to deal with due to conflicting values and different policy viewpoints. Some of the structural aspect that affect sanitation provision are: non-inclusion of the poor in the legal rights to access services or own a propriety and in the policies that conduct urban development; failure of development plans that do not consider the population growth; illegal land are more attractive to the poor for the distorted land markets, which perpetuate the problem in these areas.

Meeting the sanitation needs of informal settlements requires a significant and profound reform to win the limiting constraints. These areas require other solutions different from the conventional systems adopted in develop countries. Understanding the urban poor and shifting the institutional behavior is required and takes time (Solo, et al., 1993).

2.4. Centralized vs. decentralized sanitation systems

Centralized sanitation systems have been historically developed to protect the environment and human health. Along with the development of civilization and urban growth, providing centralized systems have always been the most effective answer, especially for developed countries (Lens, et al., 2001). However, systems have become complex due to the development of technology and high standards for the treated effluents (Henze, et al., 2008). In the other hand, cities are agglomerating increasing number of people and the provision of improved sanitation to all, especially urban poor, with centralized solutions are considered to be unsustainable (Lens, et al., 2001, Libralato, et al., 2012). Decentralized sanitation in an alternative solution that can be used to overcome challenges of access to the urban poor and has a high chance to be the answer to achieve the SDGs (Libralato, et al., 2012, Parkinson and Tayler, 2003).

2.4.1. Historical overview of centralized Sanitation

Historical records show that sanitary engineering has been developed for more than 4500 years, since the Mesopotamian Empire, towards a centralized system. The Minoans, first advanced civilization in Europe, were located in the island of Crete, which today is the most populous island of Greece. Archeological founding proof that the Minoan civilization created advanced water and wastewater systems in their palaces since 1700BC, including aqueducts, cisterns, lavatories, sinks, manholes and sewers. More than 150 meters of sewers were found in Knossos, with up to 3m of depth (Angelakis and Rose, 2014).

Over the years, sewer collection was developed along with civilization and urbanization, promoting health and protecting the population from diseases. The existing sanitary systems had centralized collection by primitive sewers. Ancient Greeks (300 BC to 500 AC) used public latrines and the wastewater was drained together with the stormwater away from the cities. In Roman times (800BC to 450AD), there was already an understanding of keeping the wastewater away from drinking water sources. However, the sanitation system collapsed along with the Roman Empire, because of the dependence on the water collection by aqueducts that used man-power from the army to work.

When cities such as London and Paris emerged from the Roman Empire, sewers did not exist and human excreta were thrown directly into the streets. Implementation of centralized collection was again attempted to clean the streets and cesspools were used to store the waste. Overflowing cesspools would contaminate drinking water sources, killing several hundred thousand people from waterborne diseases. With the industrial revolution, the new cities had a high population growth and with it, death rates from waterborne diseases also grew. The understanding of direct relation of sanitation and health increased in this era, after many deaths due to this reason. The answer to this problem was to invest in sewerage collection, guaranteeing separation from drinking water sources (Lens, et al., 2001).

The earliest treatment of wastewater was the decomposition in agricultural areas, reusing wastewater for irrigation and fertilizer in crop fields. Other type of technologies emerged in the beginning of the 20th century, with the Imhoff tanks and biological filters. Early activated sludge systems were implemented in UK, through simple aeration of wastewater and settling tank, which soon was vastly used in Europe. The treated wastewater was discharged in surface water and a new problem emerged: eutrophication. The technology to treat nutrients (nitrogen and phosphorous) developed and the treatment units became more complex (Henze, et al., 2008). While the activated sludge systems became more advanced, other technologies of treatment with different concepts also emerged in the last decades, such as anaerobic treatments with UASB and ponds, constructed wetlands and membrane systems (Lens, et al., 2001).

Centralized urban sanitation systems are usually public systems that collect large volumes of wastewater of all the city and treat them in a central wastewater treatment plant (Massoud, et al., 2009). These systems have played an important role to protect human health and the environment, increasing public comfort in the industrial world. However, there is a discussion over the sustainability of these systems, due to the large amount of clean water used for flushing, energy consumption, technical complexity, high costs and non-recovered resources – except for the water (Lens, et al., 2001). Using the state-of-the-art centralized treatment technologies to universalize sanitation services considering future population projections, are not considered sustainable (Lens, et al., 2001, Libralato, et al., 2012).

2.4.2. Decentralized Sanitation

For many years, engineers have considered centralized waterborne sewer systems the most feasible and reliable sanitarily solutions. In Europe and North America these conventional sewer systems have successfully worked. However, this is not the case for peri-urban areas in low-income countries (Strande, et al., 2014). Onsite decentralized options were considered to be temporary solutions are now becoming more attractive solutions for the world's needs (Strande, et al., 2014). Decentralized solutions are an alternative that allows improvement of environmental and health conditions of low-income areas. It also enables resources recovery and engagement of local stakeholder participation in planning and decision-making, which is the answer for a sustainable system (Parkinson and Tayler, 2003).

Decentralized sanitation is an alternative for conventional systems that is practiced in many parts of the world nowadays, especially rural areas. It is increasingly recognized as a potential solution to reduce the lack of accessibility to improved sanitation over the world and peruse the achievement of the Sustainable Development Goals (Libralato, et al., 2012). According to Isunju, et al. (2011), it is a feasible and economically appropriate solution for informal settlements. Decentralized solutions are usually simple, small, easy to operate and maintain locally, low-cost and suitable for a household or a small community, which are designed and built locally (Lens, et al., 2001). As defined by Lens, et al. (2001, p. 136), a decentralized system "employs collection, treatment and disposal/reuse of wastewater from individual homes, cluster of homes, isolated communities, industries or institutional facilities, as well as from portions of existing communities at or near the point of waste generation". Although the components of the decentralized system might be the same as the conventional centralized systems, the technology adopted is different and might enable recovery of resources. Moreover, not all decentralized systems adopt all the components (Lens, et al., 2001). While in centralized systems the final disposition is far away from the generation point, decentralized systems usually treat onsite, which means that the final disposition is near the generation point. Piping systems might also be used in clusters, however in a much smaller scale than centralized systems (Massoud, et al., 2009).

When talking about on-site decentralized sanitation, faecal sludge is the term used for the wastewater. Faecal sludge is the wastewater that is not transported by a sewer and it has variable consistency, quantity and concentration. "It is raw or partially digested, a slurry or semisolid, and results from the collection, storage or treatment of combinations of excreta and blackwater, with or without greywater" (Strande, et al., 2014, p. 1). Faecal sludge comes from on-site sanitation, such as septic tanks, pit latrines, dry toilets and aqua privies.

2.4.3. Decentralized technology selection

Many different technologies may be used in decentralized systems. The Compendium of Sanitation Systems and Technologies published by Eawag (Tilley, et al., 2014) brings a summary of different technologies for user interface, collection, conveyance, treatment and use or disposal. The technology selection in each case will depend on many factors, such as cultural aspects, water availability, financial matters and the possibility of using by-products (Tilley, et

al., 2014). The most appropriate technology must be "economically affordable, environmentally sustainable and socially acceptable" (Massoud, et al., 2009, p. 656).

As stated in the Compendium (Tilley, et al., 2014), technologies for the user interface will depend mainly on cultural aspects, water availability and the possibility of using by-products. It must guarantee the hygienic separation of human excreta and interface to prevent possible faecal contamination. Dry toilets, urinals, urine-diverting dry toilets (UDDT) are some of the examples that might be used. The separation of urine and faeces are important here if there is a possibility of making fertilizers, such as struvite out of urine. The selection of user interface device will influence the next step of the system, which is collection and storage/treatment.

One of the most common technology for collection and storage are septic tanks (Hophmayer-Tokich, 2006, Massoud, et al., 2009). Other technologies available are VIP latrines, fossa alterna, composting chamber and biogas reactors, among others. Depending on the storage time and conditions, the technology might also provide the treatment step, which is the case for septic tanks. Anaerobic baffled reactor (ABR) is an improvement of the septic tank, which due to the increased contact time by the baffles, there is an improvement of the treatment (up to 90% of BOD reduction). Anaerobic filters are an improvement of the ABR due to the use of biological filters in each baffle that increase the effluent quality by removing nitrogen up to 15%. The selection of technology to be used will mostly depend on the space availability, characteristics of the soil, groundwater level, volume of wastewater produced, management level (household, shared or public), use of by-products (e.g. biogas reactor), financial resources and local materials available (Tilley, et al., 2014).

When the collection and storage unit does not provide treatment on-site, than the sludge needs to be conveyed to an off-site facility. The technology used might be sewer-based or container-based. In the last case, motorized or human-powered emptying and transport are required. The selection will depend on: the volume of products that will be transported; the distance, accessibility and topography from the collection point to the treatment facility; financial resources; characteristics of the soil and groundwater; and availability of a service provider. Conventional gravity sewers might be used, even though it is a decentralized system. However, the length of pipe is much smaller than in a centralized system. Human-powered emptying of pits, vaults or tanks can be done as long as protection equipment such as boots, gloves, overalls and facemask are used. The emptying can be done by buckets and shovels or using a manually operated pump. Motorized emptying is usually done by a truck with a motorized pump (Tilley, et al., 2014).

Treatment facilities are usually applied for neighborhoods or city scale systems. There are conventional technologies which can be used, but will mostly depend on the financial resources. It is also commonly practiced for a conventional wastewater treatment plant to receive wastewater from the decentralized systems. Faecal sludge treatment plants are recommended in cases of creation of by-products. The choice of most appropriate treatment technology will depend mostly on financial availability, space requirements, volume to be treated, disposal or reuse requirements, availability of constant source of electricity, skills and capacity for design and operation (Tilley, et al., 2014).

Products will return to the environment in the final system step, which can be the final disposition of the reduced-risk material or a useful resource for reuse (Tilley, et al., 2014). The reuse of resources is a good solution that closes the loop of ecological sanitation as a sustainable

practice (Winblad, et al., 2004). According to Tilley, et al. (2014), the type and quality of the final product will play an important role on the possibility of reuse. Social-cultural acceptance is also important to determine if there is a possible market for the use of the product. Local demands and legal aspects might preclude the final disposition of the material in a determined space or the use of the by-product. A few of common use of products are: use of stored urine as fertilizer; application of dehydrated faeces as soil conditioner; application of treated sludge in agriculture; irrigation with treated effluent; fish pond; reuse of water with effluent discharge in water bodies or groundwater; biogas combustion for energy production (Tilley, et al., 2014). New technologies are being tested such as Latrine Dehydration and Pasteurization (LaDePa) machine that produces sludge pallets that can be combusted for energy production (Tilley, et al., 2014), and the Janicki Omni Processor, that produces drinking water and electric power out of sludge (Janicki Bioenergy, N.D.).

2.5. Decentralized Management

Onsite sanitation technologies can be a viable and more affordable solution. However, the success will depend on the appropriate management of the entire service chain, including collection, conveyance, treatment and disposal or reuse. Faecal sludge management (FSM) is a relatively new field that is increasingly being acknowledged. An effective FSM requires the interaction among many organizations and individuals from public and private sectors and civil society, which all together will manage every step of the sanitation value chain (Strande, et al., 2014).

When managing sanitation in an informal settlement, there are many difficulties that may be encountered, such as: users not being able to afford adequate emptying services; streets too narrow that impair the access of collection and transport trucks; operators cannot afford transporting the faecal sludge to treatment facilities; lack of treatment facilities for the faecal sludge. Therefore, FSM requires a system-level approach in all steps of the value chain. It combines planning with the technology selection and managing the system, as schematically presented in Figure 3 (Strande, et al., 2014).

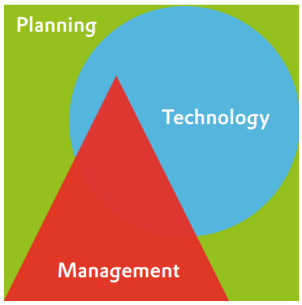


Figure 3 - FSM integrated systems level approach (Strande, et al., 2014, p. 7)

The management of a decentralized sanitation system might be either centralized or decentralized. When centralized, public authorities will still make the planning and decision-making, even though the technical solution is decentralized. However, it is more suitable in these cases to engage the community itself to manage the system, in a decentralized manner (Parkinson and Tayler, 2003). Decentralized management is defined by Parkinson and Tayler

(2003, p. 79) as the "planning, decision-making, design of physical infrastructure, and management arrangements for operation and maintenance" of the system.

There are many forms of decentralized management, due to the level of transfer of power, authority and responsibilities from the government to subordinate sectors, public independent organizations or to the private sector. The decentralization may be political, administrative or fiscal. Political decentralization gives the citizens or the community leaders the power for decision-making. Administrative decentralization is a distribution of authority, responsibility and financial resources to different levels of the central government. Responsibilities include planning, financing and management of some of the public functions. Deconcentration, delegation and devolution are the three main forms of administrative decentralization, as follows (Decentralization Thematic Team, N.D., Fragano, et al., 2001):

- Deconcentration is the shift of workload from the central government in the capital to field offices, located outside the capital;
- Delegation is a bit more broad type of decentralization, where there is a shift in the responsibilities of decision-making and administration to semi-autonomous public or private organizations;
- Devolution is when the central government transfers all the autonomy (decision-making, finance and management) to units of local governments with corporate status.

In order to fully achieve management decentralization, it is important to decentralize financial responsibilities. There are many ways to accomplish fiscal decentralization, which might be through self-financing, cost recovery through revenue services, co-financing where users contribute with labor or infrastructure, indirect charging (taxes), intergovernmental transfers, loans, etc. The most complete forms of decentralization are privatization and deregulation, where governments divest from responsibilities fully transferring them to other organizations, public or private (Decentralization Thematic Team, N.D.).

2.6. Planning towards sustainable sanitation

To achieve sustainable urban development, it is important to plan for sustainable sanitation. One of the keys in achieving that is by considering the users' needs. The most common practiced approach nowadays is supply-driven, which is focused around a favored technology rather than including the views of the users. In developing countries, supply-driven approach is criticized over its large investments and operation and maintenance needs. Moreover, the main beneficiaries tend to be the ones that can afford to pay for services and the poor urban areas are once more excluded (Lüthi, et al., 2010). A new trend for the planning process is the 'Demand Responsive Approach' (DRA), where the users of the sanitation system are consulted and their demands guide the investment decisions. The population will establish how much they are willing to contribute in cash, labor or time for the implementation, operation and maintenance of the system substantiating the planning and decision-making process (Mulenga, et al., 2004).

The communicative approach takes into consideration multiple viewpoints from different stakeholders, through an open dialog and exchange of ideas. The communicative planning will allow policy ideas to be "developed, disseminated and translated into action" (Lüthi, et al., 2010, p. 87). Participatory planning is recommended in strategic planning framework and has

proven to be effective in sanitation projects around the world (Lüthi, et al., 2010). When dealing with sanitary solutions for poor urban communities, understanding their needs and priorities will help in planning an efficient system that is more appropriate. Many times the citizens do not prioritize sanitation as a need, which will reduce their wiliness to pay for services. Their participation in the process will increase the chances of understanding the necessity and enable a much more successful outcome (Mulenga, et al., 2004).

Open Wastewater Planning (OWP) and Household-Centered Environmental Sanitation (HCES) are two innovative approaches of sanitation planning presented by Lüthi, et al. (2010). Both approaches focus on the treatment results and consider waste a resource, which ensures the sustainability of the systems. They also recognize stakeholder involvement as a requirement for effective planning. OWP is a simple and flexible method that is used to plan the most feasible technical solution, considering not only economic aspects, but also the objectives to have sanitation in the specific case. It allows planners to promote the best locally adapted solution and develop new technologies that will best fit the area, considering the system as a whole. HCES is a step-by-step demand-led planning approach that has the household as the main aspect for planning and implementation. It focuses on the community involvement in all planning steps and acts on unplanned and uncovered areas and low-income neighborhoods. This approach drives away from conventional centralized planning, includes the users' needs in the decision-making process and has the household as the main aspect of the planning process (Lüthi, et al., 2010, Schertenleib, 2005).

Implementing HCES planning in a sanitation project also has some challenges. It is a process that takes time to implement, much more than a supply-driven approach. The slow progress can cause frustration at the community level if the process is too long. Although HCES allows flexibility in the technology selections, stakeholders tend to keep on their comfort zone and choose traditional and known technologies, which are often disposal-oriented rather than re-use oriented solutions. Another feature of this planning approach is that it takes into consideration different points of view from all stakeholders, which can impair reaching a consensus among the parts. For this reason, it is important to have a trusted community leader to mediate different interests (Lüthi, et al., 2010).

After intensive piloting and evaluation of the household-centered approach between 2006 and 2010 in Africa, Asia and Latin America, the method was updated from Household-Centered Environmental Sanitation (HCES) to Community-Led Urban Environmental Sanitation (CLUES). The new approach highlights the importance of community involvement in the planning and decision-making process. The main characteristics from HCES are preserved in CLUES – it is a multi-sector and multi-actor approach, which considers stakeholders involvement from an early stage of the planning process. Lüthi, et al. (2011) propose a seven-step guideline for uncovered urban or peri-urban communities to plan and implement an environmental sanitation system considering CLUES approach. The planning steps include appraisal (process ignition and launch of the planning process), engagement (detailed assessment of current situation, prioritization, identification of service options and development of an action plan), and implementation of the action plan (Lüthi, et al., 2011, Lüthi, et al., 2010).

A precondition to adopt the CLUES approach is to have an enabling environment. It is a set of the following dynamic inter-related conditions, as shown on Figure 4 government support; legal and regulatory framework; organized institutional arrangements; technical expertise; provision

and access to financing mechanisms; and socio-cultural acceptance (Lüthi, et al., 2011, Lüthi, et al., 2010, Schertenleib, 2005).

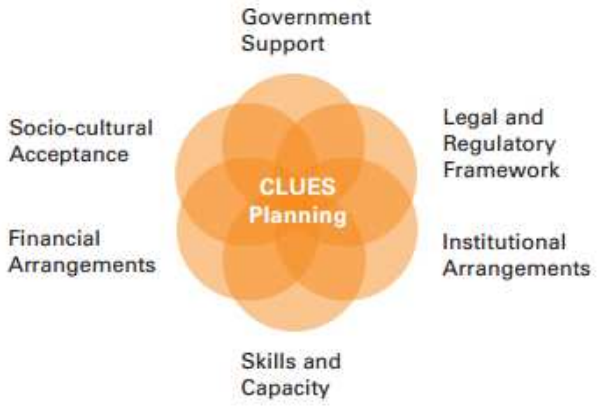


Figure 4 - Elements of the enabling environment (Lüthi, et al., 2011)

The enabling environment must be identified from the beginning of the planning phase and improved along the implementation process. It is important for the success of any investment and the six conditions will impact the implementation, sustainability and effectiveness of the project. Achieving a fully enabling environment is highly improbable, however there are some factors that are more or less enabling and should be focused on (Lüthi, et al., 2011, Schertenleib, et al., 2003).

Governmental support is extremely important for the implementation of the project. On the planning phase, it is usually assumed governmental support, but rarely assured. In the specific case of informal settlements, for a successful decentralized sanitary solution to be implemented, the local government must be engaged in providing sanitation for all, especially the poor. An enabling political environment is the government's support to decentralized decision-making and service provision as well as encouragement of community participation (Lüthi, et al., 2011).

The legal and regulatory framework will dictate how the sector will perform their functions. Laws, regulations, standards and codes define how sanitary services will be delivered, by whom, what are the standards that have to be met, which are the acceptable infrastructure, how the tariff will be implemented and so on. Many of these frameworks are adapted from developed countries and are often not applicable to developing countries situation. Introducing a new system in this context will depend on the legal and regulatory framework in place. Special attention is required on regulations of ministries or governmental agencies responsible for water supply, environmental sanitation and urban planning and also on laws that promote or prohibit community participations in environmental protection activities (Lüthi, et al., 2011).

There are many different stakeholders involved in the institutional arrangement of sanitary services. When planning a community-centered system it is important to understand the interaction between the stakeholders, their influence, interest and importance in participating on the project. The different actors that might be involved are: household members, local councilors, local schools, community-based organizations (CBO), community-level authorities, municipalities, district authorities, urban development authorities, specialized agencies, NGOs, private service providers and farmers (Lüthi, et al., 2011). Most of the Urban Environmental Sanitation Services (UESS) organizations are not familiarized with the CLUES approach, through a consultative process and responding to the household demands. This will require a shift on the behavior of these organizations adapting to the household-centered approach (Schertenleib, et al., 2003).

Assuring a high level of technical skills and capacity to conduct the project management process are fundamental for an effective implementation of a community-led decentralized sanitation system. The strengths and weaknesses of the stakeholders should be identified together with

the institutional arrangement characterization. If the involved actors do not have the required skills and capacities, they should be properly trained to guarantee the effectiveness and sustainability of the project.

Financial arrangements will deeply affect the technology selection for the sanitation system of the community. Regardless of how simple it can be, having an adequate environmental sanitation service is always costly. Not only the implementation prices have to be considered, but also the costs for administration, operation and maintenance, training of staff, expanding hardware, social marketing programs, and so on. The capital investments are still funded by the central governments and international development agencies. However, studies have showed that the urban poor are capable of gathering funds themselves for sanitation services that are properly designed for their financial status. Moreover, the wiliness to pay for these services will depend on their understanding of the benefits of having access to improved environmental sanitation. An enabling environments requires a financial arrangement that is locally anchored, easily accessible and sustainable, as it is in a full cost-recovery system (Lüthi, et al., 2011).

One of the main aspects of an enabling environment for a sustainable system is having socio-cultural acceptance of the infrastructure that is being implemented. The technology has to agree with the user's preferences, but the community has also to adapt some of their behaviors committing to long-term participation process. In this aspect, it is extremely important for the community to actively participate in the planning, management and implementation processes of the project (Lüthi, et al., 2011).

The importance of having an enabling environment is clearly exemplified by Taing, et al. (2011) in the study case of the informal settlement of Kosovo in Cape Town. The government invested USD$2.4 million on the implementation of a sanitary system that failed shortly after its commissioning. In spite of having political, financial and legal framework support, the environment did not have good conditions on the institutional arrangements, socio-cultural acceptance and skills. The sanitation system was provided by the government with a supply-driven approach and the community was not taken into consideration in the planning and management of the project. Once there were many physical and technical constraints to provide conventional sewerage system, the technical solution provided was a vacuum system. Many vacuum toilets were installed in the settlement, but there was no compatibility with the socio-cultural aspects of the community, which used alternative materials for anal cleansing. No educational program was implemented to change cultural habits and soon the toilet was used to waste other materials rather than human excreta or toilet paper. The pipes clogged shortly afterwards leading to equipment malfunction and entire shutdown of the system. In addition, the institutional arrangement was not well organized because there was no prior agreement on the planning phase of the project. Governmental departments could not agree on the responsibility of the operation and maintenance of the system, which also led to the system failure. Then, when officials undertook responsibility to save the system due to political pressure, they were unable to do it because there was no prior training of the staff. The combination of poor conditions to an enabling environment doomed Cape Town's vacuum system (Taing, et al., 2011).

2.7. Chapter summary

- Only 68% of the world's population have access to improved sanitation facilities. Although the situation has improved in the last 25 years, 2.4 billion people in the world still lack access to improved sanitation.
- Sanitation provision is a human right and has a big impact on people's lives. 65% of diarrheal diseases can be avoided by the provision of WASH facilities. Sanitation plays an important role in social and economic development of the world, since it is directly related to work productivity and school enrolment.
- Most of the people who do not have access to improved sanitation live in rural areas. However, the biggest problem is on informal settlements, due to their high population density and close human contact with their excreta.
- The Sustainable Development Goals established 17 goals to reduce poverty worldwide. One of the targets of the 6th goal is to end open defecation and provide improved sanitation for all by year 2030.
- The world fast urbanization has led to growth of poor urban communities, which are unprivileged in many aspects, including sanitary provision. Governments in developing countries tend to overlook the problem and deny providing infrastructure to these illegal dwellings to avoid attracting more people to it.
- Conventional centralized systems have been developed for many years along with human civilization. Even though centralized systems are the most adequate solution around the world, especially in developed countries, providing the state-of-the-art solution for informal settlements might not be sustainable. Decentralized systems are considered to be more appropriate for these communities.
- Decentralized sanitation does not necessarily require decentralized management, but it is more sustainable if it is applied. The total decentralization of management transfers the power, authority and responsibilities, including financial matters from the government to local organizations.
- There are new trends of sustainable planning which drive away from supply-led approaches and trust demand-led approaches. An effective and sustainable sanitary solution relies on the inclusion of the community and different stakeholders in the decision-making process.
- An enabling environment for an effective and sustainable sanitation project rely on six factors: government support; encouraging legal and regulatory framework; organized institutional arrangements; technical expertise; provision and access to financing mechanisms; and socio-cultural acceptance.

CHAPTER 3

Methodology

This chapter describes the methods that were used to achieve the specific objectives and answer the questions of this research. The section gives a brief summary of the theory involved in the methodology chosen and explains in detail the design aspects of each part of this research. A summary table and charts are presented at the end of the chapter as an overview of what was done.

3.1. Research Design

This research focuses on three specific objectives: a) investigate why informal settlements exist and how they emerged in such a planned city as Brasília; b) characterize the present sanitary situation and verify the adequacy of sanitary solutions in the study case location; and c) investigate institutional decisions towards sanitary solutions for informal settlements, regarding planning, management and technical feasibility. To reach these objectives, data collection is mainly carried through semi-structured interviews and survey and results are analyzed using qualitative and quantitative methods. This session briefly shows the methodology used.

3.1.1. Data Collection

The data collection in this research used different sources, as schematically presented in Figure 5. Kumar (2011) and Hox and Boeije (2005) categorize the data collection into two approaches: primary and secondary. The primary sources address to data collected directly from the community through surveys, interviews or scientific observations. Secondary sources are data collected from documents, such as census, institutional records, articles, journals, books, historical data and so on. In this research, both approaches were used complementing each other, as it is described on chapter 3.3.

According to Kumar (2011), the three ways to collect primary sources are through observation, interview (structured or semi-structured) and questionnaires or surveys. All of these methodologies were used in this research, selecting semi-structured interviews. Semi-structured interviews are defined by Bryman (2008) as interviews with previously formulated questions that can vary their sequence and further questions may be asked in response to significant replies. The observation method complements the other methods and uses the researcher criteria through listening and watching a phenomenon or interaction as it happens. In this research, observation has a minor importance and it was partially adopted, since the fieldwork time was reduced to apply this method appropriately.

A survey was used as source for data collection in one part of this research. Survey is defined (Bryman, 2008) as a list of structured questions that can be applied by mail, phone or in person to a group of people or individually – this research used the individual method. The data collected by the survey was done by a completion of questionnaire or structured interviews applied to many people. The amount of sampling makes the data quantifiable and comparable (Bryman, 2008). Either in structured interviews or surveys, open-ended questions (possible answers are not given) or closed questions (possible answers are given) may be applied (Kumar, 2011). This research considered both closed and open-ended questions on the survey applied in the community.

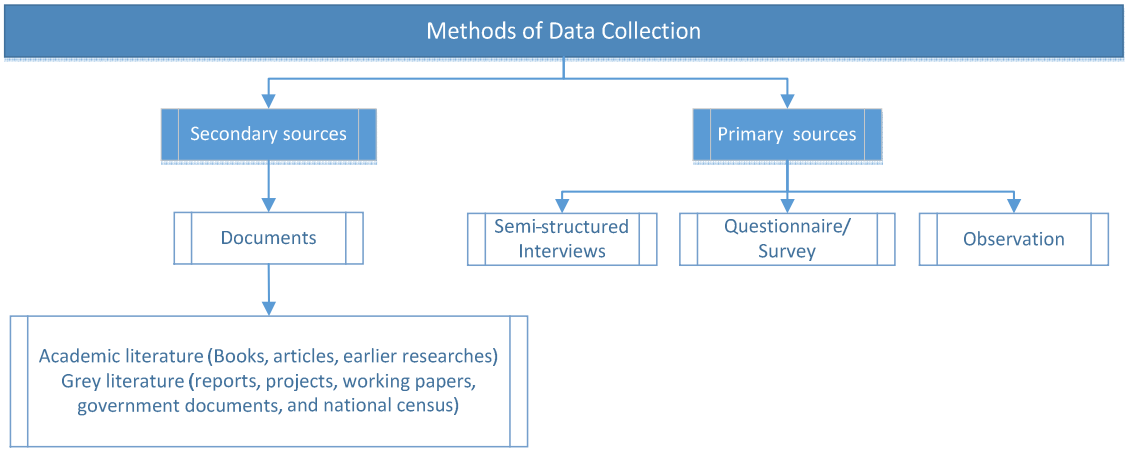


Figure 5 - Methods of data collection – Adapted from Kumar (2011)

3.1.2. Data analysis

Qualitative and quantitative methods were used to analyze the data collected. According to Kumar (2011), these methods overlap a little and differentiate according to the research conduct. The quantitative method demands standardizing the interviews and questions to be asked that should be predetermined and tested beforehand. The method has to guarantee that the data collected is truly comparable for the results to be reliable. The qualitative method is more flexible and allows freedom on the structure of the data collection (Kumar, 2011).

In this research, qualitative method was mostly used, except for Vila Cauhy' surveys, which data was first analyzed quantitatively. Qualitative analysis was used afterwards as an additional method to obtain reliable results. The complementation of these methods was given through triangulation (Figure 6). According to Bryman (2008), triangulation is the process of cross-checking findings from qualitative and quantitative methods in a mixed method approach and reinforcing it with the findings from significant literature review.

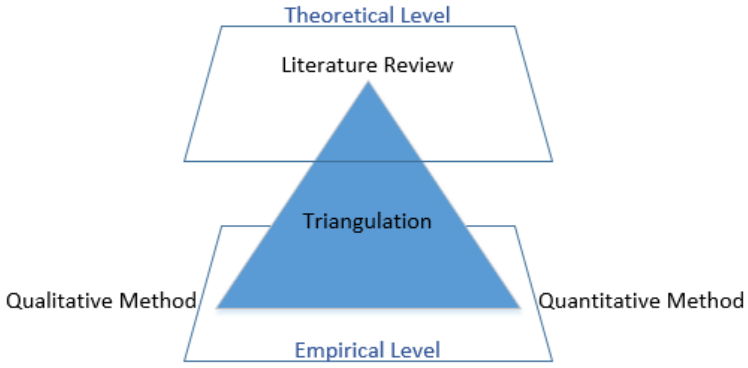


Figure 6 - Illustration of triangulation method (Adapted from (Östlund, et al., 2011))

3.2. Study case location

3.2.1. Brasília

Bringing the capital of Brazil from Rio de Janeiro to the inner side of the country was an idea that emerged in colonial times. The plan was to build a new capital in the middle of the country to protect the regency from any external attacks and to bring development to the inside of the country. The idea matured over time, with the contribution of many politicians. Since 1892, many expeditions were made to the central area of Brazil, to allocate the area of the Federal District, which was mapped and deeply studied by many experts hired by the Government. It was only in 1946 that the new capital of Brazil started to be planned and designed. In 1957 the construction works of Brasília, a city shaped as an airplane (Figure 7), finally started. It was only in 21 of April of 1960 that Brasília was finally inaugurated by the President of the time, Juscelino Kubitschek.

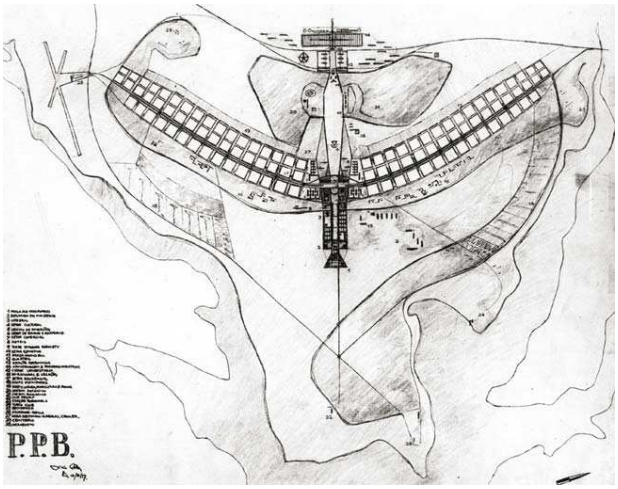


Figure 7 - The first project of Brasília by Lúcio Costa – Plano Piloto (Valle, 2012)

Along with the construction of the new capital of Brazil, many informal settlements for the construction workers emerged in the surroundings of the city as camps. One of the first camping was Cidade Livre, which means '*Free City*'. The camp was supposed to be temporary while the

workers that lived there were working in the construction of the new capital. The Government intended to demolish the '*Free City'* after the inauguration of the capital. However, '*Free City'* was growing a lot and many camps were emerging around it and inside the construction site of Brasília. To solve this issue, the Government decided to urbanize the settlement to become a city for the workers and immigrants: Núcleo Bandeirante. It was the first 'satellite-city' of Brasília (Gautherot, et al., 2010).

Over the years, the satellite-cities grew in size and population. They became practically merged with the capital as a cluster and for this reason the Federal District can be commonly referred as Brasília. The cities are now called Administrative Regions (Governo de Brasília, N.D.). The total area of 5,780km² of the Federal District that was originally planned for the population of 500 thousand is now occupied by almost 3 million people (Campos and Canes, 2015, IBGE, 2016, Setti, 2005).

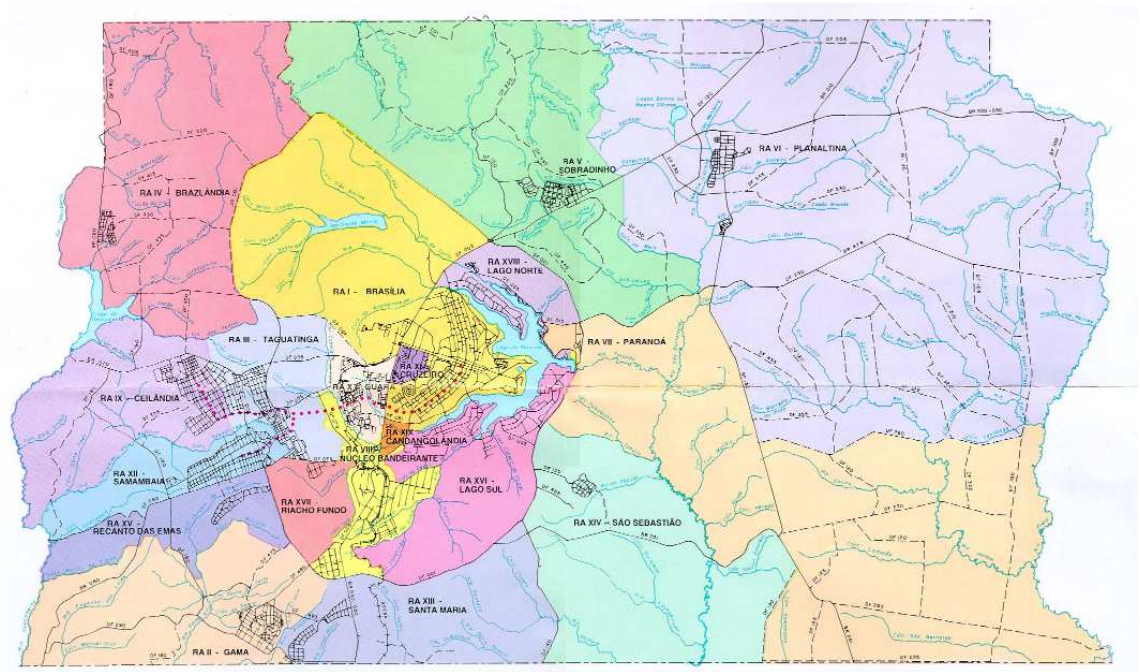


Figure 8 - The Federal District today - Administrative Regions division

3.2.2. Vila Cauhy

This research embraces not only sanitation in informal settlements, but also considers going in depth in one informal settlements to answer the second research question: "To what extent does living in an informal settlement affect accessibility to sanitation in Brasília". To answer this question, more information was needed from one of Brasília's informal settlements. According to personal communication with the Company of housing development of the Federal District (CODHAB), Brasília has 64 informal settlements today. The on for the study case was selected considering the following criteria: low-income informal settlement with sanitation problems and open-air sewer; no access to formal sanitation services; close location to the center of Brasília; easily accessed by car; small community and few households (less than 5000); non-violent community. CAESB was contacted and they could inform that Vila Cauhy met all

criteria. Furthermore, Vila Cauhy had attempted to implement a decentralized sewer system in the village. In spite of being inadequate for discharging raw wastewater directly into the nearest stream (Riacho Fundo stream), this action shows a proactive behavior of the community into solving sanitation issues of the village. This is an important characteristic to implement decentralized sanitation systems, and this is why Vila Cauhy was chosen as the specific informal settlement studied in this research.

Vila Cauhy is an informal settlement located in the administrative region of Núcleo Bandeirante. As shown on Figure 9, Vila Cauhy is located very close to the Pilot Plan of Brasília, which is an area with high real estate value. According to the latest National Census (IBGE, 2017), Vila Cauhy has a population of 1640 people living in 458 dwellings. Ninety six percent (96%) of the residences are permanent while only 4% live under other conditions of impermanent residences.

According to Barbosa (2015), the name Vila Cauhy was given to the village after an episode of flooding. The families who lived close to the Riacho Fundo stream suffered from a big flooding and Civil Defense decided to remove the families from this area of risk and relocate them to a housing complex far away. A deputy named Jorge Cauhy demanded the relocation of these families to another area inside the village. The villagers acclaimed Jorge Cauhy and named the village after him.

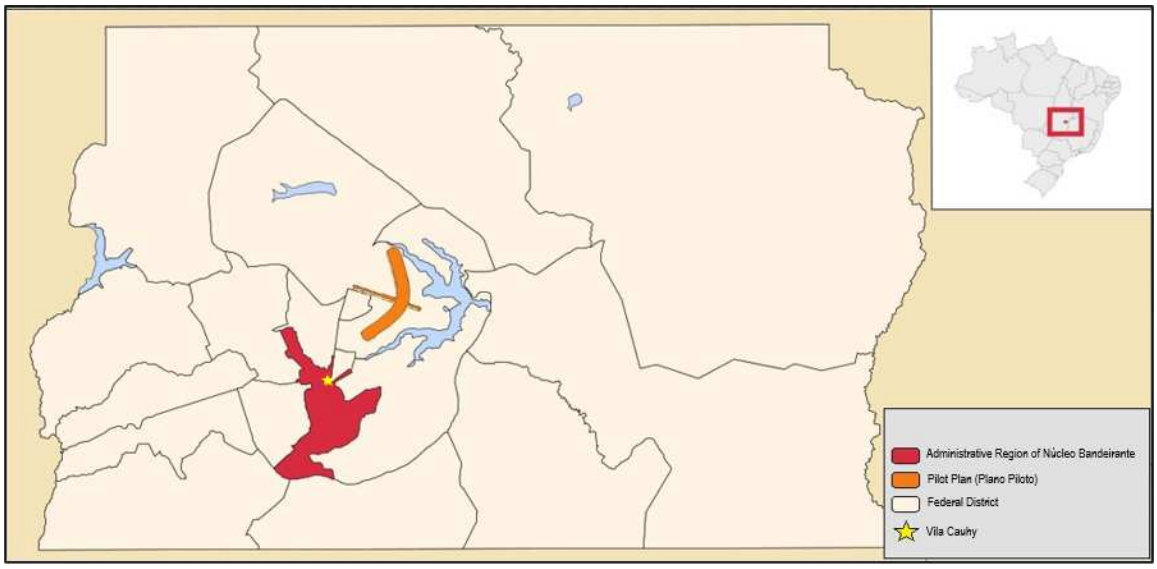


Figure 9 - Map of the Federal District - Location of Vila Cauhy - Adapted from Wikipedia (2017)

3.3. Sample

Two groups of samples were used in this study. The first group encompasses relevant stakeholders that are involved in the problem of lack of sanitation services in informal settlements of Brasília. The second group comprises residents of Vila Cauhy.

3.3.1. Stakeholders

In October 2016, organizations that have activities related to sanitation in the Federal District were listed as potential stakeholders. The criteria chosen for this study was to select organizations that had apparent interest or influence in implementing sanitation or in affecting informal settlements from becoming legalized both in Brasília and in Vila Cauhy. The list included 19 stakeholders, with the following distribution: eleven stakeholders from public organizations of the Federal District; two public organizations at national-level; one civil-society organization that acts at national level; one private and one public local-level stakeholder that act on general informal settlements of Brasília; and three local-level stakeholders that act specifically in Vila Cauhy, including community members of the village.

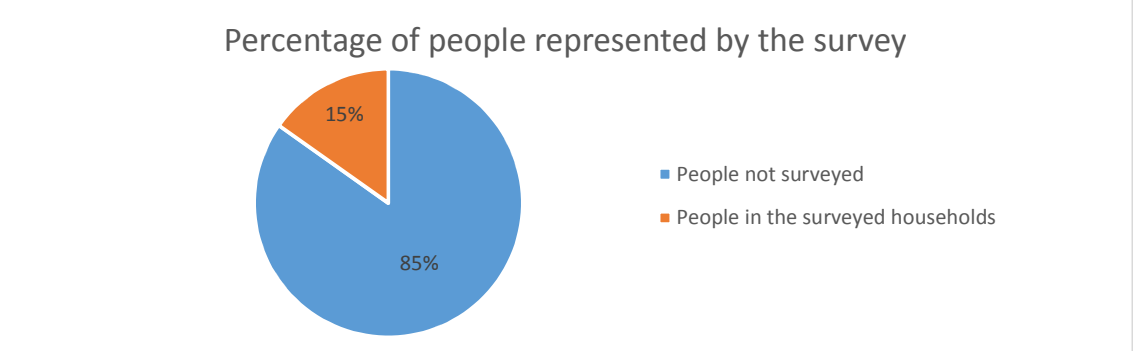
Table 1 - List of stakeholders

N.	Stakeholder	Competency
1	Community members of Vila Cauhy	Local
2	Municipality/ Town council of Vila Cauhy	Local
3	AMOVIC - Association of Community Members of Vila Cauhy	Local
4	Health center of Núcleo Bandeirante	Local
5	Vacuum truck companies	Local
6	CAESB - Environmental Sanitation Company of the Federal District	Federal District
7	ADASA - Regulatory agency of water, energy and sanitation of the Federal District	Federal District
8	SINESP - Secretariat of Infrastructure and Public Services	Federal District
9	IBRAM - Environmental Institute of the Federal District	Federal District
10	CODHAB - Company of housing development of the Federal District	Federal District
11	SEGETH - Secretariat of housing and management of the territory	Federal District
12	CODEPLAN - Company of Planning of the Federal District	Federal District
13	SEMA - Secretariat of Environment of the Federal	Federal District
14	Secretariat of Health of the Federal District	Federal District
15	Secretariat of Cities of the Federal District	Federal District
16	Agefis - Inspection agency of the Federal District	Federal District
17	FUNASA - National Foundation of Health (Ministry of Health)	National
18	Ministry of Cities	National
19	Trata Brasil Institute	National

In December 2016, stakeholders were contacted for data collection of this research. The technical directors or coordinators of the regional-level (Federal District) and national-level were chosen as contacts of these organizations, due to managerial and technical information these positions usually hold. From the list of 19 stakeholders, six were not contacted to provide data for the research. Vacuum truck companies and Agefis were not contacted because all required information were held by other connected organizations – CAESB and SEGETH. The Secretariat of Health and the Secretariat of Environment (SEMA) did not consider themselves as stakeholders. Secretariat of Health claim they do not have any interference with sanitation in the Federal District, while SEMA informed IBRAM is responsible for all environmental aspects of the Federal District. CODEPLAN was not directly accessed, however their documents were considered to complete data collection of this research. Finally, the Secretariat of Cities could not be contacted when the fieldwork was carried, because it was not well structured yet – this Secretariat was created in September 2016, three months before the data collection.

3.3.2. Community members of Vila Cauhy

On January 7th, 2017, community members of the village were contacted to answer a survey. The villagers were randomly chosen, depending on their availability in participating. Fifty three residents were accessed, representing 249 family members (including children). This represents 15% of the total population of the village – 1640 people according to National Census of 2010 (IBGE, 2017). All surveyed were adults, 51% woman and 49% men. Further information on the community members is disclosed on Chapter 4.



Graph 1 - People represented by the survey

3.4. Instruments

3.4.1. Semi-structured interviews

The interviews were pre-defined as a desk study phase of this research, where questions were elaborated to access information that had a direct influence on the research questions and were related to sanitation, environment, health, informal settlements and specific information on Vila Cauhy. The questions were elaborated based on Mulenga (2003), Muzvidzwa (2014) and Alves (2015). They comprise several aspects such as implementation of sanitary infrastructure and services in the Federal District; issues in implementing sanitation in informal settlements of Brasília; applicability and use of decentralized sanitation systems; procedures to legalize an informal settlement and sanitary implications when the legalization is conquered; and reported health issues related to lack of sanitation. Five protocols were designed, which are presented on Appendix A. Table 2 shows which interview type was applied to which of the stakeholders listed in Table 1.

Table 2 - Interview types

Interview type	Respondents
Type 1 - Information on Vila Cauhy	Municipality of Vila Cauhy AMOVIC
Type 2 - Sanitation	CAESB SINESP ADASA FUNASA Trata Brasil Ministry of Cities FUNASA

Type 3 - Environment	IBRAM
Type 4 - Informal Settlements	CODHAB SEGETH
Type 5 - Health	Health center of Núcleo Bandeirante

The interviews were all recorded with audio, except for the interview with SEGETH and the Health center, where this was not possible. The information collected was written by hand and later complemented while listening to the audio. The interview with Trata Brasil was the only one done by phone; all other were carried personally. When interview questions were not applicable to the activities developed by the organization, they were omitted during the interview.

3.4.2. Survey

The survey was designed as a desk-study phase of this research to be applied in Vila Cauhy. Many questions were adopted from UNICEF and WHO (2006a), Mulenga (2003) and Muzvidzwa (2014), while others were specifically developed for this research. As presented on Appendix B, the survey was composed of four parts. The first part comprised questions of general information about the family, such as: the number of people living under the same roof; the educational level of the head of the family; their income; time in years they have lived there; the comparison between the housing conditions they used to live and now at Vila Cauhy; and the presence of diseases related to lack of sanitation. The second part of the survey had questions regarding water and electricity services, in order to compare the priority given to sanitation services and other services. The third part was specifically designed to characterize the sanitation services in the village, from user interface until final disposal. Furthermore, some questions were directed to decentralized solutions and how community members would be willing to contribute to have their own sanitation system. The final part was a complement to the first one, where the interviewer observed the household to see the economic status of that family.

According to National Census (IBGE, 2017), Vila Cauhy had 458 households in 2010 (most recent data). Considering this number, the criteria was to interview at least 10% of the houses. However, the actual number surveyed was 53, which represents representing 12% of the households of the village. The survey was led by a group of 10 people, including eight volunteers, the researcher and the community leader. Four of the volunteers were conceded by CODHAB, which showed their support to this research by enabling their contact list with their permanent group of volunteers who assist them in studies and social work.

The survey was applied in Vila Cauhy on January 7th, 2017. The group of volunteers was gathered in the municipality building at 9AM, where they were instructed on how to apply the survey. At 10AM, the group, led by the community leader, entered the village surveying dwellers. The community leader assisted on knocking on the doors and asking the villagers to collaborate with the research. The households surveyed were located in the streets marked in red on Figure 10, which could be accessed through the main streets of Vila Cauhy. The samples were chosen randomly, however in a representative manner. Each survey took from 10 to 30 minutes, depending both on the interviewed and interviewee. The 53 households were surveyed in five hours.

Figure 10 - Streets visited for the survey

3.5. Research parts

The instruments and samples previously described are used to answer the three research questions, which respectively represent parts two, three and four of this thesis. The first part is reserved to the stakeholder analysis, which is analyzed in depth supporting the subsequent parts. Figure 11 shows a schematic overview of research parts, which are described in sequence.

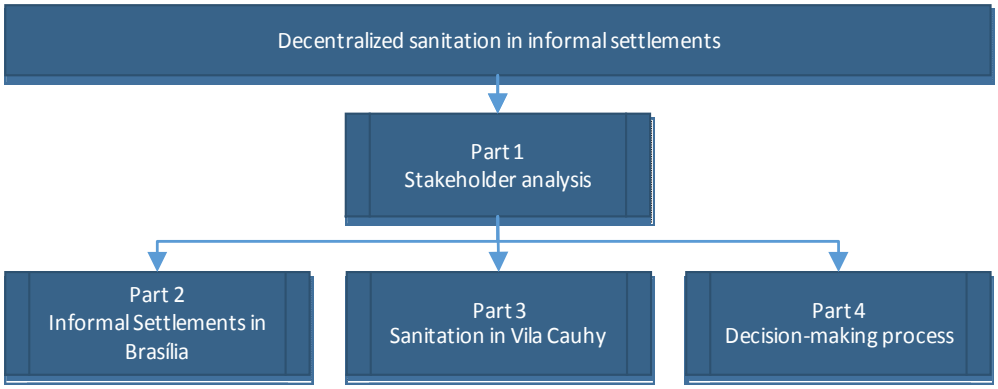


Figure 11 - Schematic overview of methodology

3.5.1. Part 1: Stakeholder analysis

A stakeholder is a "social entity, a person or an organization, able to act on or exert influence on a decision" (Enserink, et al., 2010, p. 79). Many stakeholders are involved in a problem and they interact and cooperate with each other. Understanding the motivation and objectives of

each stakeholder on participating in the same issue is essential for a problem solving. The stakeholder analysis is therefore a method used to support a project management, design an activity or to strategically advice corporations (Enserink, et al., 2010). It is "the process of identifying and characterizing stakeholders, investigating the relationship between them, and planning for their participation" (Strande, et al., 2014). According to Enserink, et al. (2010), to develop a stakeholder analysis it is first required to formulate a problem as a point of departure, than make the inventory of the stakeholders involved and exhibit as a chart with formal tasks, authorities, and relations of actors. Than it is necessary to determine the interest and influence over the initial problem and map the interdependency between actors. These steps were adopted as a methodology for the stakeholder analysis.

This part of the research is not directly linked to a research question. However, it is used to further characterize the organizations involved in the provision of sanitary services in of Brasília. The information on activities developed by each organization was collected using secondary sources during the desk study phase of the thesis and reevaluated during the interviews on fieldwork. The data was qualitatively analyzed to list roles and responsibilities of each stakeholder, which range from operation, ownership, finance and oversight aspects. The analysis enabled interpreting the level of interest and influence of the stakeholder towards the main problem in Vila Cauhy, as indicated by Enserink, et al. (2010). The final step of the stakeholder analysis was to develop a map of relations between the actors. These outcomes were used as tools to the subsequent parts of this research, which required information on stakeholders to proceed with interviews for data collection.

3.5.2. Part 2: Informal settlements in Brasília

Specific objective: Investigate why informal settlements exist and how they emerged in such a planned city as Brasília.

Research question: What factors contributed to the development of informal settlements in a planned city such as Brasília?

Providing access to improved sanitation for informal settlements is a task that might be limited by many aspects (Chapters 1 and 2). When studying the specific case of sanitation in Brasília, it is not enough to focus on the technologies or institutional aspects to provide services to informal settlements. A planned city such as Brasília did not count on the existence of these communities on the first place and yet they persist emerging and are increasing in many areas of the Federal District and surroundings. Therefore, for the sake of completeness of this study, it was included this social aspect, which contributes to the sanitation scenario of the District.

The data collected was accessed through primary and secondary data. Documents from CODEPLAN, National Census (IBGE) and the Master Plan of Territorial Order of the Federal District (PDOT) issued by SEGETH were accessed. To complement this data, semi-structured interviews were carried on with two governmental organizations that are responsible for the organization of the territory and legalization process of informal settlements: the Secretariat of housing and management of the territory (SEGETH); and the Company of housing development of the Federal District (CODHAB).

In addition, some specific questions were included in the survey of Vila Cauhy to enhance our understanding of the reasons this population came to this settlement and how they were able to settle on that land. Appendix A presents the interviews protocols and Appendix C presents the survey results. The data was analysed qualitatively and results are presented on Chapter 4.2.

3.5.3. Part 3: Sanitation in Vila Cauhy

Specific objective: Characterize the present sanitary situation and verify the adequacy of sanitary solutions in the study case location.

Research question: To what extent does living in an informal settlement affect accessibility to sanitation in Brasília?

The methodology used to carry this part of the research used the survey applied in Vila Cauhy and semi-structured interviews with local stakeholders – the municipality of Vila Cauhy and the Association of Community Members (AMOVIC). To complement some of the information on how informal settlements are serviced in Brasília and in Brazil, other stakeholders at regional level were accessed: CAESB, ADASA, SINESP, and IBRAM. At National level, FUNASA, Ministry of Cities and Trata Brasil Institute were also interviewed. The interviews are presented on Appendix A. National census data was also used for additional information on Brasília and Vila Cauhy.

With all information gathered, qualitative methods were mostly used to analyze and discuss the data. Quantitative analysis was used adding a statistical perspective of the present situation and the results were triangulated with literature review. The discussions were complemented with a graphical representation of the present value chain, adapted from Compendium of Sanitation Systems and Technology (Tilley, et al., 2014) and the graphical representation proposed by Bill & Melinda Gates Foundation (2010).

To answer the research question, three categories were first set, as presented on Table 3: Highly affected, partially affected or not affected. With the results collected, it is possible to categorize how the population of Vila Cauhy is affected and extrapolate the results to similar cases in Brasília. This part of the methodology was not retracted from literature, but developed specifically to this research.

Table 3 - Categories of impact

Highly affected	Partially affected	Not affected
Do not have access to improved facilities	Have high access to improved facilities	Have full access to improved facilities
Have been contaminated with faecal-oral diseases	Low percentage contaminated with faecal-oral diseases	Are not contaminated with faecal-oral diseases
Are in contact with open air sewerage	Some areas are in contact with open air sewerage	Do not have open air sewerage
Do not have access to formal sanitation services	Do not have access to formal sanitation services	Have formal sanitation services

3.5.4. Part 4: Decision-making process

Specific objective: Investigate institutional decisions towards sanitary solutions for informal settlements, regarding planning, management and technical feasibility.

Research question: How is the decision-making process for implementation of sanitation developed and how has planning affected technology choice, implementation and management of decentralized sanitation systems in informal settlements in Brasília?

Having a clear picture on factors that affect decentralized sanitation to be developed, delivered and uptaken in informal settlements requires an understanding of institutional decisions towards sanitary provision. To answer the research question stated above, it was made a selection of stakeholders that interfere with sanitary provision in Brasília and in Brazil and a semi-structured interview was applied. The interview followed the same protocol for all respondents (presented on Appendix A). The regional environmental agency (IBRAM) and local stakeholders were only interviewed with complementary questions where needed. The selected organizations were:

- CAESB, ADASA, SINESP and IBRAM – Public organizations at regional level (Federal District);
- FUNASA and the Ministry of Cities – Public organizations at national level;
- Trata Brasil Institute – Civil society organization that acts at national level;
- Amovic and Municipallity of Villa Cauhy – local stakeholders.

The data provided by the interviews were analyzed qualitatively and triangulated with information disclosed on literature review to achieve the specific objective. Once concluded the investigation of the decision-making process, the analysis was complemented with recommendations on what and how institutional aspects can be improved to ensure an enabling environment for the implementation of decentralized systems in informal settlements. The model proposed by CLUES (Lüthi, et al., 2011), presented on Figure 4 (page 18) was used to discuss what factors should be improved in Brasília's scenario: Governmental support; institutional arrangements; legal framework; skills and capacities; financial aspects; and social-cultural acceptance.

3.6. Limitations

The development of this research had some limitations to achieve better results. It was mainly carried from another country, so the contact with stakeholders were restricted to 1.5 months period. Had there been more time to perform all the research, the fieldwork could be extended, and more interviews could be performed with different people from the same organization. The survey was done in only 15% of the households. In spite of being a representative number, a larger number of survey can bring results that are more reliable. The survey was applied by a group of people, which also compromises the results. Stronger results could have been obtained if only one person (the researcher) collected this data. Some of the stakeholders were not interviewed, which is also a limitation to the results.

3.7. Chapter summary

The methodology used in this research is summarized in Figure 12 and Table 4. The four parts previously described are presented in this table along with the specific objective and research question it is directly linked to the data collection methods and the outcomes that will be produced from the analysis.

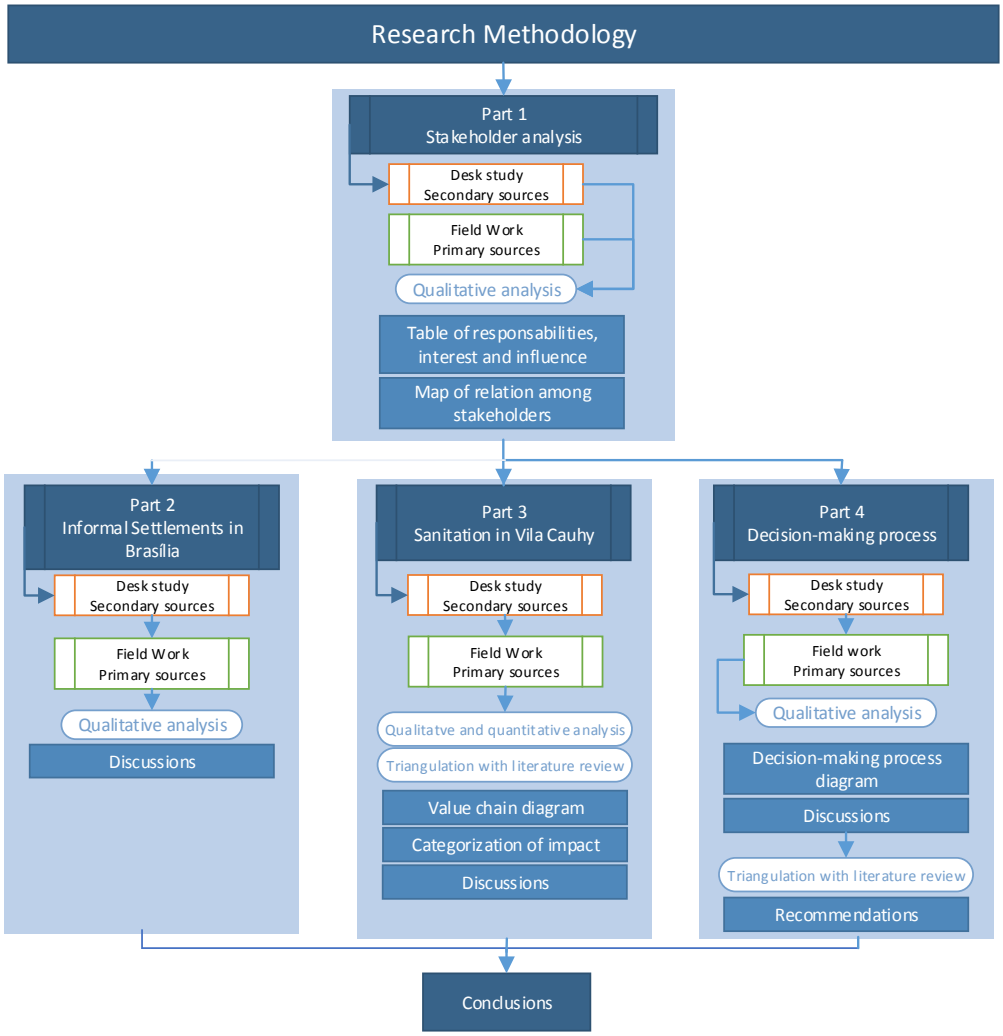


Figure 12 - Summary chart of the research methodology

Table 4 - Methodology summary

Part		Specific objective	Research question	Data collection		Analysis	Outcomes
				Secondary sources	Primary sources		
1	**Stakeholder analysis**	All four specific objectives require preliminary stakeholder analysis.		Organizations' documents and literature review	Complementary interview on activities developed	Qualitative	Table of information on the responsibilities, interest and influence; and Map of relations between the actors.
2	**Informal settlements in Brasília**	Investigate why informal settlements exist and how they emerged in such a planned city as Brasília.	What factors contributed to the development of informal settlements in a planned city such as Brasília?	Books, reports, documents	Semi-structured interviews	Qualitative	Historical background
3	**Sanitation in Vila Cauhy**	Characterize the present situation and verify the adequacy of sanitary solutions in the study case location.	To what extent does living in an informal settlement affect accessibility to sanitation services in Brasília?	National census, documents from government; Literature review on service chain.	Survey in sample dwellings and semi-structured interviews with organizations involved .	Mixed methods and Triangulation	Value chain diagram Categorization of impact
4	**Decision-making process**	Investigate institutional decisions towards sanitary solutions for informal settlements, regarding planning, management and technical feasibility.	How is the decision-making process for implementation of sanitation services in Brasília developed?	Organizations' documents.	Semi-structured interviews with organizations involved.	Qualitative	Decision-making process diagram.
			How has planning affected the technology choice, implementation and management of decentralized sanitation systems in informal settlements of Brasília?				
		Identify what and how sanitation can be improved in informal settlements of Brazil.	What are recommendations to create an enabling environment for decentralized sanitation in informal settlements of Brasília?	Literature (Books, articles and reports on international cases).	-	Triangulation	Recommendations.

CHAPTER 4

Results

This chapter brings results of data collected through the methodology proposed in the previous chapter. It is divided in four subchapters that correspond respectively to the research design parts of the methodology. The analysis of results and discussions are presented on Chapter 5.

4.1. Results on stakeholders – Part 1

The identification of stakeholders determines all organizations that need to be interviewed for other parts of the research. Furthermore, the analysis is used to understand how each stakeholder has to be approached to improve sanitation aspects of informal settlements in Brasília. The activities of each stakeholder are described here and are analyzed in chapter 5.1.

The information provided from governmental organizations resulted in a list of nineteen stakeholders that interfere with the main problem in many aspects. The description on their activities are based on the organization's websites, interviews and survey.

- **Community members of Vila Cauhy**

  Given that one part of this research evaluates the informal settlement of Vila Cauhy, community members are considered a stakeholder to the lack of sanitation service. Through information collected with the survey applied on Vila Cauhy, it is proven that community members face a problem with sanitation. Eighty three percent (83%) of the village show dissatisfaction towards sanitation aspects of the village. Although they have tried to improve infrastructure in the village, they say the problem could not be solved with their own efforts. Many of them believe the only solution is to have sanitation services formally provided by the sanitation company. Today, they use septic tanks or unsealed trenches to collect wastewater from their homes. However, appropriate sludge treatment is rarely an option adopted by the villagers and it is done when residents hire a vacuum trucks company to collect the sludge and transport it to one of the sanitation company's wastewater treatment facilities.

- **Municipality of Vila Cauhy**

  Even though Vila Cauhy is an informal settlement, it has a town council (municipality) founded by community members in 2006. This stakeholder was interviewed to understand activities developed and how they interact with sanitary problems of the village. According to the interview, the municipality of Vila Cauhy is a civil and legal entity, registered and legally recognized. The community contributes financially every month and often vote for

a mayor and vice-mayor. The municipality organizes parties, promotes social assistance, supports low-income families to find jobs, helps families to reintegrate in the community, supports kids in extracurricular activities, etc. They have a political and social nature. Their main task is to fight for the legalization of the village, which is issued by CODHAB. They interact directly to speed the process along.

The municipality takes sanitation as a priority. However, the illegalization aspect of the village impairs the government to implement sanitation infrastructure. The municipality seeks formal service provision. However, they have helped the community to get material to implement pipelines that collect wastewater in the village. They mobilized the community to collaborate with labour in this project, which helped to reduce open-air sewer. The municipality and AMOVIC stated that they do not interact and avoid working together.

- **AMOVIC - Association of Community Members**

  AMOVIC is an organization created by members of the community since 2008. This stakeholder was interviewed to understand activities developed and how they interact with sanitary problems of the village. According to the interview, AMOVIC organizes many activities with the population of Vila Cauhy to create a better living space. They organize social events, such as "the village day"; encourage the community to make the streets more beautiful – the most beautiful street wins a prize (market food basket); organize solid waste cleaning sessions; provide water connections from the community well to households; implement wastewater pipelines in the village; among others. To promote all these activities, they have fifteen members on the board, including all fields, such as President, Social Director, Culture Director, Sport Director, Legal Director, Communication Director and Executive Director.

  Sanitation is a priority for AMOVIC. They understand the hazards that lack of sanitation can cause and the linkage to spread of diseases. For this reason, they implemented pipelines in the village to collect wastewater, transporting it from the households to the nearest stream (Riacho Fundo). Community members built the wastewater pipelines organized by AMOVIC. This project improved the quality of life of the villagers and AMOVIC is proud of what they have accomplished with the resources and knowhow they have. They did not claim they are directly responsible for the maintenance of the pipes. In personal communication, they stated that they do not interact and avoid working together with the municipality.

- **Health center of Núcleo Bandeirante**

  Vila Cauhy is not equipped with a health center in the village. Whenever needed, the population goes to the nearest health center, which is in Núcleo Bandeirante (data collected from personal communication with AMOVIC and observation). This health center has a separate session for the population of Vila Cauhy and they have a doctor/nurse responsible for the community. They reported having a low record of people carrying oral-faecal transmitted diseases due to lack of sanitation.

  The Health Center does not take direct actions towards sanitation. All health centers of Brasília, including this one, are part of the Secretariat of Health of the Federal District, which establishes policies and organizes campaigns executed at the health centers (Secretaria de Saúde, 2016).

- **Vacuum truck companies**

  Septic tanks are commonly used in the Federal District. Interview responses from CAESB show that this sanitation company does not consider septic tanks as formal sanitation provision, but they recommend this use wherever they cannot provide services. The recommended way to maintain a septic tank is to mechanically empty the tanks and discharge the sludge in one of the wastewater treatment plants provided by CAESB, where the sludge will be properly treated and the final effluent will be discharged in a water body according to the regulated standards of CONAMA[3]. CAESB used to provide this service sometime in the past, however today the household owners have to hire this service with their own financial resources. CAESB has a list of over eighty authorized vacuum trucks companies that provide this service (CAESB, 2017).

- **CAESB - Environmental Sanitation Company of the Federal District**

  CAESB is the company that provides water and sanitation services and infrastructure for all Federal District – urban and rural areas. It is directly linked to the Secretariat of Infrastructure and Public Services. Their activities are in multiple fields and processes of basic sanitation, from planning and designing to execution and service provision of drinking water supply and collection, treatment and final disposition of wastewater. CAESB has the responsibility to protect surrounding areas of water springs and reservoirs in which they collect water to supply. They have the right to expropriate, vacate, recuperate, isolate, protect and maintain these areas as well as control polluting sources. They supply water to 98% and collect wastewater of 82% of the population located in legal land inside the Federal District. All wastewater collected (100%) is treated according to standard of CONAMA (CAESB, 2016),

  CAESB states in their interview that they do not provide sanitation services to informal settlements because of the illegal aspect of the land – they are not authorized to do so. If there is an authorization, they provide the services just like any other legalized area and charge tariffs over the services. The tariff is paid according to water consumption – those who consume more pay more.

- **ADASA - Regulatory agency of water, energy and sanitation of the Federal District**

  ADASA is the regulation and inspection agency of water, sanitation and energy of the Federal District. It is directly linked to the Secretariat of Environment of the Federal District. They regulate and inspect the complete water cycle with especial attention to the uptake and devolution into the water body ADASA (2016).

  In their interview, ADASA claims to inspect CAESB, which is the concessionary of water and sanitation services of the Federal District. In the concession contract, there are targets for universalization of services that CAESB has to achieve. ADASA sets the targets, each time more severe, and makes sure CAESB accomplishes them, expanding services and adjusting their systems. ADASA states they are in favour of decentralized systems because there are interested in the universalization of services. However, if there is any discharge

[3] CONAMA is the National Environmental Board and one of their duties is to regulate standards for treated wastewater effluent parameters to be discharged in water bodies.

into a waterbody, ADASA has issue a grant allowing the discharge. The grant will only be issued if the effluent is within the parameters of CONAMA.

- **SINESP - Secretariat of Infrastructure and Public Services**

  This Secretariat is responsible for projects, execution, and inspection of public construction works, infrastructure, recovery of public equipment, and public services. SINESP plans the formal neighborhoods, designs and implements all urban infrastructure with the help of subordinated agencies such as CAESB (water and sanitation services), CEB (electricity services), SLU (solid waste services) and Novacap (drainage and road infrastructure), which are directly linked to this secretariat SINESP (2016).

  SINESP has informed in the interview that they are responsible for planning all infrastructure of the Federal District. They evaluate the area's needs and study the best solutions for that place. Regarding sanitation, they study the best option to collect and treat wastewater from the community. Usually they plan for conventional methods. However, if that is not possible, they can arrange a local decentralized solution. Then they contact CAESB to implement a sewerage system and provide services. They do not plan or implement infrastructure in informal settlements, which is against the law. Instead, they plan new neighborhoods, according to SEGETH with all adequate infrastructure for the families to be relocated.

- **IBRAM - Institute of environment and water resources of the Federal District**

  IBRAM is the environmental agency of the Federal District. It is directly linked to the Secretariat of Environment of the Federal District and it executes public policies of environment and water resources. IBRAM controls and inspects the use of these resources to promote sustainable development in the Federal District and to guarantee the population benefits reached from economic growth, without putting in jeopardize the quality of life of the residents of that region IBRAM (2016).

  IBRAM informed they issue all environmental licenses in the Federal District and have the power to authorize infrastructure to be implemented (from CAESB, SINESP, etc). When it comes to sanitation infrastructure, IBRAM only authorizes construction works in areas that are possible to be legalized. To issue an environmental license in places where a decentralized sanitation system is already in place, IBRAM will only issue the license if CAESB validates the system. In case the system does not comply with the standards, IBRAM has the power to fine the landowner (CODHAB). The legalization process of an informal settlement also depends on IBRAM, which investigates environmental impacts of urbanizing the area and then SEGETH and CODHAB can process the legalization.

- **CODHAB - Company of housing development of the Federal District**

  CODHAB is a Federal District company that promotes housings to the population of the Federal District. It is directly linked to SEGETH and all plans, programs and housing projects towards social interest that CODHAB develops are in accordance with the policies established by SEGETH. The policies and programs act towards the development of economic and social functions of the population with the intention of securing the wellbeing of the communities, improve quality of life and preserve the environment (CODHAB, 2016a).

CODHAB coordinates and executes actions related to the Policy of Housing Development of the Federal District. They promote urban, environmental and land legalization or regularization of areas of social interest of the District. It also takes measures to relocate informal settlements that are illegal or precarious. Their projects have the main interest of social wellbeing and they develop urban interventions that aim establishing and fixating residents. They plan, produce and sell house units destined for low-income families and intermediate financial allocations to help these families rent, buy or built their own houses.

CODHAB promotes the legalization process of low-income informal settlements of the Federal District. According to personal communication with Terracap and Codhab, high-income informal settlements are responsibility of Terracap. The legalization process of a settlement contains an urban planning and infrastructure project proposed by CODHAB and environmental licenses issued by IBRAM. The process is approved by SEGETH.

- **SEGETH - Secretariat of housing and management of the territory**

  SEGETH is the Secretariat of the Federal District that is responsible for the use and occupation of the land. It plans, projects, manages the territory, and ensures the urban planning and the housing population in an integrated way, inclusive, participative and sustainable (SEGETH, 2016).

  SEGETH is responsible to plan the urban areas and to indicate which areas might be legalized or not. CODHAB is directly linked to this Secretariat and it follows plans and directives established by SEGETH. AGESFIS is also dictated by SEGETH and it will inspect the areas of the District according to the plan of use and occupation of the land. SEGETH is the one that analyses the legalization process and issues the authorization for a settlement to become legal.

  One of the important documents produced by SEGETH is the Directive Plan of Territory Order of the Federal District (PDOT). It is an instrument of territorial policy and that guides other public and private organizations that act on production or management of urban localities and urban or rural territory expansion.

- **CODEPLAN - Company of Planning of the Federal District**

  CODEPLAN is the company that produces and disseminates information, studies and analysis of social, economic, demographic, cartographic, urban, regional and environmental aspects of the Federal District. They analyse and evaluate public policies for the Federal Government and for society. CODEPLAN holds many records including sanitary conditions of the Federal District and records on the history of Brasília (CODEPLAN, 2016a).

- **SEMA - Secretariat of Environment of the Federal**

  This Secretariat defines policies, plan, organize, direct and control the execution of actions regarding solid waste, water resources, environmental education and protected areas, aiming the sustainable development of the Federal District. SEMA is responsible for planning, coordinating and executing programs, projects and actions towards conservation, recovery, monitoring and sustainable use of the local vegetation, fauna and water resources. They develop environmental policies instruments that assure the development and infrastructure that have environmental interference. SEMA has partnerships with other

organizations that help to implement environmental policies including solid waste and water resources in the federal District. They propose actions of protection, conservation, preservation and recovery of urban and rural environments aiming sustainable development for the Federal District. SEMA also has the right to prosecute appeals of environmental infractions. IBRAM and ADASA are executive and inspection organizations directly linked to this Secretariat (SEMA, 2016).

SEMA was contacted to be further questioned, however they did not recognize themselves as stakeholders of this case and did not open for an interview. They explained that IBRAM is the environmental agency responsible for the practical issues in informal settlements.

- **Secretariat of Health of the Federal District**

  This Secretariat is part of the executive power of the Federal District and it is responsible for organization, preparation of plans and public policies towards health promotion, prevention and assistance to health. The function of this Secretariat is to arrange conditions to protect and recover the population's health, reducing illnesses, controlling endemic and parasitic diseases and improving heath monitoring, thus improving quality of life of the Federal District's citizens (Secretaria de Saúde, 2016).

  Regarding sanitation, this Secretariat participates on formulation and implementation of sanitation policies, integrating them to health services. They may also advise on sanitary measures and preventive control of illegal or irregular activities.

- **Secretariat of Cities of the Federal District**

  This Secretariat was recently been created (September 2016) to strengthen the link between the administrative regions with the other or organizations from the Government of Brasília. It gives speed to the provision of public services and to solving the population's demands (Secretaria de Estado das Cidades, 2016).

- **AGEFIS - Inspection agency of the Federal District**

  This agency promotes the compliance of rules of use and occupation of the land in accordance to the plan issued by SEGETH. Agefis promotes, protects and preserves the quality of life of the population of the Federal District, acting as transformative agent through actions of education and inspection of urban activity. They have the right to demolish households that are built in illegal public spaces or to impair construction works that will affect the use and occupation of the land (Agência de Fiscalização, 2017).

- **FUNASA - National Foundation of Health**

  FUNASA is an executive body of the Ministry of Health and it is responsible to promote social inclusion by means of actions regarding sanitation to prevent and control diseases outbreaks. It is also responsible for the formulation and implementation of actions on promotion and protection of health considering the National Subsystem of Surveillance in Environmental Health. The actions on social inclusion are held with prevention and control of diseases caused by lack or inadequate sanitary conditions in areas such as informal settlements or indigenous settlements (FUNASA, 2017).

  FUNASA states in their interview that they are directly active in the universalization of sanitation to achieve the SDG6. They provide funding to a state or municipality to build

sanitation infrastructure to communities up to 50,000 inhabitants. Their focus is rural area, but they also act on slum or other urban settlements. They see sanitation as a human right and they are highly interested in increasing access to improved sanitation and universalize services. FUNASA does not ask for proof of land ownership to provide sanitation at the household level. However, the state or municipality might make this demand. The operation and ownership of the infrastructure is given to the state, municipality or sanitation company.

- **Ministry of Cities**

  The Ministry of Cities is in charge of making policies and supporting programs towards urban development, housing, basic sanitation, and urban transportation. They have a specific Secretariat that deals only with sanitation programs: National Secretariat of Environmental Sanitation (SNSA). This Secretariat has the mission to ensure the population human rights of access to safe water with adequate quality and quantity and life in a sanitary environment, following fundamental principles of universalization, equity and integrity. SNSA has the objective to promote, in a small timeframe, significant advance towards universalization of drinking water supply and sanitation (collection, treatment and final disposal), management of urban solid waste and stormwater drainage, hence controlling floods (Ministério das Cidades, 2017).

  The Ministry informed that they provide funding to a state or municipality to build sanitation infrastructure to communities bigger than 50,000 inhabitants. They do not ask for proof of land ownership to provide sanitation at the household level. However, the state or municipality might make this demand. The operation and ownership of the infrastructure is given to the state, municipality or sanitation company. SNSA is responsible for issuing the Plan of Basic Sanitation of Brazil, which contains a diagnostic of water and sanitation situation of Brazil and they make plans to achieve higher targets.

- **Trata Brasil Institute**

  This institute in an organization of Civil Society of public interest formed by companies that are interested in making progress on basic sanitation and protect the water resources of Brazil (Instituto Trata Brasil, 2017). They have a very high interest in improving sanitation problems in Brazil. However, their actions are not direct. As stated in their interview, Trata Brasil develops studies and guide communities in the understanding of sanitation needs. As they are formed by many companies, they can easily provide contact between stakeholders at different levels to solve issues.

4.2. Results on informal settlements of Brasília – Part 2

A planned city such as Brasília should not have informal settlements in place. These areas are susceptible to lack of infrastructure and formal services, such as sanitation, which can be a hazard to the population. Investigating why informal settlements exist there and how they emerged contributes to the understanding of how to approach universalization of sanitation services in the Federal District.

4.2.1. Informal Settlements of the Federal District

SEGETH and CODHAB were questioned about the origins of informal settlements in Brasília and their strategies in dealing with the present scenario. Table 5 presents a summary of the interviews. In addition, information was collected from CODEPLAN and National Census for historical records of informal settlements. To confront general data from the Federal District with the study case location, AMOVIC and the municipality of Vila Cauhy were interviewed and some questions were included on the survey applied in the village. Interviews and survey results as respectively presented on Appendix A and Appendix C.

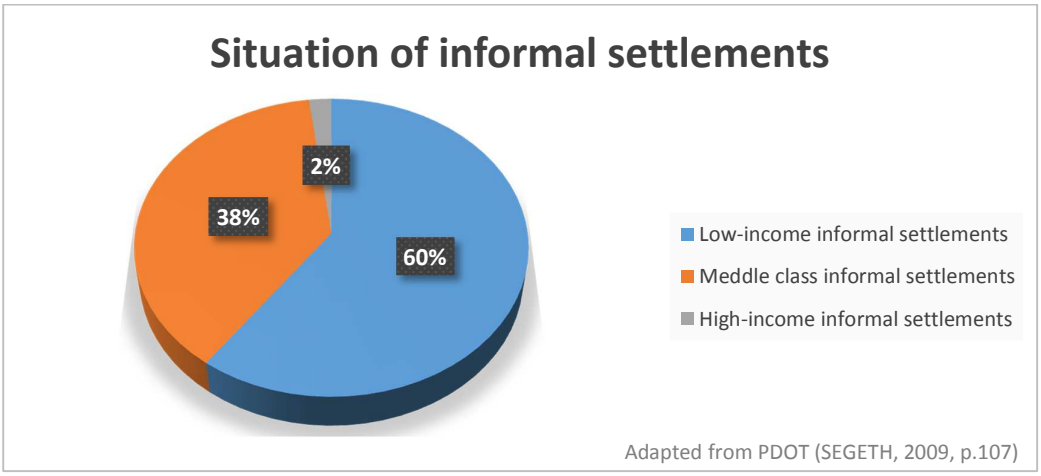
Table 5 - Interview results regarding historical data of informal settlements in Brasília

Question	CODHAB	SEGETH
Since when informal settlements exist in Brasília?	Since the construction of Brasília	
Where do most people who live in informal settlements come from?	Immigrate from other states or are from population natural growth	Most come from the northeast region of Brazil. They come looking for better conditions
Why do people continue immigrating? Is this a problem for national or regional government?	National government. There are governmental programs that try to improve conditions.	It is a policy deficiency. It is a problem for national government.
When people immigrate to informal settlements, what are they looking for?	They look for better opportunities and things they don't have in the place of origin.	They get away from draught or look for better conditions of education, health or work.
What are the strategies to prevent informal settlements from emerging?	AGEFIS inspects and remove settlements located in inappropriate places. CODHAB creates new spaces for relocation of the families.	SEGETH has housing policies regarding technical assistance, land regulation, new land and social assistance. These policies aim eliminating informal settlements and stopping new ones from emerging.
Is the strategy to remove or legalize settlements?	CODAHB legalizes what is possible and relocates what is not possible.	The government has to give a solution to areas of social interest (ARIS).
Is demolishing houses and expelling families a measure taken?	There is always a destination for relocation. CODHAB gives lots or constructs buildings and houses to relocate the families.	Removing families was a practiced measure in the 70's and 80's. There was also a lot of relocation to outside the Federal District. Today we prefer to legalize families that are already fixed [for some time] and are not in risk areas.
What are the plans to recover the Federal District?	SEGETH does the planning (use and occupation of land). They make policies involving stakeholders.	Work with Master Plan created by SEGETH and organize use and occupation of the land.
Why are there so many informal settlements in	The Pilot Plan (*Plano Piloto*) was not fully used as intended. Satellite cities	Brasília's planning enabled urban irregularity. Deficient legislation and housing policies made it possible for

Brasília, which is a planned city?	where created to eliminate informal settlements.	informal settlements to emerge (400.000 people living in 392 informal settlements). The [governmental] programs are less dynamic than they should be. There are many legal obstacles.

SEGETH (2009, p. 10) states, in their Master Plan for Territorial Order (PDOT), that usually the wealthier families can afford to live inside the city center or in neighborhoods with easy access to the center. Poor families usually have to establish themselves in peri-urban areas. However, many poor families want to settle near the city center without being able to afford living there. They establish themselves in an irregular area, regardless of urban or environmental laws and of real estate market, thus creating informal settlements. Many neighborhoods that started as informal settlements a long time ago and were legalized, naturally transformed into a high-income neighborhood, which is an irreversible process. The Master Plan also states that Brasília was planned in such a way that reinforced the idea of wealthier families living close to the city center (Pilot Plan) and poorer families living in peri-urban areas, with the justification of protection of Paranoá's river basin. Another important point to highlight is that the Federal District has many rural areas that, according to SEGETH, represent a reduced agriculture production capacity. Therefore, these areas tend to become urbanized. PDOT proposes to expand urban areas directing the occupation to areas that are more accessible to the city centers. SEGETH's strategies include avoiding informal settlements to emerge in the central area by improving accessibility of peri-urban areas to the center with public transportation and road infrastructure. Another strategy is to stimulate other areas to offer jobs, entertainment centers, hospitals and universities to create new city-centers. Taguatinga, a satellite-city of Brasília, has become the second most important center in the Federal District.

According to SEGETH (2009, p.104), many problems regarding territorial order in the Federal District are due to non-conclusion of land expropriation, fragility of land domain titles and imprecision of boundaries between private and public land. Informal settlements have emerged in the Federal District because of uncertainty of landowner, lack of housings, monopolization of the government in sharing and selling lots, lack of policy for housing loans (especially for middle class), and real estate speculation. According to the same document, in 2009, there were 347 informal settlements in the Federal District with 533,578 inhabitants (22% of total population). A recent document from CODEPLAN shows that 27% of the households in the District do not have a proper license but only the contract of buyer, which indicates an informal settlement. They state that these settlements exist in many regions of Brasília, regardless of socioeconomic conditions (CODEPLAN, 2015, p.31). This information can also be seen in PDOT, where it is stated that the Federal District has informal settlements accommodating low-income, high-income or middle class population (SEGETH, 2009, p. 107). It is shown Figure 13 formal areas in Brasília (which have a valid urban planning, but may contain informal settlements within) and in informal areas that can be legalized according to PDOT. They are either areas of social interest (ARIS) or areas of specific interest (ARINE).



Graph 2 - Informal settlements according to income

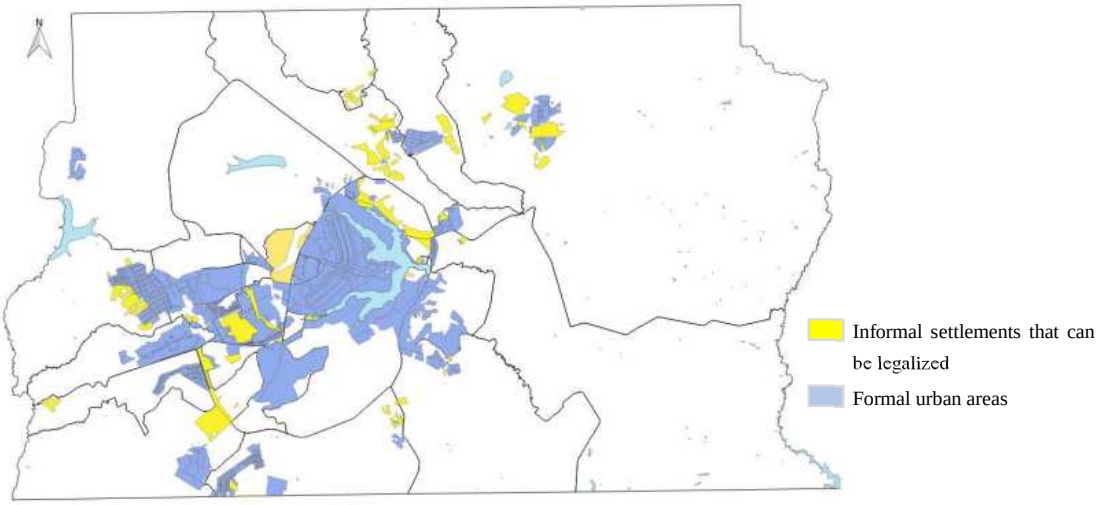


Figure 13 - Formal and informal settlements in the Federal District (CODEPLAN, 2016b, p. 20)

CODEPLAN has done many surveys in the Federal District for statistical database. According to their latest inventory, 51% of the population was born outside of Brasília and from this group of immigrants, 52% came from the Northeast region of Brazil (CODEPLAN, 2015, p.23). Immigration was a peculiar phenomenon in Brasília since its construction in 1956. According to CODEPLAN, many immigrants were attracted to Brasília due to job opportunities and a promising future of a city with better educational and health conditions. Many others had no choice but to relocate to the new capital to keep their jobs with the government. In 1958, the population growth rate was 11% per month, with a variation of 35% in a period of eight months. In this same year, the number of immigrants from the northeast of the country achieved its maximum, due to a strong draught period in that region (CODEPLAN, 2013). Today, the population of the Federal District achieved 2.98 million people, immigration rate has reduced,

and the estimated growth rate of the population is 1.74% per year (IBGE, 2016, SEGETH, 2009, p.53).

Figure 14 to Figure 16 show in red the occupation of the Federal District in 1958, when Brasília was under construction, in 1964, just four years after inauguration, and in 2016. Figure 16 shows the areas that can be urbanized according to the Master Plan (PDOT) of SEGETH.

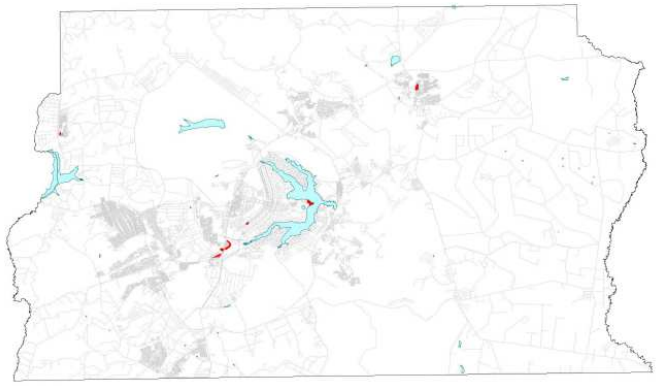


Figure 14 - Occupation of the Federal District in 1958

Retrieved from (SEGETH, 2009, p. 29)

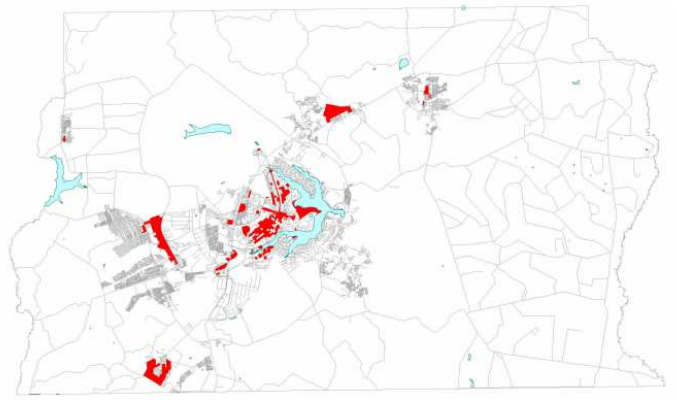


Figure 15 - Occupation of the Federal District in 1964

Retrieved from (SEGETH, 2009, p. 30)

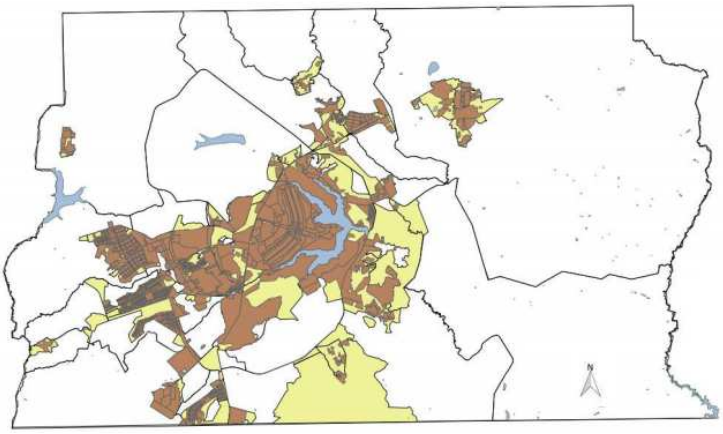


Figure 16 - Occupation of the Federal District in 2016

Retrieved from (CODEPLAN, 2016b, p. 18)

4.2.2. The informal settlement of Vila Cauhy

The information on how informal settlements emerged in the Federal District is confronted with the reality of Vila Cauhy. AMOVIC and the municipality were interviewed as well as the residents who live in the village (survey). According to the municipality of Vila Cauhy, the first houses of the village appeared about 40 to 50 years ago. The land was conceded to the Regatta Club of Guará but was never fully used for this purpose. One of the members of the club built the first house in the village and soon brought his family to help take care of the land. However, there was no investment from the Regatta Club and the area was abandoned. The ones who lived there started subdividing their lots and brought more people (mostly immigrating from other states) to live in the village. According to AMOVIC, the village still had rural characteristics until 25 years ago, when it started inflating and became more urbanized.

According to AMOVIC and the municipality of Vila Cauhy, the government tried to demolish houses of the village and remove the settlement many times in the past. There were some proposals to relocate the population to another area where the villagers would earn a lot for them to build their houses. The proposal was refused by the population. In 2007/2010, the governor José Roberto Arruda promised to legalize the land and constructed a square that marks this episode, the first public space of the village. Since then, the citizens of Vila Cauhy requested a formal process of legalization of the land, which is still running since 2012 (informed by CODHAB).

AMOVIC says the main problem with the legalization process is the lack of promptness. According to the municipality, the bigger issues in legalizing the land are due to environmental difficulties. There are many families in areas of flood risk or water springs, which are areas of environmental protection. The environmental agency (IBRAM) has demanded a project for urban adjustment to include in the legalization process. According to CODHAB, IBRAM supplies CODHAB with documentation (environmental license) for the legalization process. In personal communication, CODHAB commented on a technical study done by Zago Consultoria in 2014, which includes environmental diagnoses and urbanization aspects of Vila Cauhy. This document composes the legalization process of the village. The map on Figure 17 was extracted from this document and it shows areas that should be environmentally protected. The green hatched area is an environmental protection range of 15m from the stream. The blue hatched areas are water springs in the middle of the village that are also considered environmental protection areas.

Data from the survey applied in Vila Cauhy show that more than half the people (53%) who live in the village have immigrated from another state, outside the Federal District. From this group of people, half (50%) came from the Northeast of the country (Figure 18). Immigrants in the village came looking for better job opportunities (64%) and better living standards (43%). Most of them say they found what they were looking for. Seventy percent (70%) of the respondents claimed to have come from other urban areas before Vila Cauhy. The ones that already lived in Brasília mostly came from formal neighborhoods (42%) with appropriate infrastructure and better conditions than in Villa Cauhy. However, eighty one percent (81%) of those prefer to live where they are now because they own their household. Twenty eight percent (28%) of the interviewed families are living in Vila Cauhy for over 20 years.

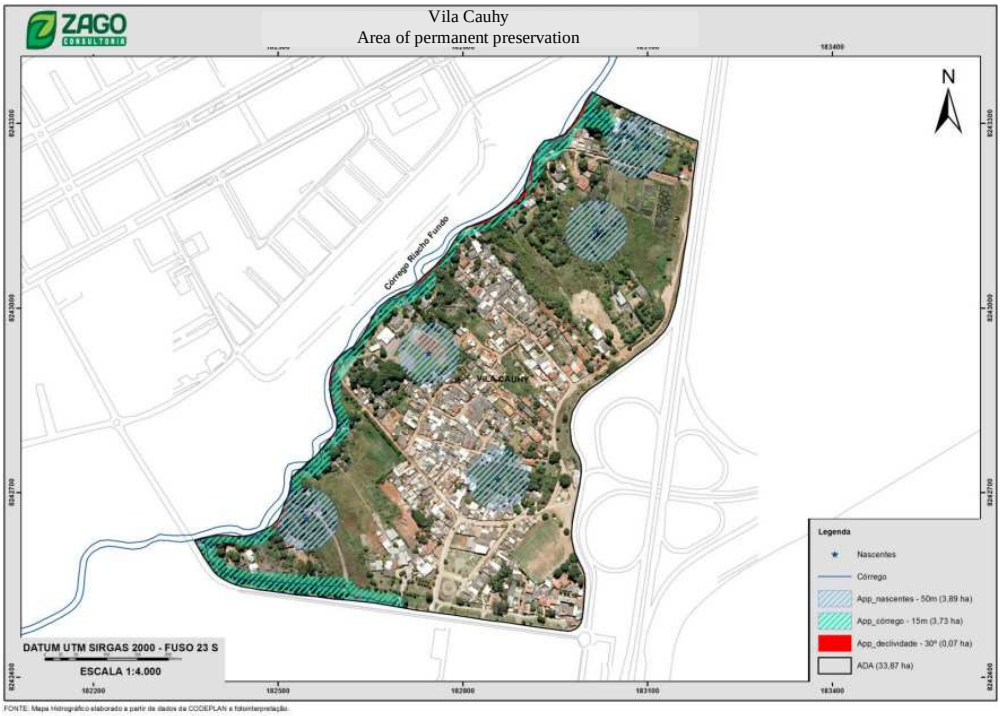


Figure 17 - Areas of environmental preservation
Extracted from a study made by Zago Consultoria – Conceded by CODHAB

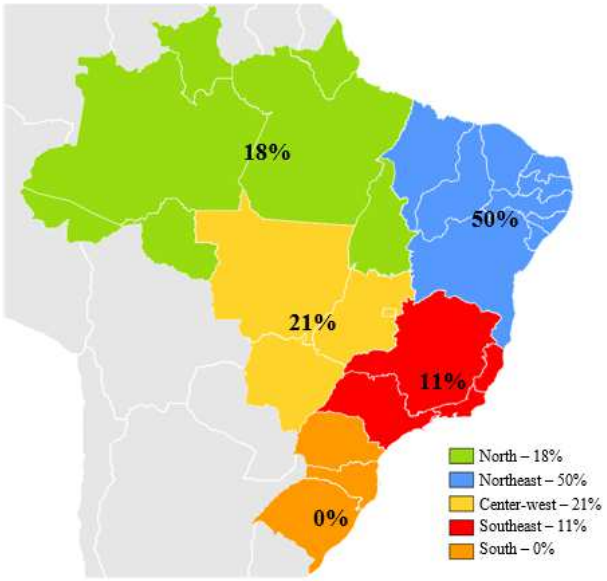


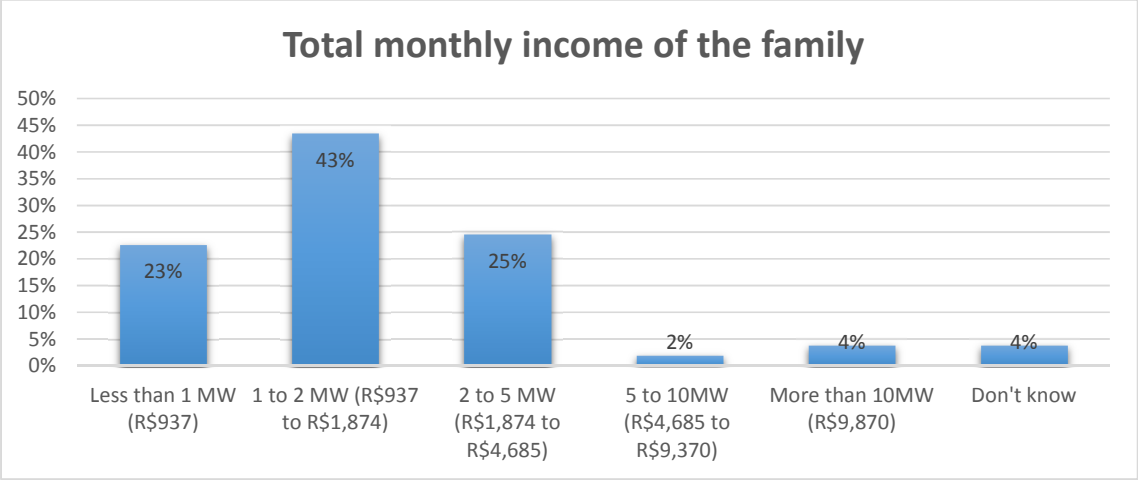
Figure 18 - Percentage of immigrants of Vila Cauhy

4.3. Results on sanitation in Vila Cauhy – Part 3

The results presented here are compiled from survey at the community of Vila Cauhy (Appendix C) and from interviews with local and regional stakeholders (Appendix A).

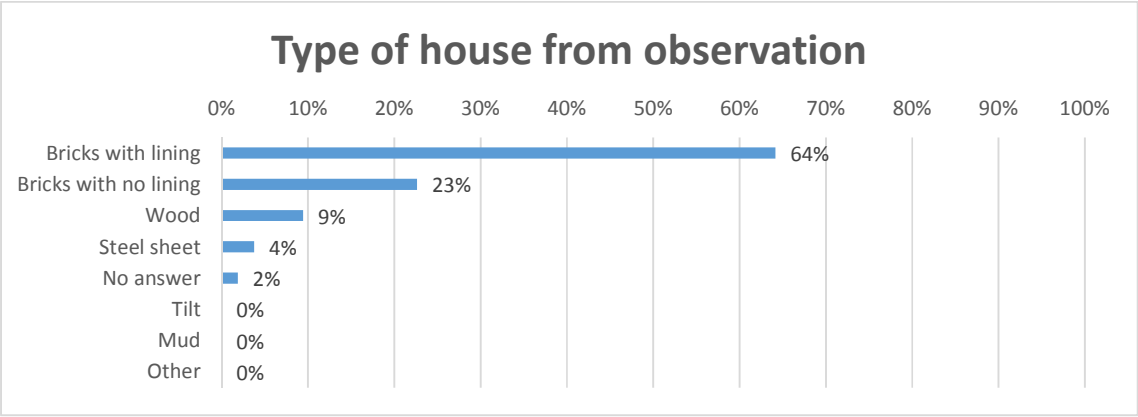
4.3.1. Household profile

Even though the settlement is informal, the socio-economic profile of the residents vary a lot. Many (23%) live with less than 1 minimum wage (MW) per month (R$937 or €277), which is 5.25 times the poverty line of $1.90/day (Cruz, et al., 2015). The majority lives with 1 to 2 MW/month (R$937 to R$1,874 or €277 to €554). However, some families (6%) earn larger amounts than 5 MW/month (more than R$4,685 or €1,386). The majority of adults in Vila Cauhy work either formally employed (49%) or self-employed (36%).

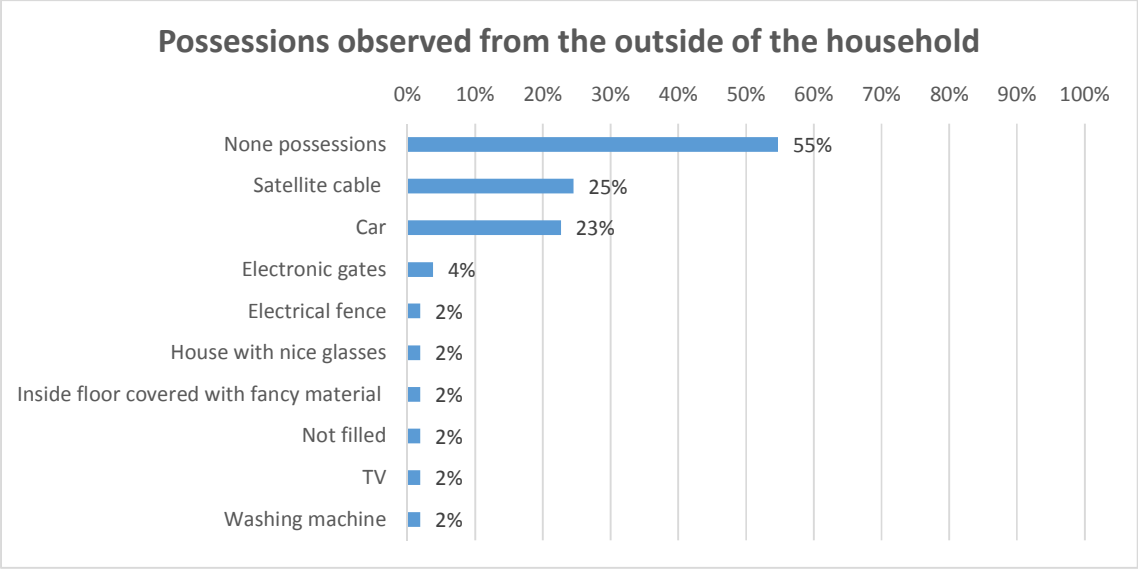


Graph 3 - Total monthly income of surveyed families

Most of the houses have some infrastructure and are built with bricks and lining (64%). It is possible to observe very simple households contrasting with a few nice ones in the village. Some families have car (23%) or satellite cable (25%), but most reflect a simple life style (55%).

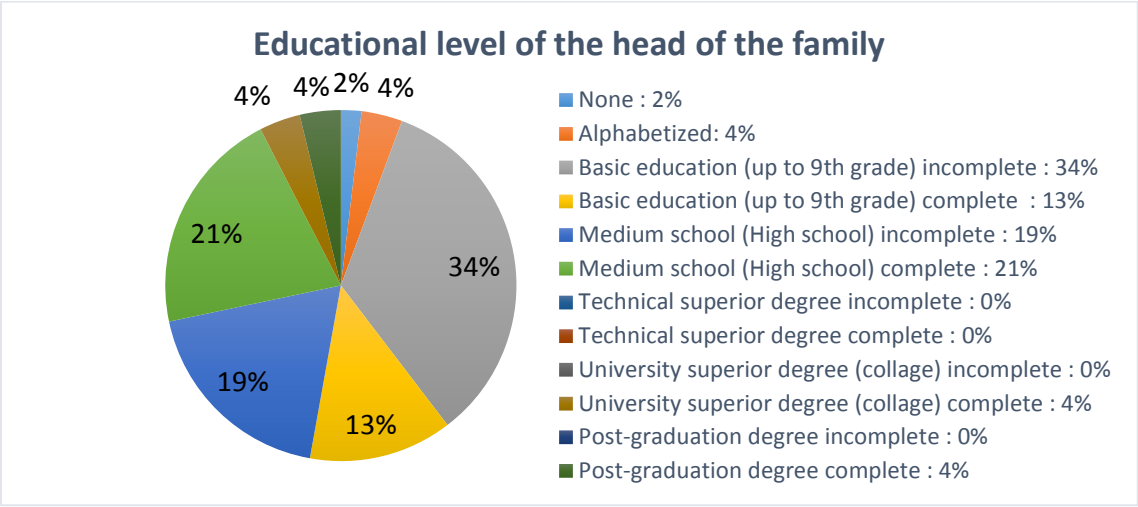


Graph 4 - Type of households observed of surveyed families



Graph 5 - Possessions observed from outside of surveyed households

As for educational levels, the majority of people have been to school. Only 2% claimed having no instructions and 4% were only alphabetized. The bigger share (34%) has studied an incomplete level of basic education (elementary/middle school) and 21% finished high-school. However there were a few people who had university degree (4%) or post-graduate degree (4%), which are the same families who earn higher monthly income.



Graph 6 – Educational level of the head of the family surveyed

4.3.2. Services provision

Six of the stakeholders presented in chapter 3 were selected to answer questions that are directly linked to sanitation in Vila Cauhy. They were asked if sanitation services are provided in informal settlements and why or why not. Results are presented on Table 6.

Table 6 - Interview answers on service provision in informal settlements

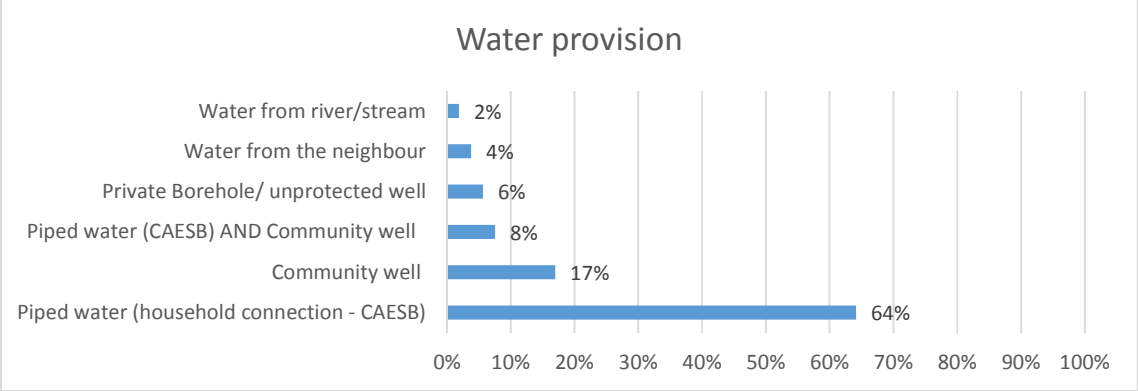
Question: Are sanitation services provided in informal settlements? Why or why not?		
Organization	**Level**	**Answer**
CAESB	Regional	No, sanitation services are not provided in informal settlements. Unless the area has a legalization process in place and already has an environmental license that allows CAESB to build infrastructure.
ADASA	Regional	No, sanitation services are not provided in informal settlements because it is illegal to build infrastructure in the area.
SINESP	Regional	No, because the area is illegal. The services are provided only in areas that are possible to be legalized.
FUNASA	National	They should have services. However, many times it is not possible to make certain actions because of the illegal aspect of the land. FUNASA has recently launched a decree retracting the demand of proof of land ownership to implement household basic sanitation improvement infrastructure.
Ministry of cities	National	Usually not, because of the illegal aspect of the land. Informal settlements are not legalized and the law prohibits services to be delivered in these areas. However, this is a contradiction to the human right to water and sanitation, established by the United Nations.
Trata Brasil Institute	National	Usually not. In some of the low-income informal settlements, there is access to sanitation services after the community has mobilized to gain this right. High-income informal settlements, which is very common in Brazil, have decentralized solutions. Most times, they use septic tanks and sometimes they buy equipment to operate a local treatment. Low-income communities are hardly able to pay for decentralized systems. This is why the solution depends on the government.

This question was further inspected to confront the results with the reality of Vila Cauhy. AMOVIC and municipality were interviewed and they were asked if there is access to formal services provision in the village. Results are presented on Table 7.

Table 7 - Interview answers on service provision in Vila Cauhy

Question: Are sanitation services provided in informal settlements? Why or why not?		
Organization	**Level**	**Answer**
Municipality of Vila Cauhy	Local	There are water and electricity services. Not sanitation.
AMOVIC	Local	Some houses have only water and electricity connections. The service is very bad and not continuous. Water pressure is not sufficient and it is decreasing as the village grows. The other part of the village have illegal connections. Some houses get water from the community well.

The survey also included questions on water and electricity services provision to understand the perspective of villagers (Results on session 2 of Appendix C). Almost all the households interviewed (92%) have water connection at home. Those who don't have a connection use water from a private (unprotected) well, get water with their neighbour or directly from the river. In cases where a private well is used, it is situated next to their household within 10 min walk (less than 500m distance). For those who do have water connection at home, the water comes mostly from CAESB (72%) and in this case they all pay for this service (average of R$129 each household). Half of the interviewed claim the amount they pay is affordable. Seventeen percent (17%) of the households get their water from a protected well in the village, which is free of charge. According to interview with local authorities (municipality/AMOVIC), they have connected this well to a piping system for the households. In personal communication, they assured no one collects water with buckets or with any direct source of contamination. They also had the water tested with IBRAM within the last year and the results stated it is clean and has good quality. There are some cases (8%) in which the households have two connections - one with CAESB and one with the community well. In personal communication with the surveyed, they said they have both connections because they trust more the water quality from CEASB and use this water for drinking purposes. The other source (community well) is used to do everything else: shower, wash clothes, clean the house, etc.



Graph 7 - Water provision in surveyed houses

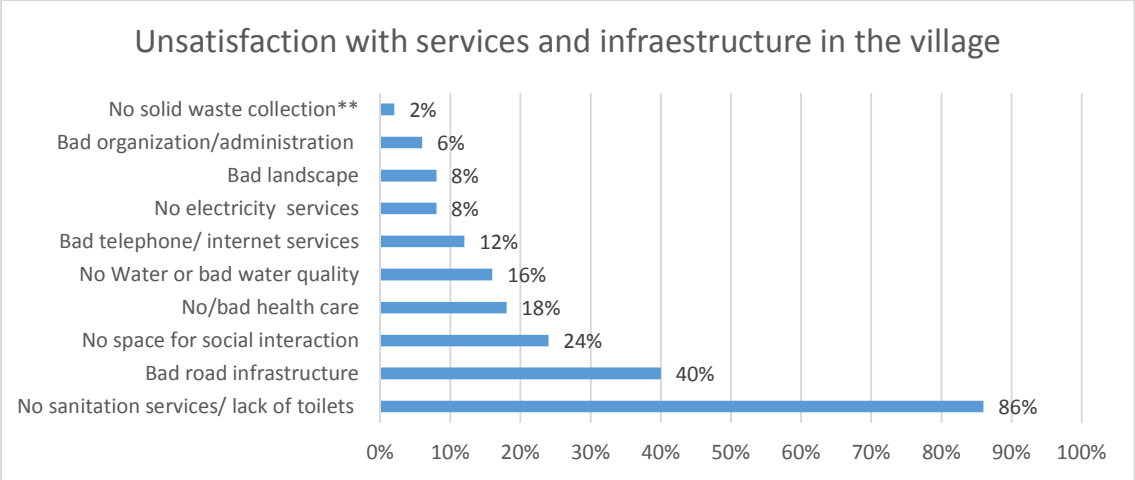
All the households (100%) have electricity at home. Twenty one percent (21%) are illegally connected to a public post and 77% are connected with the service provider (CEB), paying an average of R$147 per month. They claim the price is not affordable (53%). Two percent (2%) don’t know where they get electricity from.

Table 8 shows the percentage of people in Vila Cauhy formally serviced by CAESB with water supply and sewerage collection with treatment as well as the ones formally serviced by CEB with electricity connection.

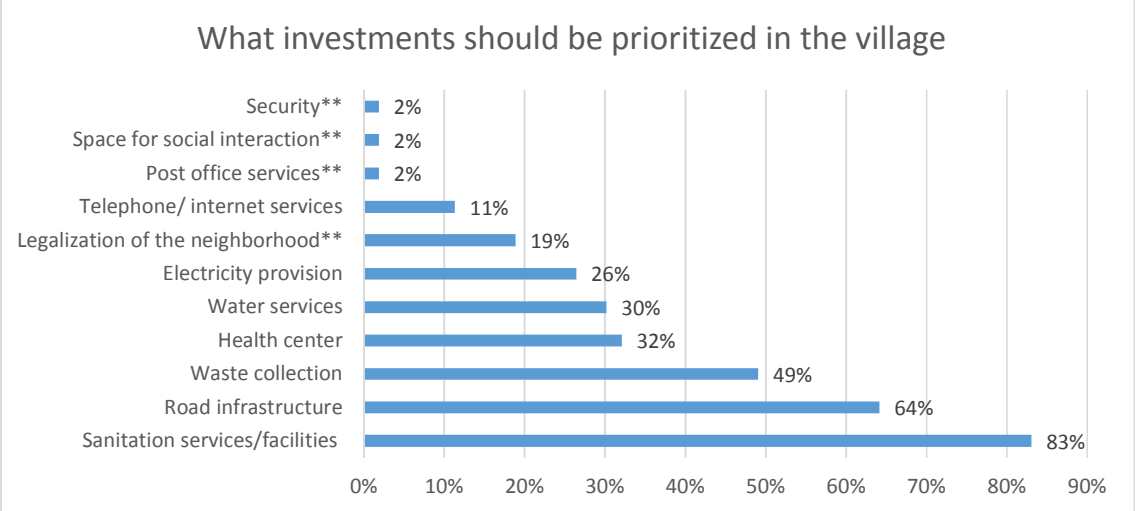
Table 8 - Households supplied with formal services

Services provided	
Water services from CAESB	72%
Electricity services from CEB	77%
Wastewater services from CAESB	0%

As presented on session 1 of Appendix C, almost all the people who were interviewed (94%) are unsatisfied with sanitation infrastructure of the neighbourhood. Eighty six percent (86%) said the main problem is the lack of sanitary services and 83% said that is where investments should be focused. Graph 8 and Graph 9 show the results for satisfaction with services in Vila Cauhy and prioritization of investments according to the villagers. It is important to highlight that during the survey, possible answers were many times given to the respondent as a way of helping with the answers. The services marked with "**" sign were not originally included in the survey and were not given as possible answers to the respondents. Therefore, it is possible that, given the possibility of this answer to other respondents, they might have also checked these options.

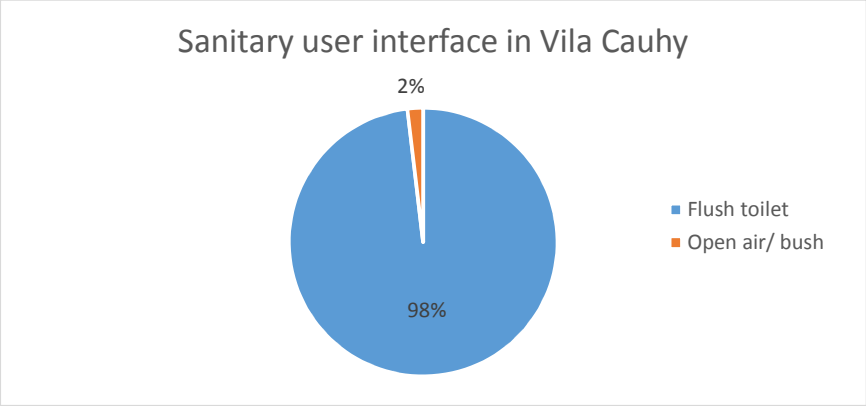


Graph 8 - Satisfaction of villagers with services and infrastructure of Vila Cauhy



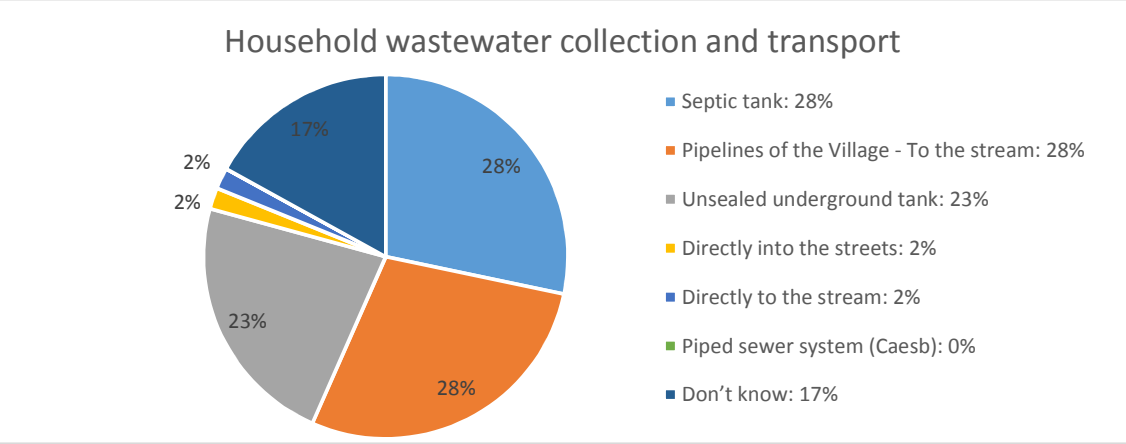
Graph 9 - Prioritization of investments categorized by surveyed villagers

AMOVIC and municipality state on their interviews that all households of Vila Cauhy are equipped with a toilet. However, the survey (Appendix C, session 3) points out that 2% of the interviewed do not have access to a toilet and practice open defecation or use plastic bags. The other 98% use flush toilets. Most of the toilets are not shared (94%) and accessed from inside the households (96%). Vila Cauhy is not equipped with public toilets. There are cases where people do not have a toilet at home and they use one from a neighbour nearby (4%). These toilets are provided by the household owner or community members, cleaned daily by the users, not designed for people with disabilities, but appropriate for women and children to use it at night. Twenty one percent (21%) of the interviewed complained about the toilet facilities they use, even the ones of private use. The reason they don't like it is due to strong smell (27%), not appropriate for women or children (27%), durability of materials (18%), toilet clogs (18%), lack of privacy (9%), safety (9%), and no sink inside the bathroom (9%). No one complained about the location or cleanness of their toilets. From the ones that complained, only 27% could not make a choice on the type of toilets they use, which was decided by the household owner.



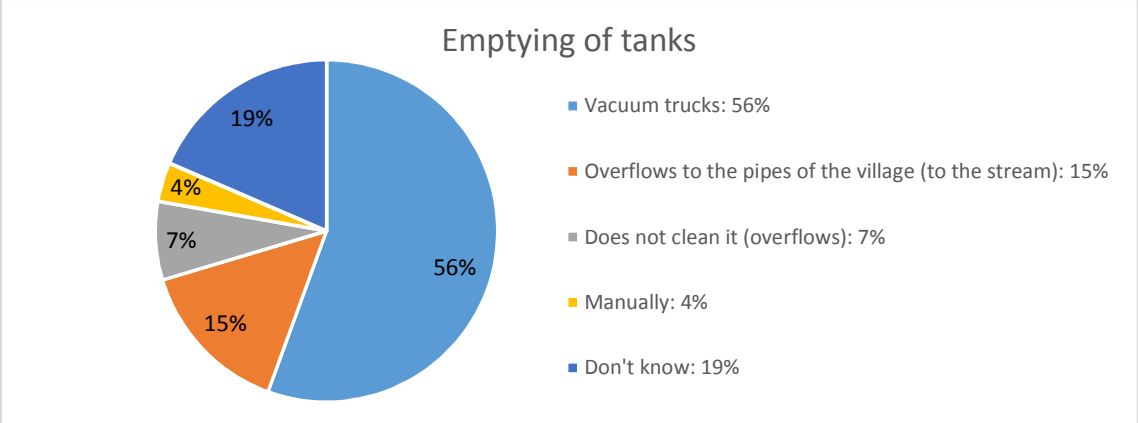
Graph 10 - Types of toilets used in Vila Cauhy

About half of the households in Vila Cauhy (51%) use some sort of tank to collect their wastewater. However, only 28% use an appropriate septic tank; the other 23% use unsealed tanks (hole on the ground) where they discharge both black and greywater.



Graph 11 - Wastewater collection and transportation

According to interviews, stakeholders from the government expect that households who use septic tanks hire mechanical cleaning from vacuum truck companies, however this only happens in 56% of the cases (septic tanks and unprotected tanks). Dwellers confirmed the information given by many stakeholders during interviews that services for emptying septic tanks have to be hired and paid by the householders. The respondents of the survey who claimed to use this service pay around R$100 to R$150 (€30 to €45) every time they have to clean the tanks (2 to 3 times a year). Sixty four percent (64%) of the ones who use this service say it is affordable. Four percent (4%) of the tanks are cleaned manually and 7% simply let it overflow. Nineteen percent (19%) do not know how the emptying is done. Four percent (4%) of the population discharge wastewater directly into the streets or the stream. Many people (17%) don't know where their wastewater goes to.



Graph 12 – Used method of tank emptying

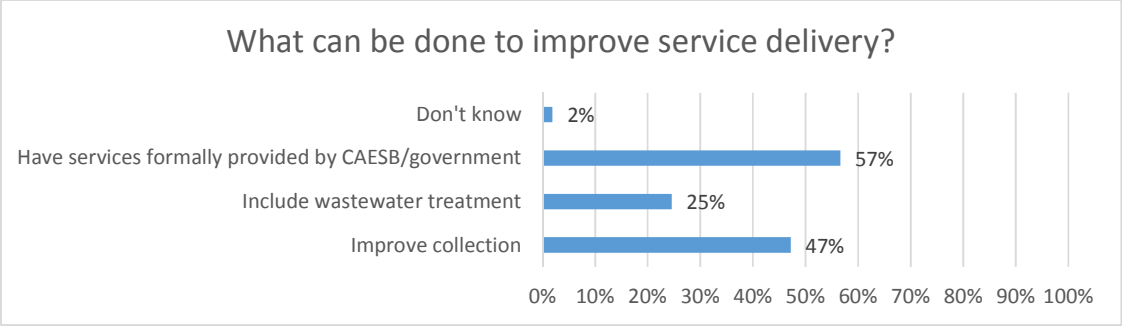
The community of Vila Cauhy, with the help of AMOVIC and the municipality, have built pipelines to collect and transport wastewater in the village. The concrete pipes were donated from Novacap and the admisitration of Núcleo Bandeirante and were implemented by the villagers, with no technical support or guidance from CAESB or other governmental organizations. Hence, there are some technical problems in the pipelines and there are places where wastewater overflows especially when it rains. The pipelines convey wastewater from the households to the nearest water stream (Riacho Fundo), without any treatment. Twenty eight percent (28%) of the households discharge wastewater directly into the pipes and 15% use the pipes to collect the overflow of their tanks. The use of this system is free of charge.

The community and local stakeholders did not organize a maintenance work plan and there are many pipes clogged or broken again overflowing wastewater into the streets. During the survey, 47% of the houses visited had wastewater running on the street nearby. There are spots where the pipes connect to open drains and at the end of the line, the wastewater runs on the street until it reaches the stream (Figure 19). The municipality and AMOVIC are proud of the work done, even though it is not technically correct. They say they did the best they could with the resources they had and that this project has improved the community's life quality. Authorities did not impair the implementation of the system, although IBRAM and Agefis have the power to do so. The media was very concerned and published stories on that, but no one ever received a fine. The discharge of the effluent directly to the river is an environmental concern and

IBRAM has the right to apply a fine to the households or to CODHAB, which legally owns that public land.

Figure 19 - Pipeline to collect wastewater in Vila Cauhy

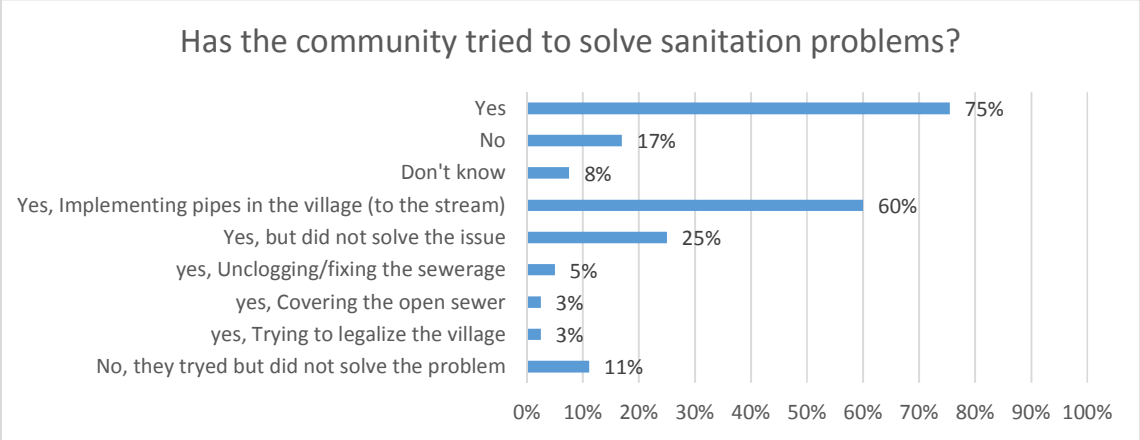
The population of Vila Cauhy thinks that sanitation services have to be improved and 57% thinks the only solution relies on the provision of formal services by CAESB. They say collection and transport of wastewater should be improved (47%) and only 25% is concerned about the lack of treatment and polluting the river.



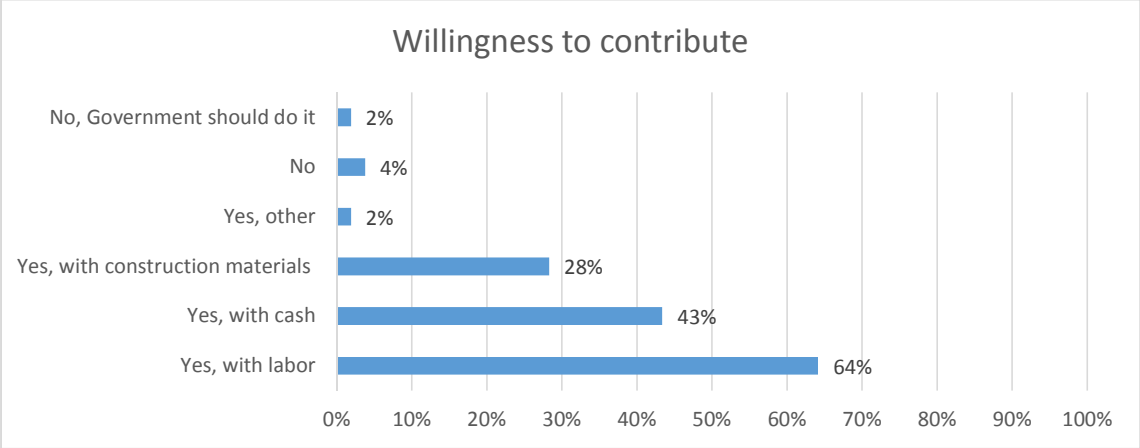
Graph 13 - Community perspective of sanitary improvement

Ninety six percent (96%) of the interviewed say that the government did not make any effort to improve the situation. AMOVIC or municipality recognize the effort of the government (administration of Núcleo Bandeirante) in donating the material to implement the pipes in the

village. Seventy five percent (75%) of the surveyed recognize their own effort as community members in trying to improve sanitary conditions. They say many things have been done such as: Implementing pipes in the village (60%), trying to legalize the village (3%), unclogging/fixing the sewerage (5%), and covering the open sewer (3%). Some recognize the effort but claim the issue was not solved (25%). Seventy seven percent (77%) of the people own their households and are willing to help with labour or donating money or material to improve sanitary conditions in Vila Cauhy.



Graph 14 - Surveyed opinion on how community has helped in solving sanitation problems

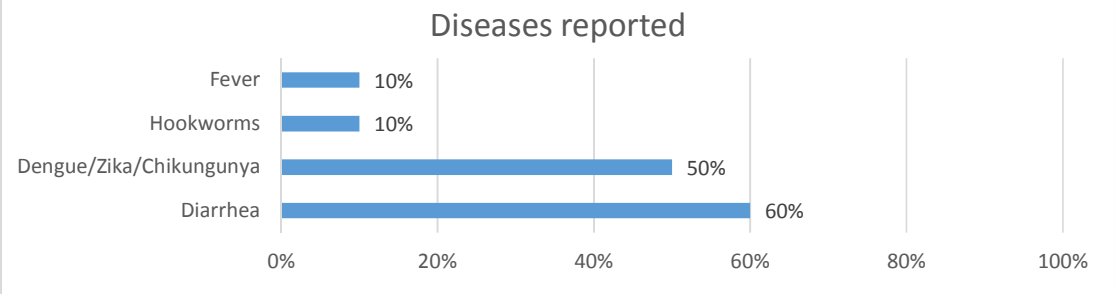


Graph 15 - Willingness to contribute with sanitary improvements

4.3.3. Health statistics

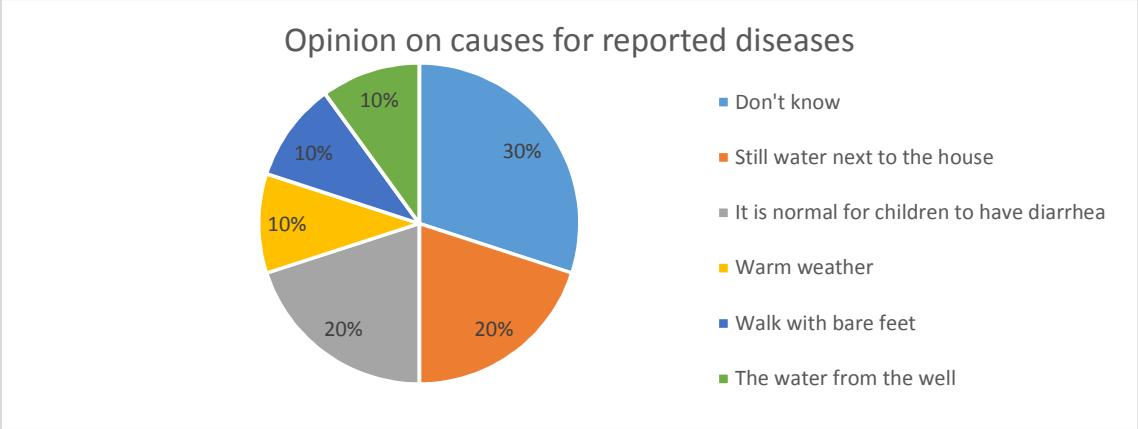
The direct contact with wastewater and the contamination of water sources may cause many diseases. Even though Vila Cauhy is affected by poor collection and transport of wastewater, only 19% of the interviewed families reported health issues. From this group, the most common diseases are diarrhea (60%), Hookworms (10%) or Fever (10%), representing 15% of the

families of Vila Cauhy. According to AMOVIC, leptospirosis has also been reported. Fifty percent (50%) of the group of sick people (9% of the families of the village) reported having Dengue, Zika or Chikungunya in the past three months. Leishmaniosis is also reported by the health center as a common case in the region. There was also a case of Elephantiasis according to the municipality.



Graph 16 - Diseases reported by the surveyed

The survey questioned about the cause of the diseases in the opinion of those families who reported having any. Twenty percent (20)% think it is normal for children to have diarrhea and 10% think it is from the hot climate. Another 10% think that the reason their kids had hookworms is from walking with bare foot on the ground. Twenty percent (20%) of the interviewed said they had dengue because of the neighbors that let still water accumulate in the backyard; 10% think it is from the water they drank from the well. Many people did not know what got them sick (30%). None of them related these diseases with the lack of sanitation or drainage services.



Graph 17 - Causes for diseases in the opinion of the surveyed

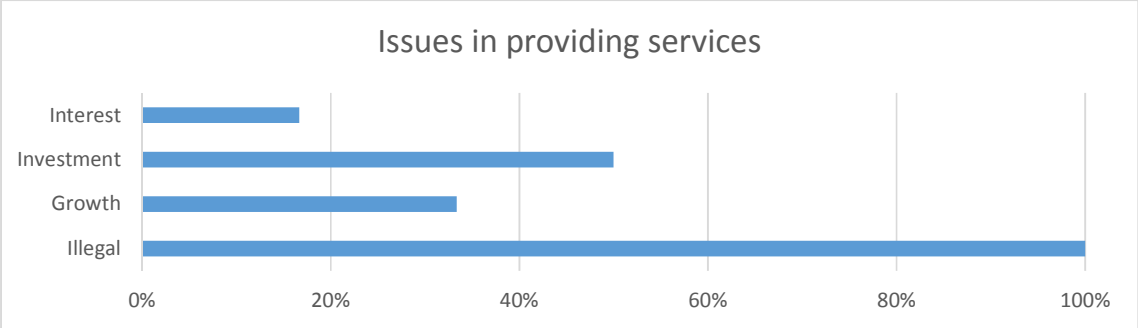
4.4. Results on decision-making process – Part 4

4.4.1. Institutional decisions

To understand how institutional decisions are made towards implementation of sanitation services in informal settlements, nine stakeholders were interviewed with the following questions. The results described here were obtained through interviews (Appendix A.2).

Q. 2.1 What are the issues in providing sanitation services in informal settlements?

Complementing the information presented on Table 6 of Chapter 4.3.2, where stakeholders report informal settlements are not provided with formal sanitation services, organizations were interviewed on the issues in giving access. All interviewed stakeholders agreed that the main issue is the illegal aspect of the settlement. ADASA and SINESP stated that implementation of sanitary infrastructure attracts more people to the settlement, which grows much faster than expected. The Ministry of Cities agreed with them on the risk of the investment, which may be lost due to population's unwillingness to pay for services or if the community is removed because it is settled in illegal area. Trata Brasil Institute, which is a non-governmental organization, pointed out that there is lack of political willingness to invest in the implementation of an infrastructure that takes a long time to build.



Graph 18 - Stakeholders perception on issues in providing sanitary services

Q. 2.2 What strategies are in place to increase sanitation services to the informal settlements of Brasília? [1][4]

CAESB's strategy to increase sanitation services is to provide services to settlements that are in the eminence of getting a license but before it becomes legal. These areas are of social interest ("ARIS") or of especial interest ("ARINE"). Trata Brasil Institute stated the government has no strategies but to allow this flexibility of anticipating service provision. ADASA claimed they do not have any strategies, however they demand from the sanitation company that services must be expanded, which impacts CAESB's plans into attending more areas. SINESP's strategy is to plan and provide areas for relocation of families, which helps to control growth of informal settlements. FUNASA and the Ministry of Cities do not demand proof of land ownership to implement sanitation through their programs, benefitting families in informal settlements. However, many times, the municipality, state or sanitation company, who are the ones that implement the programs, require proof of land ownership. IBRAM said they can issue an emergency environmental license, allowing infrastructure to be implemented in informal settlements. However to do so, there must be an engineering project properly signed and authorized by CAESB.

[4] [1] Adapted from Muzvidzwa D (2014) A revised framework for pro-poor water and sanitation benchmarking : case of Epworth, Zimbabwe. MSc, UNESCO-IHE

Table 9 – Strategies to increase services in informal settlements

Organization	Services for almost legal settlements	Demand expansion of services	Relocation	No proof of land ownership	No strategy	Emergency licenses
CAESB	x					
ADASA		x				
SINESP			x			
FUNASA				x		
Ministry of cities				x		
Trata Brasil Institute					x	
IBRAM						x

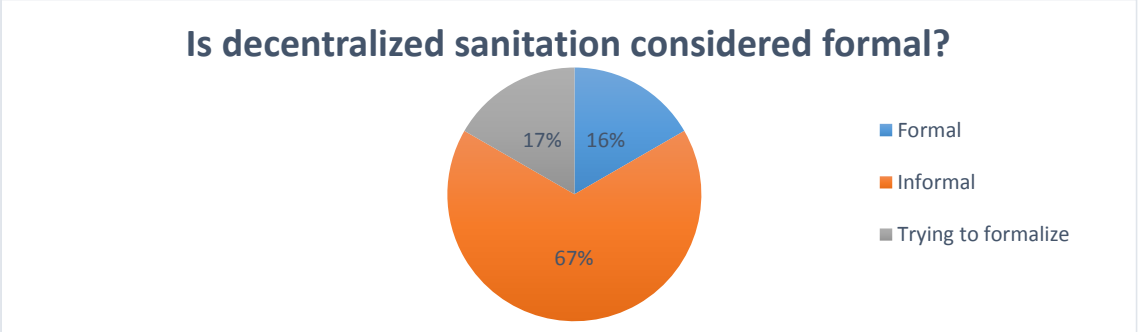
Q. 2.3 Is decentralized sanitation considered a reliable alternative for informal settlements?

Most of the interviewed stated that on-site systems can be reliable as long as there is appropriate final disposal or if they do not discharge effluent into a water body. CAESB, ADASA and the Ministry of Cities related decentralized systems to septic tanks. ADASA emphasized reliable tanks must follow CAESB standards. The Ministry of Cities considers septic tanks as reliable sanitation in the Basic Sanitation National Planning. Trata Brasil Institute added that decentralized systems is something new in Brazil and that it needs to be further developed to become more efficient.

CAESB complemented saying that centralized systems are more reliable and they aim to optimize it. In their opinion, in an economic point of view, there is not much difference between a centralized and a decentralized system. However, technically it is much harder to control a decentralized system, because it depends on the water table, soil permeability, type of construction, cleaning period, sludge management, effluent quality, and methane emission.

Q. 2.4 Is decentralized sanitation considered a formal or informal service?

Most of the interviewed (CAESB, ADASA, SINESP and Trata Brasil Institute) agreed that decentralized systems are considered informal services. At the national level, FUNASA considers it formal and the Ministry of Cities is trying to formalize it by including septic tanks as improved sanitation in the Basic Sanitation National Planning.



Graph 19 – Stakeholders' perception on formality of decentralized services

Q. 2.5 Once the area is legalized, how is the decision for implementation of sanitation? What technologies are considered?

CAESB, ADASA and SINESP stated that once the area becomes legal, the sanitation company provides a centralized solution. CAESB usually uses one of the 16 existing conventional wastewater treatment plants in the Federal District. CAESB and SINESP said that if the community is not close to one of these systems another solution might be recommended such as septic tanks or UASB. FUNASA said the solutions they study in their programs should not confront future plans of the municipalities, who are responsible for the system once the settlement is legalized. The Ministry of Cities does not decide on the technology choice; it is a decision for the sanitation company.

Q. 2.6 How is sustainability of the facilities or services provided ensured?[1]

The municipality is responsible for operation and maintenance of sanitation systems. They guarantee sustainability through tariff systems. Usually wastewater services are charged through the water bill (question 3.14) according to water consumption. There might be crossed subsidies, where the poor population pays a low tariff and wealthier areas pay more to compensate.

Q. 2.7 When a technology is considered for a poor community, are social/ financial conditions of the residents taken into account?

CAESB and ADASA stated the usual solution is connecting the community to the existing centralized systems. Trata Brasil Institute agreed with the information and added that, in Brazil, alternative solutions used are septic tanks. SINESP said they collect data and study the area, including the community's social and financial conditions. However, usually they opt for conventional collection and treatment. There might be alternative solutions depending on the location of the community. FUNASA studies the best solution locally that can be provided individually or collectively. The Ministry of Cities does not choose the technology to be implemented; they only analyze the proposals.

Q. 2.8 Is there any inspection towards decentralized sanitation in informal settlements?

None of the interviewed (CAESB, ADASA, SINESP and FUNASA) claimed inspecting informal settlements. The Ministry of Cities and Trata Brasil Institute do not provide inspection services, and for this reason, they were not questioned. IBRAM only inspects when there is a legalization process in place. If there is a system in place that does not comply with standards, IBRAM can apply a fine to the owner of the public land (CODHAB).

2.9 What strategies are in place to implement or increase sanitation service provision in Vila Cauhy?

The municipality of Vila Cauhy has only one strategy to improve sanitation in the village: fight for and obtain the legalization of the village for the government provide formal services. AMOVIC has some other ideas that would depend on external support, as for instance, implementing decentralized ecological septic tanks shared by two households.

Q. 3.16 In case of using septic tanks, is the service paid by authorities or the dwellers? Is there a different pricing for poor communities?

All stakeholders agree that residents are responsible to pay for their own septic tanks, including the maintenance. It is the dwellers' responsibility to hire particular services to clean the septic tanks. CAESB used to offer this service some time ago, but not anymore. The Ministry of Cities recommends in the National Plan of Basic Sanitation that sanitation companies should offer the service of maintenance of septic tanks, even though fees are charged. CAESB does not follow this recommendation.

Q. 3.17 Does the community participate in the decision-making process?

At regional level, decision-making process does not involve the community, except for condominial sewerage. CAESB explained that in this case, the project is developed by their technical team and there is a strong social-technical work to involve the residents in choosing the location for the pipeline – in front or in the back of their lot. This action promotes an investment reduction, especially in unplanned areas, where the urbanization is already settled. However, in their experience, in 95% of the time, residents rather pay more for the sanitation company to take responsibility for the system rather than collaborating in the construction or operation of pipelines, even in low-income communities. FUNASA and the Ministry of Cities understand the importance of community participation and they include social aspects within their programs, including education and health programs. Trata Brasil also considers social participation important, especially considering community explanations on the importance of sanitation.

Local stakeholders of Vila Cauhy – AMOVIC and municipality – were also interviewed on this matter. They stated that the villagers do not participate on decisions taken by the government. They offer meetings for explanation of decisions already taken. Meanwhile, the approach of AMOVIC and the municipality to the villagers is very different. They have meetings to present proposals and discuss actions to be taken with community members. Usually villagers participate and contribute to the projects with ideas, money, material or labor, depending on their own interest.

4.4.2. How planning affects decentralized sanitation

The following questions were added to the interviews to understand how planning has affected technology choice, implementation and management of decentralized sanitation systems in informal settlements. The results described here were obtained through interviews (Appendix A.2).

Q. 3.1 Are there governmental programs that help informal settlements to have access to improved sanitation?

At regional level, CAESB, ADASA and SINESP stated there are no programs to implement sanitation in informal settlements. The only actions are relocating families to a formal settlement with adequate infrastructure or provide sanitation services when the [informal] settlement is about to become legalized.

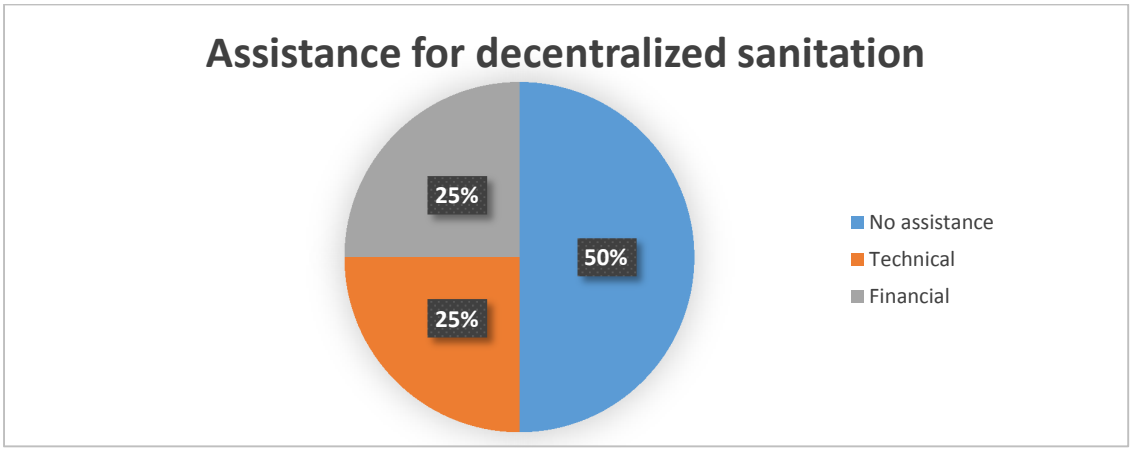
Even though Trata Brasil said there is no interest from the government in implementing programs, FUNASA and Ministry of Cities reported having programs for informal settlements.

These programs can be applied in these areas because the Ministries do not require land ownership proof. Municipalities or states have to require FUNASA or the Ministry of Cities to implement the program in a specific area. The ministries allocates funding to the other governmental entity, give technical assistance, and inspect the implementation of the funding.

- Program of Household Sanitary Improvement – FUNASA: Implement sanitation infrastructure to rural areas or municipalities with less than 50,000 inhabitants.
- Integrated Sanitation – Ministry of Cities: Implement sanitary infrastructure and complementary construction works that impacts sanitation. This program focus is on water and sanitation but includes stormwater drainage services, solid waste management and urban equipment.
- Slums Urbanization – Ministry of Cities: Improvement of housing in slum areas. Sanitation is not the focus but it is part of an integrated solution.

Q. 3.2/3.11/3.12 Is there support from the government for these communities to find sanitation solutions on their own?

ADASA, SINESP and IBRAM do not provide and assistance for communities to implement a decentralized sanitary solution. CAESB does provide technical assistance, but the community has to request it. Trata Brasil provides technical assistance showing the community how important sanitation is and how they can require services from the government – but they do not assist on finding decentralized solutions. The Ministry of Cities provides financial assistance to implement any sanitation projects, which has to be requested from the municipalities (over 50,000 inhabitants). Operation and maintenance of the systems should be financed by the sanitation company or the municipality. FUNASA provides technical and financial assistance to communities that request it (less than 50,000 inhabitants). The community has to map the necessities and improvements needed and FUNASA executes the constructions or makes a partnership and gives financial resources for the municipality to execute the construction, in which case FUNASA will inspect it. It is the municipality's responsibility to operate and maintain the systems.



Graph 20 - Governmental assistance for decentralized sanitary solutions

Q. 3.3 If a sanitary decentralized solution is technically correct, will it be kept in place once the land becomes legalized?

At regional level, all interviewed stakeholders agreed that CAESB is responsible for determining if the system will be kept. CAESB stated that they standardize the systems and equipment. CAESB has no interest in operating many different types of systems that does not integrate to the existing [centralized] system. Usually the community is connected to the existing sewerage system. For the Ministry of Cities, once the settlement becomes formalized the sanitation company, which has concession of the service, can demand the ownership of the system, assume services and charge tariffs. FUNASA complemented saying that the decentralized system should be kept and, for this to happen, studies must be aligned with local sanitation plans to predict what actions will be taken for the investments not to be lost.

Q. 3.4 Will the sanitation company operate and maintain decentralized systems already in place while it is an informal settlement and when it becomes legal?

Regional stakeholders agreed that the sanitation company will only operate and maintain the system once the settlement becomes legal/formal. When FUNASA is involved, they agree on transferring all responsibilities to the municipality, which will operate and maintain systems even if the settlement is informal. The Ministry of Cities states that when a settlement becomes legal, the sanitation company is bound to assume, maintain and operate the system. Even if the settlement is illegal, the sanitation company can demand the ownership of the system, because the concession law dictates that they have to assume all sanitation services. However, if the sanitation company is responsible for the system, they can decide to keep the existing system or substituting it for a new centralized system.

Q. 3.6/3.8 To apply a decentralized sanitary solution in an informal settlement, are there regulations applied? Is any law against decentralization of sanitation?

Stakeholders agreed that the Brazilian sanitation law or environmental laws do not specify anything against decentralized sanitation systems. However, if there is any discharge in a water body, the effluent quality has to comply with CONAMA's standards. In the Federal District, it is also required ADASA's permission to discharge. CAESB stated it is possible to have decentralized systems in the Federal District and ADASA supports this solution. However, if there is a sewer line settled in front of a household, they are bound to connect to the centralized system.

Q. 3.13 How are services financed in informal settlements? [1]

Services are financed through a tariff system. FUNASA and Ministry of Cities can finance systems, which are sustained through tariff charge.

Q. 3.5 Will there be any sanitation tariffs applied in a decentralized system that already exists once the land becomes legal?

All regional stakeholders agree that the tariff system would be applied. FUNASA stated it is a decision of the municipality, while the Ministry of Cities demands that a tariff system is applied.

Q. 3.14/3.15 Is there any special tariff system for the poor communities? [2][5] Is the sanitation service tariff system considered sustainable?

The tariff system is a concern for regional and local governments. In the Federal District, sanitation tariffs are charged within the water bill according to water consumption. The tariff system is the same for everyone. It is possible for a family with low-income to require for a social tariff. In this case, an inspector from CAESB verifies the household conditions (living standard and family income) to make sure the social tariff is applicable. The Secretariat of Social Services used to cover the difference of charge, but this is not happening anymore. So it has become very rare to grant this tariff. Social tariffs are granted per family and not for an entire community.

The tariff system of the Federal District is considered sustainable by CAESB and ADASA. However, the regulatory agency highlights that the tariff system is suitable for the model applied with conventional centralized treatment. If there were other types of sanitation systems [decentralized], the tariff system would have to be reshaped.

4.5. Chapter summary

This chapter has presented data collected from documents, interviews and survey, as proposed in the methodology of CHAPTER 3. After collecting data on stakeholders involved in sanitation aspects of Brasília and activities developed by them, other data was collected focused on research questions. The main important data found in summarized in the following box. The analysis and discussion of this data is presented on Chapter 5.

- Nineteen stakeholders were found to be related to the main problem focused on this research: lack of sanitation services in informal settlements of Brasília
- Informal settlements have existed since the construction of Brasília. The new capital attracted people from all states of Brazil looking for new and better opportunities. However, the planned part of the city was not affordable to low-income families, which had to settle in informal settlements close to the city.
- Recent documents from CODEPLAN show that 27% of the households in the District are considered informal settlements. This situation is developed regardless of socioeconomic conditions.
- Vila Cauhy exists for over 20 years as an informal settlement of Brasília and sanitation services are still not being provided. The community has tried to implement pipelines collecting wastewater from their households and discharging untreated sewer into the nearest stream.

[5] Adapted from Alves PJRdB (2015) Pro-poor economic instruments in the water supply service : a case study of peri-urban areas in Maputo, Mozambique. MSc, UNESCO-IHE

- Fifteen percent (15%) of the population of Vila Cauhy was surveyed. From this group, 86% claim to be unhappy with sanitation in the village. Nineteen percent (19%) have reported having health issues, which can be related to lack of improved sanitation.
- Interviewed stakeholders claim the biggest issue in providing sanitation to informal settlements is the illegal aspect of these areas. Services cannot legally be delivered – however, they do provide water services to informal settlements. Other reasons are: increasing attractiveness to informal settlements, leading to uncontrollable growth; risk of investments for families that might be relocated; lack of political interest in investing on infrastructure that takes a long time to build.
- Relevant reported strategies are: to provide services to settlements that are in the eminence of being formalized/ legalized; relocate families to formal neighborhoods with adequate infrastructure and services; or retract necessity to proof land ownership to apply for national sanitation programs.
- The sanitation company of the Federal District provides services through conventional centralized systems, which is the only formal service considered by them. When connecting to the sewer system is not a possibility, they recommend the use of septic tanks, which, even though considered informal, is a reliable technology choice.
- Supply-driven approach is used in the Federal District to provide services to the community. There is no involvement of community members in the decision-making process.
- Decentralized systems is allowed by the Brazilian sanitation law; however, there is no interest from the sanitation company to operate alternative on-site treatment facilities. Even though technically correct, once a settlement becomes legalized, it is probable that decentralized systems are deactivated and substituted by conventional centralized collection and treatment.

CHAPTER 5

Analysis of results and discussions

This chapter presents analysis and discussions based on the results presented on CHAPTER 4. The first subchapter is an analysis of the stakeholders. The following subchapters discuss the specific objectives of the research and answers the questions established in chapter 1.4. The final subchapter brings a summary of reflections on all the ideas developed leading to the final chapter of Conclusion.

5.1. Discussions on Part 1 – Stakeholder analysis

From the analysis of the list of stakeholders and the results found for their activities, it is possible to take some conclusions upon their roles and responsibilities, their level of interest and influence upon the main problem and map which stakeholders are interconnected. This analysis identifies key stakeholders when dealing with lack of sanitation services in informal settlements of Brasília. The analysis is used to understand how to engage stakeholders into improving the sanitation service chain in these areas.

5.1.1. Roles and Responsibilities

Many stakeholders have a direct role with sanitation systems and others interact some other way that affects sanitation of informal settlements. Table 10 shows the roles and responsibilities of each stakeholder regarding operation, ownership, finance and oversight.

Three of the stakeholders operate sanitation systems: CAESB, Vacuum truck companies and community members. CAESB operates and maintains all formal wastewater systems, from collection to final disposal. However, according to the results, CAESB does not provide services to informal settlements. Therefore, community members must own septic tanks, which they operate by hiring vacuum truck companies to empty the tanks and transport the sludge to be treated in one of CAESB's wastewater treatment plants. Householders have to finance the tanks and the services themselves. This is considered an informal service, but is expected to take place wherever CAESB cannot provide services. The only formal sanitation system in the Federal District is the one provided by CAESB, which is centralized. They own all infrastructure and finance it with the payment from tariffs. CAESB has to comply with standards and they are inspected by ADASA. Both of these stakeholders have a role on oversight – CAESB monitors their own systems and ADASA inspects CAESB's services.

Table 10 - Stakeholder information - summary

N.	Stakeholder	Competency	Stakeholder Analysis			
			Operation	Ownership	Finance	Oversight
1	Community members	Local	Operate their own septic tanks	Own septic tanks	Implementation and maintenance of septic tanks	-
2	Municipality	Local	-	-	They got resources to implement the wastewater pipelines.	-
3	AMOVIC	Local	-	They implemented the pipes of the village	They got resources to implement the pipelines.	-
4	Health center	Local	-	-	-	-
5	Vacuum truck companies	Local	Clean septic tanks and transport the sludge to a WWTP.	-	-	-
6	CAESB	Federal District	Operate and maintain all formal wastewater systems	Own all infrastructure of formal wastewater systems	Invest on the infrastructure they implement	Monitor their own systems to comply with standards and regulations
7	ADASA	Federal District	-	-	-	Inspects water and sanitation services from CAESB
8	SINESP	Federal District	-	Owns infrastructure of the Federal District (CAESB, CEB, Novacap, SLU).	Finances all infrastructure implemented.	Inspects the implementation of the infrastructure.
9	IBRAM	Federal District	-	-	-	Monitor discharges of wastewater into the waterbodies, which has to comply with standards from CONAMA. Informal systems are not monitored.
10	CODHAB	Federal District	-	-	-	-
11	SEGETH	Federal District	-	-	-	-
12	CODEPLAN	Federal District	-	-	-	-
13	SEMA	Federal District	-	-	-	-
14	Secretariat of Health	Federal District	-	-	-	-
15	Secretariat of Cities	Federal District	-	-	-	-
16	Agefis	Federal District	-	-	-	Inspect illegal settlements.
17	FUNASA	National	-	-	Finance programs on sanitation for communities smaller than 50,000 pp.	Inspect the implementation of the project and infrastructure and make sure the investment is well applied.
18	Ministry of Cities	National	-	-	Finance programs on sanitation for communities bigger than 50,000 pp.	Inspect the implementation of the project and infrastructure and make sure the investment is well applied.
19	Trata Brasil Institute	National	-	-	-	-

The local stakeholders (municipality and AMOVIC) have a role in the sanitation of Vila Cauhy because they helped in getting material to implement the pipelines that collect wastewater in the village. Community members built the pipelines themselves with the help and coordination of AMOVIC. Neither AMOVIC nor municipality reported the role of operating and maintaining the system.

SINESP has a role of planning and executing construction works in the Federal District. CAESB and other service providers are under the umbrella of this Secretariat. This is why it is considered that they own all infrastructure. Once they plan and authorize the implementation of a sanitation system, CAESB, which is directly related to SINESP, will provide the infrastructure. SINESP can also finance their projects, which includes all infrastructures. They inspect the implementation of the systems.

IBRAM plays an important role on oversight, because they inspect all interactions with environment. This environmental agency can apply a fine if there are any discharges on water bodies that cause pollution. However, informal decentralized systems are not inspected by IBRAM. AGEFIS is the agency that will inspect and stop any actions that go against the plan of use and occupation of the land. They may stop construction works in illegal settlements.

FUNASA and the Ministry of Cities both finance projects, which are required by states or municipalities of Brazil. They support sanitation infrastructure to be implemented and they inspect if the investment is well applied. The ownership and operation of the system is responsibility of the municipality, which required the investment. FUNASA and the Ministry of Cities will inspect if the services are being provided and if they comply with their policies.

Some stakeholders do not have a direct role or responsibility towards sanitation in informal settlements. However, they affect the main problem (lack of sanitation in informal settlements) or the problem owner (community members) in some way. The local health center and the Secretariat of Health need to be prepared to manage the consequences of lack of sanitation of the population. These organizations do not directly interfere with sanitation, but they can help control diseases outbreaks and help with hygiene education. CODHAB and SEGETH are responsible for the legalization process of the settlement. Once it becomes legalized, all organizations of the Federal District will act on the settlement and will implement all infrastructure including sanitation, water supply and solid waste management. CODEPLAN and Trata Brasil will study the present situation and provide data and information that helps other organizations to take actions. SEMA will provide policies and regulations that have to be followed by IBRAM and ADASA. The Secretariat of Cities will play an important role reducing bureaucracy between the administrative regions (satellite cities) and the other organizations of the Federal District.

5.1.2. Interest and influence

The level of interest and influence of each stakeholder will vary depending on their roles and responsibilities. These levels were categorized from very low to very high. It is important to highlight that the categorization is a subjective interpretation from the data collected on chapter 4.1 and might vary a little from one interpreter to another. This interpretation is described below and graphically represented in Figure 20, which is an adaptation from Enserink, et al. (2010).

- **Community members of Vila Cauhy:** The community is unsatisfied with sanitation services today and are highly interested in improving the picture. Their influence is very low, even when trying, they are not able to provide adequate infrastructure themselves.
- **Municipality of Vila Cauhy:** They have a high interest in solving the problem, but not as high as the community members, because they have other priorities as well. They have a medium influence because they cannot ask for service provision before legalizing the settlement, but they can ask for material to build pipelines for wastewater collection.
- **AMOVIC - Association of Community Members**: They have a very high interest in solving the problem (the same as community members), but have a low influence to solve the problem, although they try it with the minimum resources they have.
- **Health center of Núcleo Bandeirante**: They have some interest in solving sanitation issues, to improve the health of the community. Their influence in solving any sanitation issue is very low. All they can do is provide some hygiene education to those who come to the health center with some disease.
- **Vacuum truck companies:** They have no interest in the implementation of sewer lines because they rely on non-sewered sanitation. However, they have some influence in the sanitary situation of informal settlements, because they provide cleaning services and transportation of sludge.
- **CAESB - Environmental Sanitation Company of the Federal District:** They have a very high influence in the problem, because they are the ones who prove the infrastructure. Their interest is also very high because giving services and charging for them is their business.
- **ADASA - Regulatory agency of water, energy and sanitation of the Federal District:** They have a high interest in solving sanitation problems in the Federal District and they make sure CAESB is attending all they can. The influence is high on CAESB's actions.
- **SINESP - Secretariat of Infrastructure and Public Services:** The influence over implementing sanitation services is very high. However, the interest of attending informal settlements is very low.
- **IBRAM - Environmental Institute of the Federal District:** The interest in providing licenses to implement sanitation is exclusively environmental, not social. However, the influence is extremely high because they issue licenses that allow CAESB, CODHAB, SINESP to take actions, plan the urban space, implement sewer infrastructure and provide services.
- **CODHAB - Company of housing development of the Federal District:** They have a very high influence on sanitation for informal settlements, because once they issue the legalization of the land, CAESB is authorized to implement the sewer system. Their interest in solving the problem is high, because they have social projects and act to improve the quality of life of the citizens.
- **SEGETH - Secretariat of housing and management of the territory:** They have a very high influence on sanitation for informal settlements, because this Secretariat will dictate if an area can or cannot be legalized. Their interest is high because they have a social nature.

- **CODEPLAN - Company of Planning of the Federal District:** They have no interest or influence on sanction aspects of the District; they simply observe and record. The dissemination of information has some influence on the decision-making processes of the Government towards sanitation.
- **SEMA - Secretariat of Environment of the Federal:** They have a high interest in protecting the environment and therefore having appropriate sanitary solutions in the Federal District. Their influence is very high because they dictate the rules followed by IBRAM and ADASA.
- **Secretariat of Health of the Federal District**: Although the Secretariat of Health is has some concern with the health of the population, they have no action in the sanitation problems of the Federal District. This information was confirmed by personal communication with staff member and website of the Secretariat.
- **Secretariat of Cities of the Federal District:** They have a high interest in solving the sanitation issues of the administrative regions. Their influence is also high, but they depend on other organizations of the Federal District to take actions.
- **Agefis - Inspection agency of the Federal District:** They have a very low interest on sanitation problems of the Federal District. They have a medium-low influence because investments in an illegal settlement might not be done because Agefis might demolish the houses and the investment is lost.
- **FUNASA - National Foundation of Health:** As FUNASA is a branch of the Ministry of Health, they have a very high interest of improving sanitation services in Brazil, independently of the status. They include informal settlements in their programs and do not require the proof of land ownership to increase the number of people benefited. Their interest is also high because they are concerned in achieving SDG6 target. Their influence is high because they can finance any sanitation project adapting to their policies.
- **Ministry of cities:** This Ministry has the same powers as FUNASA, but they have bigger programs for cities over 50,000 inhabitants. Their interest is very high because they have a big concern in achieving SDG6 and they have a big influence over municipalities and states of Brazil to achieve this goal. The Plan of Basic Sanitation of Brazil has a big influence on local plans to improve sanitation services provision at municipal and state level.
- **Trata Brasil Institute:** They have a very high interest in improving sanitation problems in Brazil and their influence is medium-high, because they do not act directly.

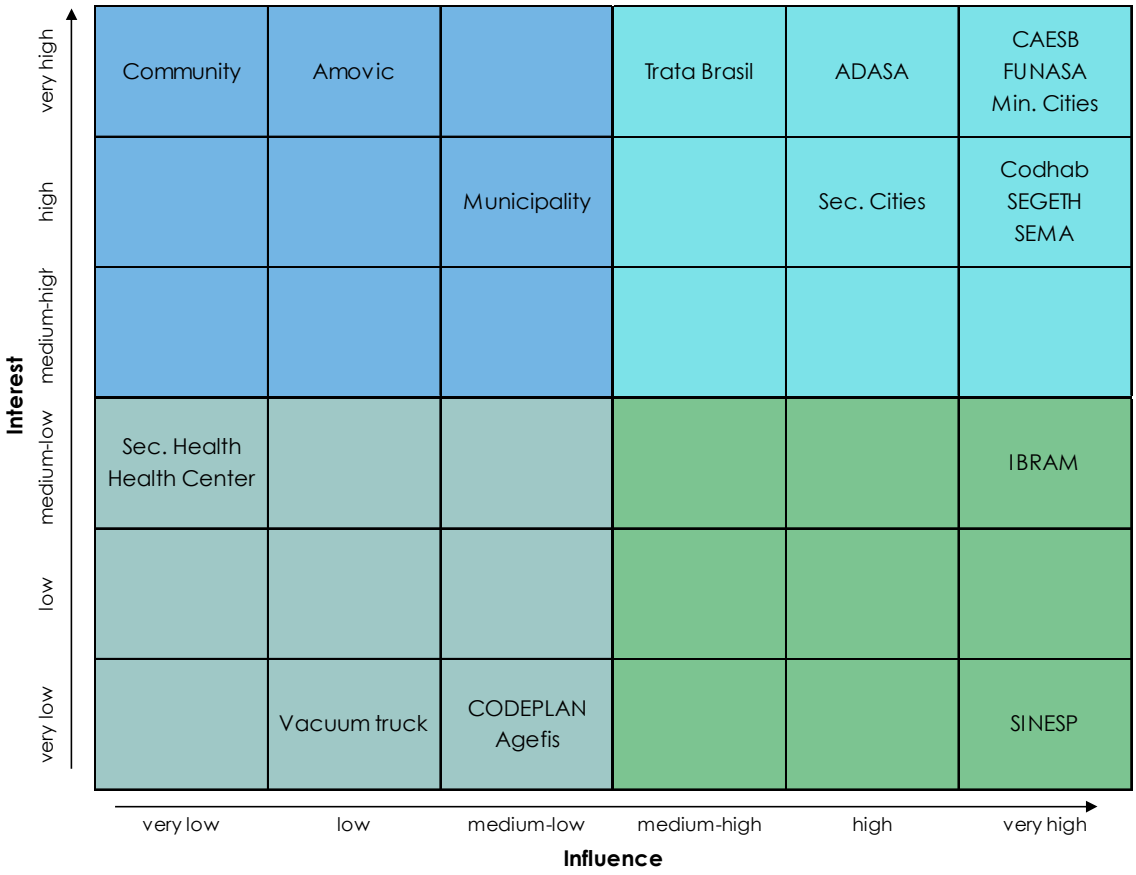


Figure 20 – Graphic representation of Interest and influence of stakeholders
Adapted from (Enserink, et al., 2010)

From Figure 20 it is possible to see four groups of stakeholders, which can be categorized according to the legend below. The actions to be taken are recommended by Enserink, et al. (2010) depending on the quadrant of the stakeholder.

	Group 1: Low influence, Low interest
	Group 2: Low influence, High interest
	Group 3: High influence, Low interest
	Group 4: High influence, High interest

Group 1 represents stakeholders with low influence and low interest on the problem. This group is represented by the Secretariat of Health, Health Center, the vacuum truck companies, CODEPLAN and Agefis. This is the least important group on the stated problem. However, any action taken in changing the present scenario in sanitation must be communicated to them.

Group 2 represents stakeholders with low influence and high interest in sanitation for informal settlements in Brasília. This group is represented by the stakeholders of the settlement: community members, municipality and association of community members (AMOVIC). This group of stakeholders has to be involved as needed. If there is a chance for them to get more involved and have a bigger influence in this matter, that should be worked on. For instance,

when dealing with decentralized sanitation, it is important to empower the community members (along with associations and municipality) to improve sanitary conditions in the settlement. If this happens, these stakeholders migrate to group 4 and become key stakeholders.

Group 3 characterizes stakeholders with high influence and low interest on the sanitation problem. This group is represented by SINESP and IBRAM. These stakeholders need to be invested in to increase their interest levels. If they have a high influence in improving sanitation in informal settlements, they should be aware on how important it is for them to engage their resources in this area. When their interest increases, they become key stakeholders and move up to group 4.

Group 4 are the key stakeholders of the problem. They have high influence and high interest in solving the problem. The group is represented by CAESB, FUNASA, Ministry of Cities, ADASA, CODHAB, SEGETH, SEMA, Secretariat of Cities and Trata Brasil Institute. These stakeholders should be focused on. They are allies to projects on the sanitation sector of Brasília and should be consulted regularly and be involved in the decision-making process. However, it is important to highlight that the Ministry of Cities and FUNASA might be involved or not on the program, depending if the Government requests for their partnership and finance. Furthermore, these two organizations are complementary to one another – Ministry of Cities is involved in bigger projects (more than 50,000 inhabitants) and FUNASA in smaller projects (up to 50,000 inhabitants).

5.1.3. Map of interdependencies

The interaction among stakeholders is mapped in Figure 21. There are three big groups separating the stakeholders into levels – national, regional and local. The colors of the boxes represent the group categories of Figure 20.

Under local level, there are five stakeholders: community members, AMOVIC, municipality, health center and vacuum truck companies. Community members may access the municipality or AMOVIC to demand some kind of action toward the problems they face, such as the sanitation problems of the village. At the same time, the municipality and AMOVIC elaborate projects and ideas and involve community members to collaborate. The municipality and AMOVIC do not work together as they do not get along. Community members also have a direct link to the health center, which they look for in case of illnesses. The health center is subordinated to the Secretariat of Health of the Federal District and they follow the policies established by the Secretariat. The Secretariat is not linked to any other stakeholders regarding sanitation problems. Community members of the village also have a link with vacuum trucks companies, which are triggered when septic tanks need cleaning. The discharge of the sludge is directly into a wastewater treatment plan of CAESB, which represents a link between these stakeholders.

FUNASA, Ministry of Cities and Trata Brasil Institute compose the stakeholders at national level. FUNASA can make projects and repass funding directly to the municipality, once Vila Cauhy has less than 50,000 inhabitants. The municipality would have to request the funding and FUNASA would make sure the funding is well applied. FUNASA can also make projects and partnerships with any other federative organization at regional level (Government of the Federal District). The Ministry of Cities works the same way as FUNASA, however for cities

above 50,000 inhabitants. In this case, it can repass funding to a federative organization from the Government of the Federal District that would support Vila Cauhy as a part of Brasília. In this case, the municipality cannot request a direct partnership with the Ministry of Cities. Trata Brasil Institute can be contacted by anyone from local or regional level to give technical support regarding basic sanitation. Trata Brasil will put stakeholders in contact to solve the sanitary issues.

Eleven organizations compose the regional level stakeholder's group. As already mentioned, the Secretariat of Health is not connected to any other stakeholders regarding sanitation. CODEPLAN provides the studies and statistical analysis of the situation of the Federal District, including sanitation analysis (how many households use septic tanks or are connected to the sewer lines, or do not have sanitation at all, etc). For that, CODEPLAN applies surveys at local level and interacts with other organizations of the Federal District (regional level). The Secretariat of Cities is linked to all other organizations of the Government of the Federal District. They were implemented to accelerate the interaction between the Administrative Regions of the Federal District with the other parts of the Government. Vila Cauhy is a village located inside the Administrative Region of Nucleo Bandeirante, which is connected to the Secretariat of Cities. The Secretariat of Environment embraces IBRAM and ADASA, which are key stakeholders to the sanitation of the Federal District. Both ADASA and IBRAM operate under the policies of the Secretariat of Environment. ADASA inspects water and sanitation services from CAESB. IBRAM is responsible for all environmental licenses and inspection. Therefore, IBRAM is linked to CAESB and SINESP, which depend on environmental licensing to implement infrastructure and discharge the treated effluent into water bodies (in the case of CAESB). IBRAM is also a core stakeholder regarding the legalization process of the land, which is performed by CODHAB, which is directly linked to SEGETH. CODHAB also interacts with the municipality, the main interested in the legalization of the land, and SINESP, which will plan all urban equipment and order CAESB the implementation of the formal wastewater system. Finally, Agefis interacts with SEGETH and the organizations at local level. According to the land organization and planning established by SEGETH, Agefis has the right to demolish households that are built in improper public spaces (illegal settlements), which intimidates investments that might be lost in the area.

5.1.4. Conclusion of Part 1

The stakeholder analysis regarding sanitation aspects of informal settlements in Brasília was necessary for the other parts of research, which collected data through interviews with these organizations. Nineteen organizations were listed and studied to investigate their roles, responsibilities, and levels of interest and influence in the lack of sanitation in informal settlements of Brasília. Results outlined four group of stakeholders that have to be approached in different ways. While key stakeholders need to be considered in every step of sanitation sector of Brasília, others need to be just kept informed. To guarantee accessibility to sanitation in a specific settlement, local stakeholders should be empowered, especially when considering decentralized sanitation as an alternative. Once stakeholders were identified, it was possible to develop the other parts of the research, which used interviews with relevant actors for data collection.

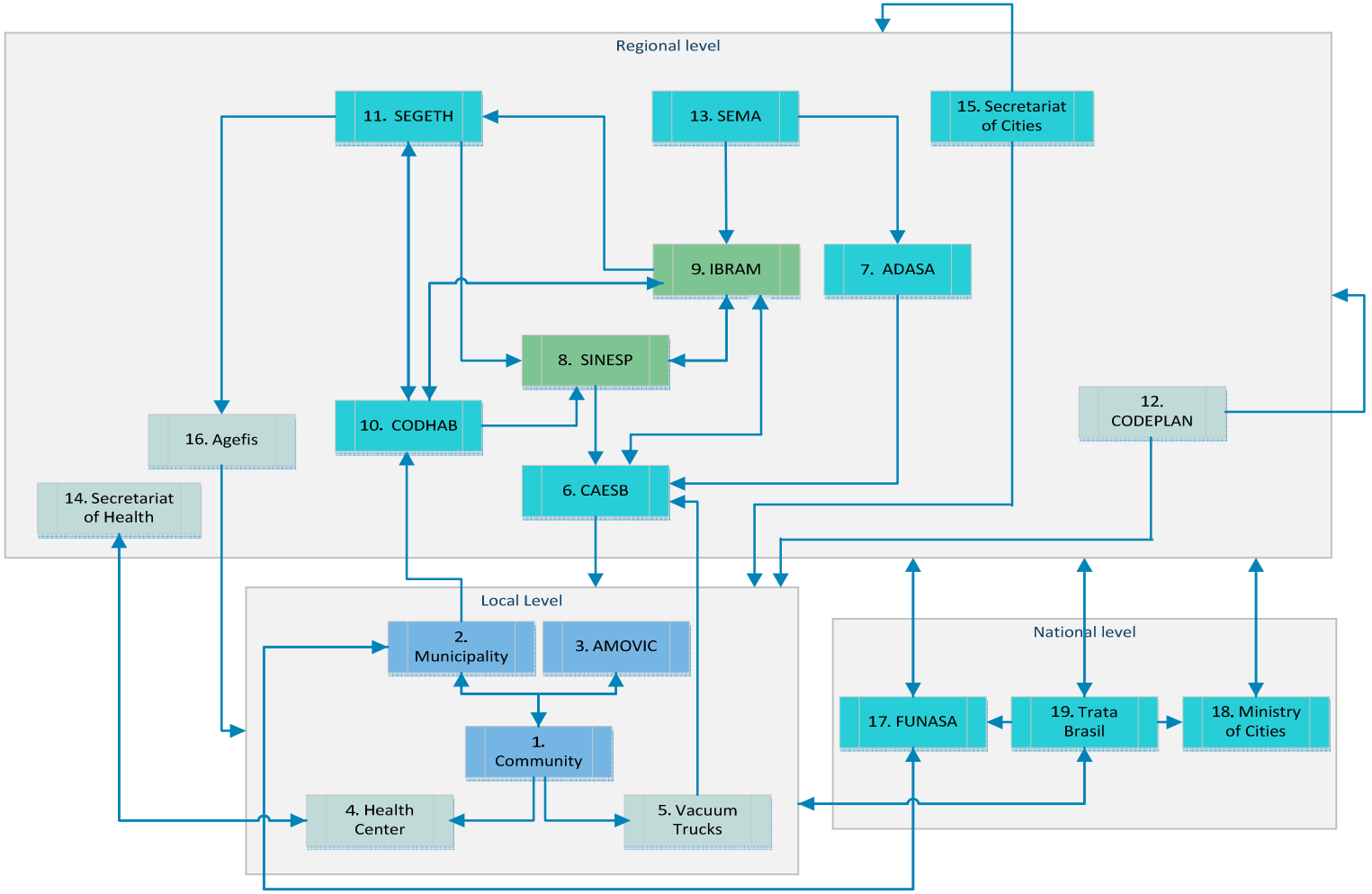


Figure 21 - Map of interdependencies among stakeholders

5.2. Discussions on Part 2 – Informal settlements in Brasília

What factors contributed to the development of informal settlements in a planned city such as Brasília?

Brasília was planned to be free from poverty. However, this is not the reality observed in the city. Many informal settlements arose in which people live under hazardous conditions with no basic services provided from the government. This is an important issue when trying to accomplish the SDG sanitation target in Brasília. Studying the history of how informal settlements emerged and what factors contributed to it contributes to the understanding of the sanitation issues of Brasília.

5.2.1. How informal settlements emerged in Brasília

Many stakeholders (CODHAB, SEGETH, and CODEPLAN) and authors (Gautherot, et al., 2010, Vasconcelos, 1988) agree that informal settlements exist in Brasília since the capital's construction. Many workers immigrated in the years that preceded the inauguration of the new capital and established themselves in areas close to the Pilot Plan. Some households were removed and some settlements were organized by the government and they became satellite-cities. However, the city kept growing and informal settlements continued emerging. Many people were transferred from Rio de Janeiro to keep working with the government; others came looking for new opportunities, better educational system and health conditions (CODEPLAN). The central part of Brasília (Plano Piloto) was planned to absorb middle and high classes of the population, leaving the low classes to peri-urban areas. However, the poor population also wanted to fixate themselves in or close to central areas, where they could find work and easily access all benefits from the capital. Thus, they established themselves in informal settlements, regardless of legal or environmental policies of the area. This situation is still a reality today. There are 347 informal settlements in the Federal District with 533,578 inhabitants (22% of total population) in these areas. Low-income informal settlements are more common, however middle- and high-income informal settlements are also observed in Brasília (SEGETH, 2009).

Documents from CODEPLAN evidence that Brasília begun with immigrants from all over Brazil. The immigration rate was very intense in early years of the new capital, and slowly decreased. The growth rate decreased from 11% per month in 1958 (extremely high) to 1.74% per year in 2015 (normal standards). The population of the Federal District nowadays have achieved nearly 3 Million people. Since the construction of Brasília, there were strong movements from families coming from the Northeast of the country with people running away from draught and seeking new opportunities, better educational system and health conditions. This occurrence can also be observed from the survey applied in Vila Cauhy, where 50% of immigrants of the village came from the Northeast of the country.

Immigration is a characteristic of the population of Brasília and therefore it is not directly related to the occurrence of informal settlements. However, the number of people immigrating from other states, especially from the Northeast, is a strong indicator that opportunities and life

conditions there are not good. Therefore, the number of immigrants that contribute to the growth of informal settlements in Brasília should also be a concern for the national government (CODHAB and SEGETH).

5.2.2. Factors that contributed to existence of informal settlements in Brasília

When the Federal District was delimited, the land was expropriated from local farmers. However, according to SEGETH, there are still vestiges of inconclusive legal documentation for land expropriation, land domain title and imprecision boundaries of public and private land. These factors combined with uncertainty of landowner, lack of housings, monopolization of the government in sharing and selling lots, lack of policy for housing loans (especially for middle class), and real estate speculation, contribute to existence of informal settlements. SEGETH, as the part of the government responsible for planning and executing measures for an appropriate use of the land, have studied the axes of population growth and mapped the areas that can be urbanized in the future (Figure 16). Then, they mapped informal settlements inside these areas that can be legalized/formalized (areas of social interest – ARIS, and areas of special interest – ARINE) (Figure 13). Their strategy is to direct urban expansion to areas that are more accessible to the Pilot Plan and other important city centers, such as Taguatinga. To do so, they improve accessibility of peri-urban areas, which are less expensive and more affordable, to the city centers by improving public transportation and road infrastructure. They also stimulate satellite-cities to have better job offers, entertainment centers, hospitals and universities to create new city-centers. This is an important part of the plan, because when low-income informal settlements located close to central parts of the city become legalized, their real estate value increases. Thus, low-income families are pushed away to peri-urban areas and the settlements are replaced with higher-income families. This is why improving accessibility of peri-urban areas to city centers avoid new informal settlements from emerging near the center. By working on this plan, SEGETH intends to recover the Federal District from the present situation.

Furthermore, CODHAB's actions also contribute to the reduction of informal settlements. They provide the legalization process of the land, which is preferred nowadays rather than removal of families. The legalization is a formal mechanism that allows the population to have access to urbanized land and guarantees the ownership of their households. In a legalized and formalized settlement, the government concedes a school, health center, water, electricity and sanitation services, etc. Winning these improvements usually takes a long time. In the case of Villa Cauhy, the process is taking even longer due to conflicts between environmental legislation and the use of the land to acquire the necessary licenses to occupy the area. The settlement is located too close to a stream (Riacho Fundo) and there is a zone considered by IBRAM as a risk area. This same area is constantly suffering from flooding, a hazard to the families who live there.

Whenever legalizing is not possible, CODHAB relocates the families to appropriate houses or lots. They built housings and create new spaces for this purpose in accordance to SEGETH's planning. Moreover, they promote social assistance as an additional asset to eliminate informal

settlements and stopping new ones from emerging. AGESFIS is an ally that inspects and removes families from inappropriate places to relocate them into CODHAB's housings.

The non-inclusion of the poor in the legal rights to own a propriety and in the policies for urban development contribute to structural constraints in providing sanitation services, as exposed by Solo, et al. (1993).

5.2.3. Conclusion of Part 2

Immigrants from all states of Brazil came to the new capital looking for better opportunities. While high and middle classes could establish themselves in the planned part of the city, low-income families settled around it, in informal settlements. While many settlements were legalized and turned into satellite-cities, others have never achieved this status. Legal aspects of the land in the Federal District have not been appropriately concluded. This factor added to a deficient legislation and housing policies enable informal settlements to emerge until today. Furthermore, the city is growing and the central planned area does not accommodate everyone. As a result, 27% of the households in the District are located in informal settlements, regardless of socioeconomic conditions. Strategies are being implemented by the government to suppress the growth of informal settlements, which is to stimulate peri-urban formal areas to become more attractive, formalize settlements that are possible to be legalized, or relocate families to other formal neighborhoods. However, the system is very bureaucratic and processes are very slow, thus leading to a slow improvement of this picture. The non-inclusion of the poor in the legal rights to own a propriety and in the policies for urban development contribute to structural constraints in providing sanitation services, as exposed by Solo, et al. (1993). Thus, these factors influence achieving universalization of access to improved sanitation in informal settlements.

5.3. Discussions on Part 3 – Sanitation in Vila Cauhy

To what extent does living in an informal settlement affect accessibility to sanitation in Brasília?

Results of the survey presented on chapter 4.3 suggest that sanitary conditions in Vila Cauhy are not as bad as in other parts of the world. Even though sanitation services are not provided in the village, the community tried to improve the situation on their own to increase their quality of life. Moreover, the village is supplied with water and electricity, which takes them off misery conditions. To characterize the situation, support data is used to compare with accessibility to sanitation services. The interviews with local, regional and national stakeholders complement the results and permits extrapolation for other settlements in Brasília.

5.3.1. Prioritization of sanitation services provision in informal settlements

Sanitation services are usually not provided to informal settlements. This is the situation of Brasília and other cities of Brazil, according to interviews with stakeholders (Table 6). The illegality aspect of the land is the main issue interfering with services provision. When the community is illegally settled, the law dictates that households should be removed from that place and no services can be provided. Once the legalization process is in place and there is an environmental license, then CAESB is allowed to give access to sanitation services. FUNASA and the Ministry of Cities are trying to reduce the bureaucracy of demanding land ownership proof in the projects that they finance, thus trying to service people living in informal settlements or slums inside urban areas. Both organizations, which act at national level, are concerned about the human right to have access to safe water and improved sanitation and achieving SDG6. Nonetheless, the regional-level organizations do not have the same posture in universalizing services. Although they acknowledge the importance, they treasure the plan of use of the land. According to Trata Brasil Institute, high-income informal settlements, which are very common in Brazil, usually have ways to provide their own decentralized solutions. However, low-income settlements have no choice but to rely on the government.

In Vila Cauhy, sanitation services are in fact not provided, as stated by AMOVIC and municipality (Table 7). However, water and electricity services are formally supplied, even though it is an informal settlement (Table 8). CAESB stated that water is considered a basic service and it is supplied to all Federal District, regardless of the illegality aspect. According to AMOVIC and the municipality, it was an initiative from the Government to supply water and electricity to Vila Cauhy a few years ago. As results of the survey point out, 72% of the people have access to water services formally provided by CAESB and 77% have access to electricity services by CEB. These households pay for services according to their consumption. Even though people complain more about the energy bill than the water bill, they each represent in average between 8% and 9% of the family's income. When services are not provided, families usually get water from community well, the river or from the neighbour and energy from connections to the light pole on the street. This way, 100% of the community somehow have access to water and electricity. The same prioritization that the government did to water and electricity services was not made to sanitation services. The Ministry of Cities says sanitation companies usually find this investment very risky, because families might be removed from the settlement and the investment would be lost. The community is unhappy with this decision and are clearly unsatisfied with the lack of sanitation in the area. As shown on Graph 8 and Graph 9, there is a lot of investment necessary in the village, however sanitation is considered by the population as the most important one.

5.3.2. Community's actions on sanitation

To improve the situation, villagers believe that the collection system needs to be upgraded. Only 25% have shown to care about direct discharge of raw wastewater into the river and believe that wastewater treatment should be implemented. Most of them think that the best way to improve sanitation is by having formal services provided by CAESB. Even though they expect the government to take measures, they have tried to solve problems with their own efforts. The population of Vila Cauhy has shown self-initiative in improving the collection and transportation of wastewater in the village. Vila Cauhy is situated in a floodable land and the

water table is very high. Therefore, whenever it rains a lot, septic tanks or unsealed tanks do not drain the liquid into the soil like they should and the wastewater overflows to the surface. Emptying the tanks to avoid overflow becomes a problem and it is not affordable for all, especially having to empty it many times a year. Thus, they decided to build concrete pipelines connecting the houses and the tanks to drain out the wastewater. These pipes eliminate or reduce the amount of wastewater on the streets. Still, their wastewater is not treated and the final disposition is the nearest stream (Riacho Fundo). Even though this action had a positive impact on the community and reduced direct human contact to wastewater, it is not considered an appropriate solution because of the discharge of raw wastewater into the stream.

It was possible for the community of Vila Cauhy to have gotten some guidance on how to proceed technically in implementing the pipelines. CAESB states that one of their roles is to give technical support and guidance to the community when needed. They could have given some guidance to the population of Vila Cauhy if required, independently of the informality aspect of the village. Trata Brasil is also willing to provide support by promoting the contact between stakeholders or point out the organizations that can be supportive. FUNASA can also give support and in this case, the municipality or regional government (Federal District) has to make an official request and has to be responsible for the construction works, operation and maintenance. SINESP believes that the support has to come from the third sector (NGO). However, they say that these actions are against the governmental actions of land legalization. Moreover, none of these stakeholders would approve the solution found by the community on discharging raw wastewater into the stream. Still, they could give support into finding a better solution.

The self-initiative the community in trying to improve the place they live in is a strong characteristic necessary to develop decentralized solutions. Survey results (Graph 14) show that residents recognize that their own efforts have benefited the population somehow. Ninety six percent (96%) of the population is willing to help donating money, material or labour to sanitary projects.

5.3.3. Service chain

To complete the characterization of sanitation in Vila Cauhy, the service chain is graphically represented in Figure 22, which is an adaptation of the sanitation value chain from Bill and Melinda Gates Foundation. This image shows the elements found in the village composing all steps of the value chain from capture to final disposal of wastewater. Some elements such as the existence of open defecation and streets as place for final disposal already indicate that the sanitation value chain of the village is not adequate and needs improvement. The survey indicates that the human interface with wastewater capture is mainly through flush toilets and in 2% of the cases there is open defecation or use of plastic bags, in which case the final disposition of excreta is on the streets. Sludge is stored in septic tanks or unsealed trenches. They can be emptied through vacuum trucks that take sludge to be treated at the nearest wastewater treatment plants, which are activated sludge systems: ETE Sul or ETE Riacho Fundo I. In the case of ETE Sul, the treated effluent is discharged into Paranoá lake; ETE Riacho Fundo I discharges at Riacho Fundo Stream. Both wastewater treatment plants unload the final sludge to a landfill. According to CAESB, there is no reuse of the final effluent or the sludge. When using buckets to manually emptying the septic tank or unsealed trenches, the survey did

not identify the final disposition, but it is possible to have the streets or Riacho Fundo stream as a final disposition. Many households use the community's pipelines to transport raw wastewater to Riacho Fundo stream. The pipelines are either directly connected to the household or to the septic tank or unsealed trenches. It was observed that the pipelines lead to open channels in some parts of the village. Therefore, open channels were also included here as a wastewater transport method.

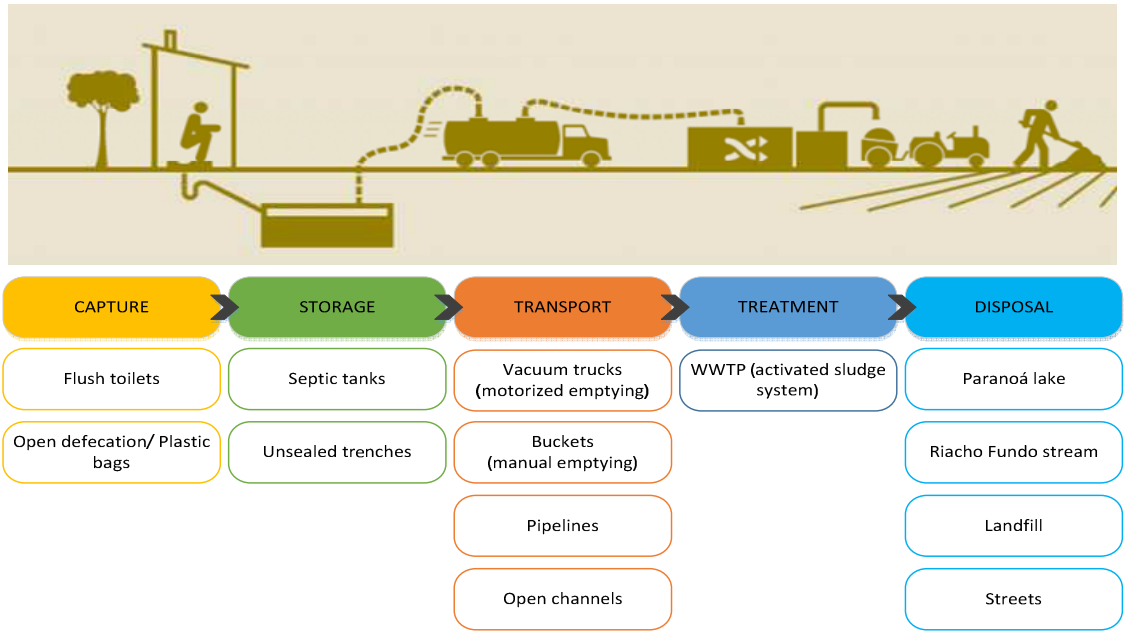


Figure 22 - Service chain – Present situation in Vila Cauhy - Adapted from Bill & Melinda Gates Foundation (2010)

Another method used to represent the sanitary characterization of the village is using the diagram proposed by Tilley, et al. (2014). This diagram shows a detailed link between products in each step of the value chain, as presented on Figure 23.

There are two input products that were not mentioned before and interact with the wastewater – greywater and stormwater. AMOVIC states that some of the households separate blackwater and greywater, however this behaviour was not observed in the survey. It is represented infiltrating in the septic tanks/trenches and the pipelines, together with the blackwater. There is also a separate line indicating the discharge of greywater directly into streets or Riacho Fundo Stream. There is no appropriate drainage system in Vila Cauhy so the stormwater either infiltrates together with blackwater on tanks/trenches or the pipeline/open channels or it runs-off on the streets towards Riacho Fundo stream.

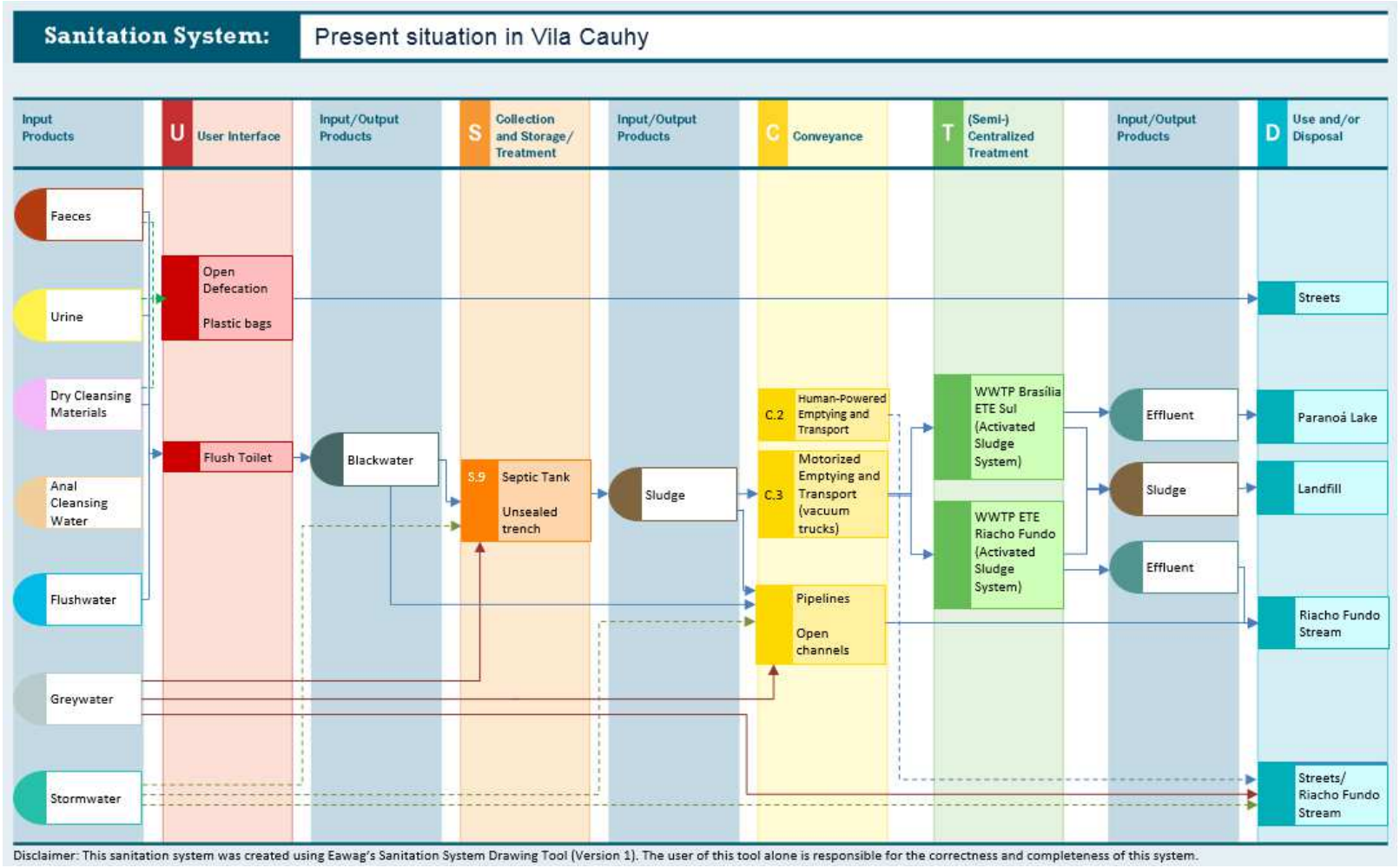


Figure 23 - Service chain diagram layout – Present situation in Vila Cauhy
Adapted from Compendium of Sanitation Systems and Technologies (Tilley, et al., 2014, p. 16)

5.3.4. Access to improved sanitation in Vila Cauhy

According to the definition of Unicef and WHO (2015, p. 50), an improved sanitation facility "hygienically separates human excreta from human contact". In 98% of the cases, the population of Vila Cauhy uses flush toilets, which separates the direct contact to human excreta. In only 2% of the cases, open defecation is practiced or a plastic bag is used (Graph 10), which is considered completely unimproved. AMOVIC and the municipality did not expect this situation to happen in the village. They state in their interviews that all villagers have a toilet inside their household, when in fact this is not true. Moreover, some dwellers do not have a toilet inside their households and there are no public toilets in the village. Therefore, they share toilets with neighbors, which was also not foreseen by the local authorities. However, these toilets are cleaned by the users, are appropriate for women and children to use and are easily accessed by the users. Shared toilets are also categorized by Unicef and WHO as unimproved sanitation.

Results presented on chapter 4.3 suggest that the biggest problems in sanitation in Vila Cauhy is after the user interface: collection, transport, treatment and final disposition. These steps of the service chain also have to be evaluated to categorize sanitary conditions as improved or not. Septic tanks are considered improved sanitation when appropriately emptied and when the sludge is transported to be treated in a wastewater treatment facility (Unicef and WHO, 2015). Many of the interviewed stakeholders recommend the use of septic tanks when they cannot provide services. Any other systems that discharge wastewater elsewhere other than a treatment facility is not considered improved sanitation by Unicef and WHO (2015).

In Vila Cauhy, only 28% of households use septic tanks. Combining results from questions 31, 32, 33, and 36 of the survey (Combined results of Appendix C), it is possible to observe that from this group, some share their toilets with neighbors and some do not clean the septic tank appropriately, characterizing a management issue of the applicability of this technology, as exposed by (Strande, et al., 2014). Twenty six percent (26%) have adequate conditions fully recognized as improved sanitation: use flush toilets, have septic tanks and empty them appropriately with vacuum trucks, which transport the sludge to a wastewater treatment facility.

There are other collection and transportation methods used in Vila Cauhy: pipelines built by the villagers, unsealed tanks, and direct discharge to streets or water stream. None of these methods are considered improved, because wastewater is discharged somewhere other than an appropriate treatment facility. The pipelines discharge raw wastewater directly to the nearest water stream and it does not work appropriately, frequently overflowing wastewater to the surface (Figure 19). The unsealed tanks, even when correctly emptied, are also a hazard due to direct infiltration to the ground and probable soil and aquifer contamination. Most of these tanks overflow to the pipelines of the village. Therefore, only 26% of the households are considered to have improved sanitation, 58% are unimproved and 15% are undefined because the surveyed did not know where their wastewater goes.

Table 11 - Improved and unimproved sanitation in Vila Cauhy

Improved sanitation	Households with non-shared flush toilet, septic tank emptied with vacuum truck	26%
Unimproved sanitation	Households with non-shared flush toilet, unsealed trench emptied with vacuum truck	6%
	Open defecation/ Plastic bags	2%
	Shared Flushed toilet	6%
	Non-shared Flushed toilet with wastewater going elsewhere	45%
Undefined	Household with non-shared flush toilet, but the interviewed does not know how the wastewater is collected	15%

The population who lives in informal settlements of Brasília do not have access to formal provision of sanitation services. Therefore, the accessibility to sanitation services will depend on the family income and educational level. Comparing results from Table 11, Graph 3 and Graph 6 (Combined results of Appendix C), it is possible to learn from the example of Vila Cauhy that improved sanitation is affordable for all of those (100%) who have a monthly income over 5 Minimum Wages (R$4,685 or €1,386). Otherwise, many of who studied until high school (complete or incomplete level) give it enough importance and invest on septic tanks (29%), which does not happen a lot for the ones who studied until completed or uncompleted basic education (17%). It is important to emphasize that improved sanitation in this case is having access to non-shared facilities with flush toilet discharging to septic tanks, which are appropriately emptied and have sludge treated at a wastewater treatment plant, represented by the group of 26% in Table 11.

Table 12 - Conditions of people with improved sanitation in Vila Cauhy

More than 5MW/month	100%
Less than 5MW, high school complete or incomplete	29%
Less than 5MW, basic education complete or incomplete	17%

It is possible to observe and extrapolate this data to other informal settlements of Brasília and conclude that accessibility to sanitation services in these communities depends on affordability of implementing appropriate infrastructure. This will vary from one place to the other, as it is presented on Figure 24 and Figure 25, which show very different conditions on two informal settlements of Brasília - one with high-income population and the second with very low-income. It is possible to see that the high-income neighborhood is not affected by lack of sanitation, because they provide it themselves. Meanwhile, in the low-income neighborhood, the lack of sanitation services is a big hazard and the population does not provide it themselves.

Figure 24 - Low-income informal settlement of Santa Luzia in Brasília

Extracted from Google map street view (15/02/17)

Figure 25 - High-income informal settlement of in Brasília

Extracted from Google map street view (15/02/17)

Figure 26 - Sanitary conditions in Vila Cauhy

5.3.5. Impact of accessibility to sanitation services

As proposed by the methodology, the impact of accessibility to sanitation services is categorized in three levels: highly affected, partially affected and not affected. Four conditions are evaluated to measure impacts – accessibility to improved sanitation; contamination by faecal-oral diseases; contact to open-air sewerage; and accessibility to formal sanitation services.

As discussed on the previous session, ninety eight percent (98%) of the villagers have access to improved facilities (flush toilets). This conditions falls into the category of partially affected communities. The community has no access to formal services and, as presented on Table 11, only 26% of the families have access to improved sanitation.

As for contamination with faecal-oral diseases, results show that 15% of the surveyed had diarrhea, hookworms or related fever in the past three months. However probable, it is not possible to assure that these diseases resulted from lack of sanitation in the village. In addition, 9% of the interviewed also complained having dengue/zika/chikungunya, which is very common in Brasília and can be related to lack of drainage services in the village. The community does not have a clear understanding of contamination sources and none of them related diseases with lack of sanitation or drainage systems. They tend to think it is their fault they were infected rather than thinking it is due to lack of service provision in their neighborhood. However, it was observed during the survey that 47% of the visited houses had wastewater running nearby in the streets. Therefore, there is a big probability that diseases are due to lack of sanitation in the village.

In conclusion, the population of Vila Cauhy is partially affected by accessibility to sanitation services. They have a high access to improved facilities; low percentage of families contaminated with faecal-oral diseases; some areas are in contact with open-air sewerage; and they do not have access to formal sanitation services.

Table 13 - Impact of accessibility to sanitation services

Access to improved facilities (user interface)	98%	Partially affected
Contamination with faecal-oral diseases	15%	
Areas in contact with open air sewerage	47%	
Access to formal sanitation services	0%	
Access to improved sanitation	26%	

5.3.6. Conclusion of Part 3

Research results indicate that Vila Cauhy is partially affected by accessibility to sanitation services. Even though sanitation is not prioritized by the government as water and electricity, the community has found ways to improve collection and transportation of wastewater reducing the amount of open-air sewer in the streets. However, the pipelines they built are not appropriate and do not qualify as improved sanitation. Results of survey show that only 26% of the families have access to improved sanitation, with private flush toilets inside their households and adequate use of septic tanks that are cleaned by a vacuum truck company, which takes the sludge to be treated in one of the wastewater treatment plants of CAESB. For the rest of the

community, investments have to be made in the sanitation chain enabling adequate access for all.

It was indicated from analysis of results that access to improved sanitation depends on the family's income and level of education. Most families who have access to improved sanitation either earn more than 5 MW/month or have studied up to high school. It is possible to extrapolate the results and observe this situation in other informal settlements in Brasília. It is observed that high-income informal settlements have access to improved sanitation, while low-income do not.

Vila Cauhy's access to sanitation is partially affected by being an informal settlement. Though they do not have access to formal sanitation services and some areas are in contact with open-air sewerage, they have a high access to flush toilets (improved facilities) and low percentage of families contaminated with faecal-oral diseases. The community shows a lot of self-initiative, an important characteristic to implement a proper decentralized system once they have an enabling environment for it.

5.4. Discussions on Part 4 – Decision-making process

How is the decision-making process for implementation of sanitation developed and how has planning affected technology choice, implementation and management of decentralized sanitation systems in informal settlements in Brasília?

Institutional decisions towards implementation of sanitary infrastructure and services in Brasília are fundamental to the understanding of factors that affect decentralized sanitation in informal settlements. This chapter brings a qualitative analysis of interview results presented on chapter 4.4 on implementation of sanitation services and planning aspects of the decision-making process. Based on results, recommendations are made to create an enabling environment for decentralized sanitation in informal settlements of Brasília.

5.4.1. Implementation of sanitation services

From results of the interviews with CAESB, ADASA, SINESP, Ministry of Cities, FUNASA and IBRAM it is possible to outline the process in which institutional decisions are made to implement sanitation services in Brasília.

Informal settlements are not provided with formal sanitation services and the issues are mainly due to illegal aspects of the settlements. These factors exemplify a structural constraint to the implementation of conventional sanitation, as exposed by Solo, et al. (1993). CAESB states that servicing informal settlements means benefiting illegal areas without the mechanisms recognized by law, which is through formalization of the area – Contradictorily, they provide water supply to all the Federal District. The investment for implementing sanitation infrastructure in illegal areas is considered risky by the stakeholders. They claim investments may be lost if families are required to be removed from the area. Another concern is that providing sanitation services attracts more people to the settlements and it becomes harder to control population growth in these illegal areas.

Therefore, the first aspect that regional stakeholders analyze is the possibility to formalize/legalize the settlement. If it is not possible, the community should be removed from the area and relocated to a formal settlement, previously planned by SINESP and supplied with an appropriate conventional sanitation system. If there is a possibility to legalize, the community may apply for a legalization process, which is only approved if the environmental agency (IBRAM) concedes a license. As seen in previous chapters, the legalization is only possible if SEGETH authorizes the use and occupation of the land. If successfully legalized, the settlement earns the right to be serviced with a formal centralized sanitation system. SINESP and CAESB claim they study social and financial aspects for the best technology selection. However, they usually prefer conventional collection and treatment. If there is a sewer line near the settlement, CAESB will connect the community to that conventional system, regardless of the income of the neighborhood or population's willingness to pay for services. Depending on the location, if this is not possible, they usually recommend using septic tanks. It is possible to implement another technology for decentralized system, although this is a rare case in the Federal District.

At national and regional level, stakeholders give a preference to conventional centralized treatment. Decentralized sanitation is considered an alternative only when it is not possible to connect the settlement to a central sewerage, which, in Brasília, is the only formal service in place. Trata Brasil Institute claims non-sewered systems is a new concept for urban areas in Brazil and the options need to be further explored to become reliable and efficient. CAESB considers decentralized systems much harder to manage, thus they only trust on septic tanks as an alternative to the centralized conventional system. Stakeholders agree that decentralized systems are reliable when there is no effluent discharge in the water body, and when the sludge is properly treated and have adequate final disposition. However, there is no inspection from governmental agencies to the existing decentralized systems in informal settlements. IBRAM only inspects the area when they are required to issue environmental licenses and in this case, if there are any systems operating off-standards, they may apply a fine to the landowner – CODHAB.

There are some strategies in place at regional and national level to increase provision of sanitation services. At regional level (Federal District), strategies mainly involve legal aspects of the land. When the settlement is almost legalized, the sanitation company (CAESB) can already implement formal services. Other than that, the environmental agency (IBRAM) can issue an emergency license to allow infrastructure implementation. The regulatory agency's (ADASA) strategy is to demand expansion of services from the sanitation company, which has to comply and reevaluate their plans. However, they respect the law of use and occupation of the land and still do not provide services to informal settlements. The remaining alternative at regional level is to relocate families to areas that are planned and are already provided with adequate infrastructure. At national level, the illegality aspect of the land is not a concern. The ministries (Ministry of City and FUNASA) are aligned with United Nation's Sustainable Development Goals and they believe sanitation is a human right. To avoid social exclusion, they recently decided to retract land ownership proof to implement their programs. However, the ministries only provide support for the implementation of any sanitary infrastructure if required by a municipality or state government, which earn the rights and obligations of the project. In this case, the local or regional governmental entity might require proof of land ownership to provide infrastructure, as it happens with the Federal Government.

Although considered important by many authors (Lüthi, et al., 2011, Mulenga, et al., 2004, Strande, et al., 2014), community participation is not commonly practiced in the decision-making process of sanitary implementation in Brasília. It is confirmed in the survey applied in Vila Cauhy (Appendix C) that indeed the community did not participate in decisions of services implemented in the village. CAESB's experience is that demand-driven approaches are not effective in the Brazilian culture – in their experience, when they involve the community to implement condominial sewer systems they find resistance in collaboration. As a result, people tend to pay more and leave the construction and operation of the system for the sanitation company rather than doing it themselves at a lower cost. However, examples such as Vila Cauhy show that it is possible to have a positive outcome out of participative approaches. The municipality and the community association of this informal settlement have successfully implemented a community well and a wastewater collection pipeline (although technically inappropriate – Chapter 5.3.2) in the village with collaboration of dwellers. They claim trying to legalize the settlement to earn formal sanitation services, but they also have decentralized sanitation systems that can be implemented meanwhile. The survey shows that the villagers are willing to collaborate donating money, services or material, which is an important aspect for the successful implementation of a decentralized system.

Figure 27 presents a scheme for the decision-making process to implement sanitation services in Brasília, which is developed under a supply-driven approach, as exposed by Lüthi, et al. (2010). It is important to highlight that within an informal settlement, decentralized systems may be used, such as septic tanks or other alternative technology. Even though the government recommends using septic tanks, it is possible for a community to find another alternative that is more suitable. However, there are no rules for the decision-making process in these settlements.

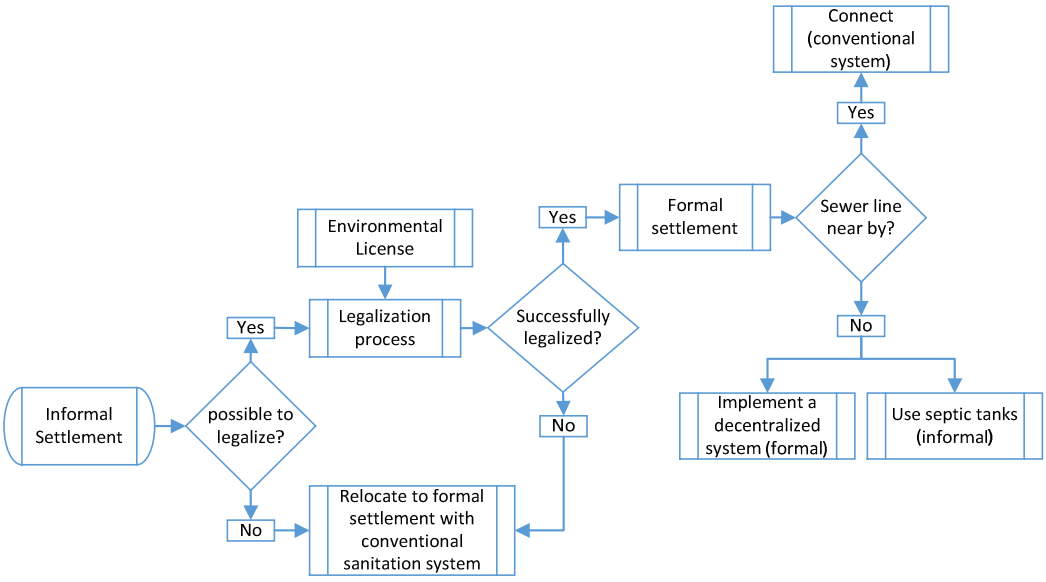


Figure 27 - Decision-making process to implement sanitation services in Brasília

5.4.2. Planning aspects

Since formal services are not provided, informal settlements need to rely on decentralized sanitation systems. As concluded on chapter 5.3, while high-income communities may use septic tanks adequately or build a decentralized system, low-income communities might not be able to afford the same and depend on external assistance to access improved sanitation. At regional level, there are no governmental programs to provide sanitation access to informal settlements or to stimulate communities to implement independent decentralized systems. If a community decides to have an alternative system, it is possible to request technical assistance from CAESB. However, the sanitation company will not operate or maintain that system while the settlement is still illegal and the community will have to manage it themselves. Furthermore, if there is on-site sludge treatment with effluent discharge into a water body, the community has to request a license from ADASA to operate the system. The effluent has to comply with CONAMA's standards, otherwise IBRAM may apply a fine to the landowner. However, there is a poor inspection over activities in informal settlements – IBRAM states in the interview that they only inspect areas in which there is an active request for environmental licenses.

National level stakeholders have adapted conditions to enhance outreach of sanitation accessibility. They have developed specific programs to help municipalities to implement sanitary infrastructure. Their assistance is mainly financial, but can also involve technical participation, especially for small cities. FUNASA focus on household aspects, including household facilities to improve accessibility to improved sanitation. The Ministry of Cities act on bigger areas, improving quality of life of slum areas and informal settlements, implementing sanitation as part of the program. To achieve these communities, they do not require proof of land ownership to provide this benefit. Municipalities have to request for the funding to implement this program. The Government of the Federal District could also request the funding to improve sanitation aspects of informal settlements. However, the planning of use and occupation of the land is in conflict with this action and impairs the implementation of formal services in illegal areas. Although, if there are other services being supplied to these settlements (water and electricity) there is a possibility for sanitation services to be implemented as well.

The Brazilian regulatory and policy system does not confront with the possibility to implement on-site sanitation systems in the Federal District. Therefore, it is possible to plan for neighborhoods with alternative solutions or formally operate a system previously implemented by a community prior to formalization of the settlement. However, CAESB has no interest in operating an alternative system and they standardize two possibilities – centralized treatment or septic tanks. Therefore, the investment done to implement a decentralized system may be lost when the sanitation company takes over. To avoid this, technology selection has to be aligned with future plans for that area. Moreover, if the sanitation company assumes the existing system, they will charge tariffs, which are not suitable for a decentralized service model and in this case, the tariff system would have to be restructured.

Since sanitation planning in the Federal District does not include decentralized systems as a formal service provision, alternative systems are not further developed in Brasília due to lack of interest from institutional power. Services are monopolized by CAESB, which manage their systems as industrial models. Thus, managing alternative systems and on-site treatment is affected by the planning of the sanitation company on how to operate and maintain systems that are not within the formal structure. Decentralizing the management of a decentralized system, as defined by Parkinson and Tayler (2003), is not formally conceived by the public

organizations of the Federal District. Table 14 presents a summary of factors encountered that affect decentralized systems.

Table 14 - How planning affects decentralized systems

Implementation

- Lack of incentives from the Federal District to assist implementation of decentralized systems in informal settlements;
- Low-income communities cannot afford the implementation of adequate systems and they rely on external assistance.
- The planning of use and occupation of the land of the Federal District is in conflict with national programs to implement sanitation in informal settlements.

Technology choice

- Technology selection has to be aligned with future plans for that area because they may be removed by the sanitation company and substituted for centralized conventional systems.
- On-site treatment with effluent discharge into a water body is overlooked due to difficulties of achieving and inspecting effluent quality.

Management

- Servicing informal settlements or operating decentralized systems are not included in the sanitation company's management plan.
- Decentralized systems have to be managed by the community itself.
- Decentralized management is not considered by the Federal Government.

5.4.3. Recommendation for improvement

Results from previous sessions suggest that the main fragility into developing decentralized sanitation systems in Brasília relies on institutional aspects. Interviews have showed that there are financial resources and technical capacity to use alternative solutions at community scale in informal settlements. However, the planning for use and occupation of the land and sanitation model adopted in the Federal District do not accommodate creative arrangements. Using CLUE's model (Lüthi, et al., 2011) to adequate the scenario of Brasília into an enabling environment for implementation of decentralized sanitation in informal settlements, three main conditions have to be improved: governmental support; legal and regulatory framework; and institutional arrangements.

Providing access to improved sanitation for all must be a governmental concern. Since Brazil has agreed to deliver UN's Sustainable Development Goals, the Government is bound to work towards accomplishing these goals, including giving access to adequate and equitable sanitation to all by year 2033. Although the National Government has created programs to peruse this target, the Government of the Federal District is not aligned with this mission. Not only should the Federal District be more engaged into achieving universalization of sanitation services, but also the National Government should be more active and persuasive in engaging regional and local governmental entities into doing so. An imposing attitude from the National Government

could reinforce Brasília, as well as other cities to become allies in achieving this goal. In practice, Ministry of Cities and FUNASA should actively engage municipalities, as well as the Federal District, into their programs instead of waiting for them to submit proposals.

Figure 28 - Adapted from CLUES (Lüthi, et al., 2011)

The legal and regulatory framework of the Federal District impairs organizations to provide services for informal settlements. The law is very restrictive in including only formal settlements into the planning of Brasília, thus ignoring the rest of the population. To achieve universalization of sanitation services, the legal framework needs to be amended allowing formal service provision or decentralized alternatives, even though temporary, to informal settlements of the city. This reform can only be done if all stakeholders involved – especially at regional level – agree in making some changes. IBRAM would have to approve sanitary infrastructure to be implemented – if the settlement is not immediately removed, guaranteeing environmental sanitation reduces environmental impact. ADASA would have to reform the tariff system including co-exiting decentralized system. CAESB should provide services to informal settlements and conceive alternative technologies that could be more appropriate for low-income informal settlements – even though solutions might be temporary. SEGETH would need to reduce bureaucracy and speed processes to legalize or relocate informal settlements.

Incorporating decentralized sanitation for informal settlements into the sanitation model of the Federal Districts demands adaptation of institutional arrangements. Engaging all stakeholders into solving the problem is the first step to be taken. The stakeholder analysis carried on chapter 5.1 proposes: immediate involvement of key actors (CAESB, FUNASA, Ministry of Cities, ADASA, CODHAB, SEGETH, SEMA, Secretariat of Cities and Trata Brasil Institute); raising the interest of important actors that have a big influence in the case (IBRAM and SINESP); empowering local stakeholders into taking more action; and keep other stakeholders informed on decisions and changes. Furthermore, to successfully implement on-site sanitation, community participation should be a key factor not just on the planning phase, but also should be included on operation and maintenance of the systems, thus contributing to sustainability of the projects.

To enable sustainable sanitation using the model proposed by CLUES (Lüthi, et al., 2011), skills and capacity, financial arrangements and socio-cultural acceptance are also key factors to be considered. However, to adapt the situation of Brasília to a co-existent decentralized model, these factors are not so critical as the other three previously mentioned. Developing skills and capacity are easily done when there is a present sanitation company with high-skilled professionals such as CAESB. If the institutional arrangement decides for decentralized management of on-site sludge treatment in informal settlements, CAESB's team can train the community to operate systems. Financial matters need to be arranged in each specific case, considering the income of the community that will be aid. National stakeholders can be investors of infrastructure implementation, but it is also important to consider a local revenue system that will contribute to the sustainability of the project. Social-cultural acceptance will also depend on the specific propositions of projects, especially if there is a change in the user interface such as use of UDDT[6]. These recommendations were built under the perspective of the Federal District. However, it is applicable to other cities of Brazil that face the same problem.

5.4.4. Conclusion of Part 4

Although water and electricity services are formally provided to informal settlements, stakeholders agree that the illegal aspect of the land is an impeditive factor to provide sanitation services. Infrastructure implementation requires a high investment, which can be lost if families are removed. Furthermore, there is a general concern that sanitation services will attract more people to live in informal settlements, thus impacting the use and occupation of the land. For these reasons, legalizing the settlement is the first step to be resolved before deciding to implement sanitation services. The only formal technology considered in the Federal District is centralized collection and conventional wastewater treatment. While septic tanks are considered reliable, it is an alternative option used only when conventional methods are not applicable. When septic tanks is also not a viable option, it is recommended relocation of the community. Alternative on-site treatment is usually not considered and the sanitation company has no interest in operating different systems.

Planning aspects have affected the development of decentralized sanitation in Brasília. The technology choice has to be aligned with plans for the settlement to avoid losing investments. When the sanitation company assumes service provision for the settlement, they might deactivate the on-site facility to substitute for their centralized solution. Furthermore, the technology has to guarantee effluent parameters to comply with local standards for discharge into a water body, which may be a discouraging factor to opt of alternative treatment. Implementation of decentralized systems are impacted by the lack of incentives from the government of the Federal District. Although assistance may be offered by the sanitation company, the community has to ask for guidance. However, low-income informal settlements usually cannot afford an appropriate system, thus requiring external assistance. The National Government has programs that could finance local projects. However, these resources are allocated to other governmental entities to aid a community. Thus, in the Federal District, its applicability is impaired by the law of use and occupation of the land and illegal aspect of the land. Managing decentralized systems is also affected by planning. Communities have to

[6] Urine diverting dry toilets.

manage their own systems because the city's planning does not include services for informal settlements or operation of decentralized systems. Furthermore, the government does not consider decentralized management as part of formal framework.

Results have indicated that an enabling environment as proposed by Lüthi, et al. (2011) for development of decentralized sanitation in informal settlements of Brasília rely on three factors that need to be improved: Governmental support, legal framework, and institutional arrangements. While the National Government has developed programs to support municipalities into improving sanitary provision, they should be actively engaged in the implementation. Encouraging local and regional governments to apply for these programs will increase chances of universalizing sanitation services. However, the uptake of these incentives for informal settlements are only possible if the local regulation systems allow aiding communities regardless of legal aspects of the land. The legal framework of the Federal District should be amended allowing informal settlements to be serviced and including decentralized technology as an option for these communities. When implementing decentralized sanitation in informal settlements, it is also recommended reinforcing the institutional framework engaging all relevant stakeholders into adapting to the new scenario. Community members should also be incorporated in this aspect, shifting decision-making processes into a demand-driven approach, thus guaranteeing sustainability of projects. These recommendations are valid to other cities of Brazil that live under the same reality.

5.5. Chapter summary

This chapter has presented analysis and discussions of all data collected in the previous chapter. The discussions answered the research questions and achieved the specific objectives of the research. The summary box below presents the main findings of each part of this research.

- Key stakeholders in sanitation aspects were found to be CAESB, FUNASA, Ministry of Cities, ADASA, CODHAB, SEGETH, SEMA, Secretariat of Cities and Trata Brasil Institute. It is important to raise the interest of stakeholders with high influence, but low interest in the problem – SINESP and IBRAM. Local stakeholders should be empowered to improve sanitation access in their community.
- Although Brasília was well planned, legal aspects of the land were not appropriately concluded when the city was implemented. Deficient legislation and housing policies enabled informal settlements to emerge around the city.
- Strategies developed to decrease the number of informal settlements are to: stimulate peri-urban formal areas to become more attractive; formalize settlements that are possible to be legalized; and relocate families from informal settlements that cannot be legalized to other formal and planned neighborhoods.
- The study case of Vila Cauhy has shown that access to improved sanitation depends on the family's income and level of education. High-income informal settlements are not affected by lack of services, while low-income are.

- Vila Cauhy is partially affected by lack of formal sanitation services provision. Even though they do not have access to services and some areas are in contact with open-air sewerage, they have a high access to flush toilets (improved facilities) and low percentage of families contaminated with faecal-oral diseases.
- The decision-making process of sanitation services in Brasília is developed in a supply driven approach. The main attention is given to the legalization process of the land to implement formal conventional wastewater collection and treatment, which is the only formal technology adopted in the Federal District. If it is not possible to formalize the settlement, they relocate families to a formal and planned neighborhood with adequate infrastructure.
- Planning affects implementation of decentralized sanitation due to lack of incentives from the Federal District; low affordability for low-income informal settlements to implement adequate systems; and use and occupation of the land, which is in conflict with applicability of national programs.
- Technology choice is affected by planning because if it is not aligned with future plans for the settlement, investments may be lost – the sanitation company might deactivate the system to substitute if for conventional collection and treatment. Moreover, legal framework is very restrictive of effluent discharge into water bodies, which might discourage certain technologies to be implemented.
- Management aspects are affected by the city's planning, which does not include services for informal settlements or operation of decentralized systems, thus submitting the management to the community itself. However, the government does not consider decentralized management as part of formal framework.
- Governmental support, legal and regulatory framework and institutional arrangements are key factors that need to be adapted to provide an enabling environment for on-site treatment in informal settlements of Brasília.

CHAPTER 6

Conclusions

Ensuring accessibility to adequate and equitable sanitation for all is a challenging SDG target for the Government of Brazil to achieve, especially in urban areas where informal settlements do not receive public services due to a variety of physical, financial, institutional or structural constraints. If implemented, the National Plan of Basic Sanitation will increase safe sanitation accessibility to 92% across the nation by 2033, which does not meet the SDG target of universal coverage. Decentralized sanitation is an alternative option that the government can potentially support in informal settlements to achieve universalization of sanitation services.

This research aimed to increase understanding of the factors that affect the development, delivery and uptake of decentralized urban sanitation in low-income informal settlements of Brazil, through a study case in Brasília. This objective was achieved through analysis of interviews with representative stakeholders and survey in the community of Vila Cauhy. Results show that the decision-making process to implement sanitation and the government's procedures towards informal settlements influence decentralized systems in low-income informal settlements in Brasília. This chapter describes the conclusions and summarizes the answers to each of the research questions based on the research findings.

6.1. Conclusions to research questions

6.1.1. What factors contributed to the development of informal settlements in a planned city such as Brasília?

Informal settlements have emerged in Brasília since the new capital was constructed. Construction workers settled in camps surrounding the central area of the city, which were supposed to be demolished after the inauguration of Brasília, but were not. Although the city was planned, it could only accommodate high- and middle-income families, while the poor had to settle elsewhere. Most of these informal settlements were legalized and organized by the government and they became satellite-cities of Brasília. Other settlements have never achieved this status and still exist today as informal settlements. Today, 27% of the households in the District are located in informal settlements, regardless of socioeconomic conditions. When considering accessibility to sanitation, the persistence of informal settlements is a concern because it is a structural constraint to the formal provision of sanitation services (Solo, et al., 1993). Legal aspects of the land have not been appropriately concluded since the construction period of Brasília. This factor added to a deficient legislation and housing policies enable informal settlements to continue to emerge until today. There are strategies in place to suppress the growth of informal settlements by stimulating peri-urban formal areas to become more attractive, formalize settlements that are possible to be legalized, or relocate families to other

formal neighborhoods. However, the system is very bureaucratic and processes are very slow, thus leading to a slow improvement of this picture.

6.1.2. To what extent does living in an informal settlement affect accessibility to sanitation in Brasília?

Research results combined with observation methods indicate that decision-making of improved sanitation systems in informal settlements are significantly linked to household income and the head of the household's level of education, in instances of limited government assistance. These findings corresponds with literature (Mulenga, et al., 2004, United Nations, 2015b), as it has been observed that high-income informal settlements in Brasília are not affected by lack of public services, while the low-income informal settlements are. In Vila Cauhy, for example, 29% of families who earned less than 5 times the national minimum wage (MW) but had a head that attended high school had access to improved sanitation. All of those who earned more than 5 times the MW had access to improved sanitation. From an affordability perspective, only 56% of the population could afford to have their tanks to be desludged by vacuum trucks. Although some families (26%) have access to improved sanitation, the majority does not and as result, the whole community is potentially exposed to a range of faecal-oral morbidities. In Vila Cauhy, 15% of the interviewed reported having diseases in the last three months that can be linked to lack of sanitation. In this village, community members have attempted to build a wastewater collection system. Although the pipelines do not connect with all households and raw wastewater is discharged into a nearby stream, the project has reduced the volume of open-air sewerage. This village, like many other under the same conditions, are partially affected by accessibility to sanitation services. This is further compounded by the fact that the community does not have the support of the sanitation agency due to the unplanned and illegal nature of the settlement, even though water and electricity are formally provided.

6.1.3. How is the decision-making process for implementation of sanitation developed and how has planning affected technology choice, implementation and management of decentralized sanitation systems in informal settlements in Brasília?

Although water and electricity services are formally provided to informal settlements, the same priority is not given to sanitation services in Brasília. The illegal aspect of the land, the high and risky investments combined with the fear of attracting more people to informal settlements are impeditive reasons for sanitation service provision. Therefore, the initial step to concede formal sanitation services is to legalize the informal settlement. The decision-making process is developed in a supply-driven approach, where the only formal sanitation service is through centralized conventional systems and community participation is not practiced. On-site treatment is usually not considered and the sanitation company has not showed any interest in operating alternative systems. Although the government recommends implementation of septic tanks in informal settlements, low-income communities cannot afford the implementation of adequate systems and they rely on external assistance. Even in situations where governmental organizations can provide some form of support, there are no incentives for communities to seek guidance or resources and this ultimately affects the uptake of decentralized sanitation. Thus, the implementation of decentralized systems is affected by lack of incentives to assist communities. On-site treatment with effluent discharge into a water body is overlooked due to

difficulties of achieving and inspecting effluent quality, affecting the technology choice for decentralized systems. Planning aspects have also affected the development of decentralized sanitation in Brasília because technology choices must align with plans for the settlement to avoid losing investments. Servicing informal settlements or operating decentralized systems are not included in the sanitation company's management plan. Thus, the management of any decentralized system has to be held by the community itself. Results have indicated that an enabling environment for development of decentralized sanitation in informal settlements of Brasília relies the improvement of governmental support, legal framework, and institutional arrangements.

6.2. Overall Conclusion

The initial hypothesis of this research is confirmed by the outcomes of the specific objectives of the study. While decentralized systems may be the answer to achieve universalization of sanitary services, this option is overlooked by the government as a reliable and sustainable solution. Once formal services cannot be provided to informal settlements, indicating a structural constraint to the implementation of conventional sanitation (Solo, et al., 1993), it opens a gap to deliver decentralized sanitation services. However, the government has shown no interest in providing any type of services due to illegal aspect of settlements, using this to control growth of these communities. The risk of losing investments is another factor that reduces the interest of sanitation agency interest in delivering services in unplanned low-income settlements. The only form of decentralized sanitation recommended by the government is the use of septic tanks, which is considered informal sanitation and is not subsidized by the government. The lack of reliability in other alternative systems affects the development and delivery of new decentralized technologies. Moreover, results from interviews point out that the sanitation company has no interest in operating alternative systems, which affects the choice of which technology may be implemented. The lack of reliability in on-site treatment facilities discourages the development and implementation of decentralized systems.

Research findings have pointed out that low-income informal settlements are affected by lack of sanitation depending on their income and educational level. Although they rely on decentralized systems, they cannot afford the implementation of appropriate technologies and they must rely on external assistance. Even though assistance may be provided by governmental organizations, there are no incentives for communities to seek guidance or resources, which ultimately affects uptake of decentralized sanitation. Moreover, the management of these systems are not included in the formal framework of sanitation companies. The communities have to manage their own systems, which also a contributing factor to the development and uptake of decentralized systems.

It is concluded from research findings that institutional factors are the reason why sanitation is not provided to informal settlements and decentralized systems are overlooked. Decentralized sanitation can be an alternative for informal settlements of Brasília and Brazil if governmental support, legal and regulatory framework and institutional arrangements are adapted, creating an enabling environment as proposed by Lüthi, et al. (2011). It is recommended an active support of the National Government to regional and local Governments to implement sanitation services in informal settlements, regardless of illegal aspects to avoid discrimination. Along with this action, it is recommended adjusting the legal framework of states, municipalities and

the Federal District allowing informal settlements to be serviced and including decentralized technology as a reliable option. Finally, institutional arrangements are recommended to be adapted to incorporate changes and for stakeholders to work collaboratively in this cause.

Giving access to a human right such as sanitation cannot exclude people for living in informal settlements. If local and regional governments work together with the National Government, it is possible to meet the SDG target 6.2 by year 2030.

6.3. Proposed future researches

This research is a starting point for a reflection on how to implement a reform in the sanitation sector of Brazil to accept service delivery to informal settlements and the adoption of decentralized systems as a complementary method to urban sanitation. It is necessary to study further what Brazilian laws could be affected by the change towards the provision of decentralized sanitation services to informal settlements and how these measures could be implemented. It is also necessary to review and propose a new regulation model to each state of Brazil to adopt decentralized sanitation as a formal alternative. A complementary study could undertaken to identify alternative on-site treatment technologies that could have a higher chance to be accepted in Brazil, in accordance to socioeconomic conditions of the communities and governmental planning factors.

When stakeholders where identified for this research, the Secretariat of Environment (SEMA) and the Secretariat of Cities of the Federal District could not be contacted. Thus, it is recommended to include these actors to the study case to identify possible factors that can be relevant to this study. When looking at the perspective of the whole country, new actors may be listed as relevant to this change of scenario.

This research could be reproduced in other states of Brazil and compare results to confirm findings and complement with additional recommendations. These recommendations could be further explored to serve as a practical guide. A following step should be to engage stakeholders into reflecting on these proposals to make an actual change in the Brazilian sanitation scenario.

References

Perfil Institucional [Instituitional Profile] (2016) http://www.adasa.df.gov.br/institucional/perfil. Cited 01/11/2016

Sobre a Agefis [About Agefis] (2017) http://www.agefis.df.gov.br/?q=sobre_agefis. Cited 24/01/2017

Alves PJRdB (2015) Pro-poor economic instruments in the water supply service : a case study of peri-urban areas in Maputo, Mozambique. MSc, UNESCO-IHE

Angelakis AN, Rose JB (2014) Evolution of sanitation and wastewater technologies through the centuries IWA Publishing, London :

Barbosa PEC (2015) Participar é mais - Vila Cauhy [Participate is more - Vila Cauhy]. BSc, University of Brasília [in Portuguese]

Bill & Melinda Gates Foundation (2010) Water, Sanitation and Hygiene Fact SheetGlobal Development Program, United States.

Bryman A (2008) Social research methods, 3rd ed. edn Oxford University Press, Oxford

A CAESB [The CAESB] (2016) https://www.caesb.df.gov.br/empresa/a-caesb.html. Cited 01/11/2016

Veiculos e Operadores Autorizados a Descartar Fossa Séptica e Gordura na CAESB [Vehicles and operators authorized to discharge sludge and grease at CAESB] (2017) https://www.caesb.df.gov.br/lista-de-autorizados-de-descarte.html. Cited 08-02-2017

Estações de Tratamento de Esgoto [Wastewater Treatment Plants] (N.D.) http://atlascaesb.maps.arcgis.com/apps/MapJournal/index.html?appid=9babae05a8a1444180cdf3df83f67fb7. Cited 30-10-2016

Brasília - 55 anos [Brasília - 55 years] (2015) http://agenciabrasil.ebc.com.br/especial/2015-04/brasilia-55-anos. Cited 30-10-2016

CODEPLAN (2013) Evolução dos movimentos migratórios para o Distrito Federal 1959-2010 [Evolution of immigration movements to the Federal District 1959-2010]. In: SEPLAN SdEdPeOdD- (ed) Governo do Distrito Federal, Brasília.

CODEPLAN (2015) Pesquisa distrital por amostra de domicílios do Distrito Federal - PDADDF 2015 [Distrital research by household sampling of Federal District - PDADDF 2015]. In: Secretaria de Planejamento OeG (ed) Governo de Brasília, Brasília.

A Companhia [The Company] (2016a) http://www.codeplan.df.gov.br/a-companhia/a-secretaria.html. Cited 30/10/2016

CODEPLAN (2016b) Estudo urbano e ambiental consolidado do Distrito Federal [Consolidated urban and environmental study of the Federal District]. In: DEURA DdEUeA- (ed) CODEPLAN, Brasília.

A História [The History] (2016a) http://www.codhab.df.gov.br/pagina/3 Cited 02/11/2016

RA8 - NÚCLEO BANDEIRANTE - VILA CAUHY (2016b) http://www.codhab.df.gov.br/pagina/96. Cited 26-10-2016

Cohen B (2006) Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. Technology in Society 28: 63-80 DOI http://dx.doi.org/10.1016/j.techsoc.2005.10.005

Cruz M, Foster J, Quillin B, Schellekens P (2015) Ending Extreme Poverty and Sharing Prosperity: Progress and Policies World Bank Group.

The Online Sourcebook on Decentralization and Local Development (N.D.) http://www.ciesin.org/decentralization/English/General/Different_forms.html. Cited 29-09-2016

Enserink B, Kwakkel J, Bots P, Hermans L, Thissen W, Koppenjan J (2010) Policy analysis of multi-actor systems Lemma Publishers, The Hague

Fragano F, Linares C, Lockwood H, Rivera D, Trevett A, Yepes G (2001) Case studies on descentralization of water supply and sanitation services in Latin AmericaStrategic Paper.

Competências [Competencies] (2017) http://www.funasa.gov.br/site/conheca-a-funasa/competencia/. Cited 24/01/2017

Gautherot M, Frampton K, Burgi S, Titan Jr S (2010) Building Brasilia Thames & Hudson, London ;

GDF, Brasília: A cidade-sonho [Brasília: The dream-city] (N.D.) http://www.brasilia.df.gov.br/index.php/2015/10/21/historia/. Cited 15-09-2016

Henze M, Loosdrecht MCMv, Ekama GA, Brdjanovic D (2008) Biological wastewater treatment: principles, modelling and design IWA publishing

Hophmayer-Tokich S (2006) Wastewater Management Strategy: centralized v. decentralized technologies for small communities

Hox JJ, Boeije HR (2005) Data collection, primary vs. secondary. Encyclopedia of social measurement 1: 593-599

IBGE - Instituto Brasileiro de Geografia e Estatística [Brazilian Institute of Geography and Statistics] (2016) http://www.ibge.gov.br/estadosat/perfil.php?sigla=df. Cited 15-09-2016 2016

Censo 2010 Aglomerado Subnormais [Census 2010 Subnormal Cluster] (2017) http://www.censo2010.ibge.gov.br/agsn/. Cited 27/01/2017

Regimento Interno do Instituto [Internal Regulation of the Institute] (2016) http://www.ibram.df.gov.br/sobre-o-instituto/regimento-interno.html. Cited 01/11/2016

Quem somos [Who we are] (2017) http://www.tratabrasil.org.br/quem-somos. Cited 24/01/2017

Ishtiyaq M, Kumar S (2011) Typology of Informal Settlements and Distribution of Slums in the NCT, Delhi. Journal of Contemporary India Studies: Space and Society 1: 37-46

Isunju JB, Schwartz K, Schouten MA, Johnson WP, van Dijk MP (2011) Socio-economic aspects of improved sanitation in slums: A review. Public Health 125: 368-376 DOI http://dx.doi.org/10.1016/j.puhe.2011.03.008

Janicki Bioenergy (N.D.) http://www.janickibioenergy.com/omni-processor/how-it-works/. Cited 28-09-2016

Kumar R (2011) Research methodology : a step-by-step guide for beginners, third ed. edn Sage, London

Lens P, Lens PN, Zeeman G, Lettinga G (2001) Decentralised sanitation and reuse: concepts, systems and implementation IWA publishing

Libralato G, Volpi Ghirardini A, Avezzù F (2012) To centralise or to decentralise: An overview of the most recent trends in wastewater treatment management. Journal of Environmental Management 94: 61-68 DOI http://dx.doi.org/10.1016/j.jenvman.2011.07.010

Lüthi C, Morel A, Tilley E, Ulrich L (2011) Community-Led Urban Environmental Sanitation Planning: CLUES. Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland

Lüthi C, Panasar A, Schütze T, Norström A, McConville J, Saywell D (2010) Sustainable sanitation in cities: A framework for action

Mara D, Lane J, Scott B, Trouba D (2010) Sanitation and health. PLoS Med 7: e1000363

Massoud MA, Tarhini A, Nasr JA (2009) Decentralized approaches to wastewater treatment and management: Applicability in developing countries. Journal of Environmental Management 90: 652-659 DOI http://dx.doi.org/10.1016/j.jenvman.2008.07.001

Ministério das Cidades (2015) Relatório de avaliação anual do Plano Nacional de Saneamento Básico, Ano 2014. [Annual evaluation report of the Nacional Plan of Basic Sanitation, year 2014]. In: Ambiental SNdS (ed) Ministério das Cidades Brasília, Brazil.

O Ministério [The Ministry] (2017) http://www.cidades.gov.br/institucional/o-ministerio. Cited 24/01/2017

Mulenga M (2003) Barriers to implementation of the demand responsive approach (DRA) methodology in urban sanitation programmes: a study of Zambia and South Africa. University of Southampton

Mulenga M, Manase G, Fawcett B (2004) Building links for improved sanitation in poor urban settlements

Muzvidzwa D (2014) A revised framework for pro-poor water and sanitation benchmarking : case of Epworth, Zimbabwe. MSc, UNESCO-IHE

Östlund U, Kidd L, Wengström Y, Rowa-Dewar N (2011) Combining qualitative and quantitative research within mixed method research designs: A methodological review. International Journal of Nursing Studies 48: 369-383 DOI http://dx.doi.org/10.1016/j.ijnurstu.2010.10.005

Parkinson J, Tayler K (2003) Decentralized wastewater management in peri-urban areas in low-income countries. Environment and Urbanization 15: 75-90

Schertenleib R (2005) From conventional to advanced environmental sanitation. Water Science and Technology 51: 7-14

Schertenleib R, Morel A, Kalbermatten J, Saywell D (2003) Guidelines for the implementation of the Bellagio-Principles and the household centred environmental sanitation approach (HCES)Proceedings of the 2nd International Ecosan Symposium IWA, GTZ, Lübeck, pp. 93-100.

SDG Foundation, From MDGs to SDGs (2016) http://www.sdgfund.org/mdgs-sdgs. Cited 19-09-2016

A Secretaria [The Secretariat] (2016) http://www.cidades.df.gov.br/sobre-a-secretaria/a-coordenadoria.html. Cited 24/01/2017

A Secretaria [The secretariat] (2016) http://www.saude.df.gov.br/sobre-a-secretaria/a-secretaria.html. Cited 03/11/2016

SEGETH (2009) PDOT: Plano diretor de Ordenamento Territorial do Distrito Federal [PDOT: Master Plan of territorial order of the Federal District]. In: SEGETH (ed) SEGETH, Brasília.

Missão, visão e valores [Mission, vision and values] (2016) http://www.segeth.df.gov.br/sobre-a-secretaria/missao-visao-e-valores.html Cited 02/11/2016

A Secretaria [The Secretariat] (2016) http://www.semarh.df.gov.br/sobre-a-secretaria/a-secretaria.html. Cited 03/11/2016

Setti AA (2005) O saneamento no distrito federal : aspectos culturais e socioeconômicos FUBRAS and CAESB, Brasília

A Secretaria [The Secretariat] (2016) http://www.so.df.gov.br/sobre-a-secretaria/a-secretaria.html. Cited 01/11/2016

Solo TM, Joyce S, Perez E (1993) Constraints in providing water and sanitation services to the urban poor Citeseer

Strande L, Ronteltap M, Brdjanovic D (2014) Faecal Sludge Management: Systems Approach for Implementation and Operation IWA Publishing

Taing L, Armitage N, Spiegel A (2011) Cape Town's problematic vacuum sewer: A reflection on the technical, social and institutional blockages that constrain municipal management12th International Conference on Urban Drainage, Porto Alegre/Brazil.

Tayler K, Parkinson J, Colin J (2003) Urban Sanitation - A guide to Strategic Planning Practical Action Publishing

Tilley E, Ulrich L, Lüthi C, Reymond P, Zurbrügg C (2014) Compendium of sanitation systems and technologies, 2nd edn Eawag

UN-Habitat (2015) Habitat III Issue papers - 22 - Informal settlements

Unicef (1999) Towards better programming: A manual on hygiene promotion

UNICEF, WHO (2006a) Core questions on drinking water and sanitation for household surveys

Unicef, WHO (2006b) Meeting the MDG drinking water and sanitation target: the urban and rural challenge of the decade

Unicef, WHO (2014) Progress on sanitation and drinking water: 2014 update World Health Organization

Unicef, WHO (2015) Progress on Sanitation and Drinking-Water: 2015 Update and MDG Assessment. World Health Organization: Geneva, Switzerland

United Nations (2015a) Transforming our World: the 2030 agenda for sustainable development: A/RES/70/1 United Nations New York.

United Nations (2015b) World Urbanization Prospects: The 2014 Revision. Department of Economic and Social Affairs. Population Division, United Nations

United Nations (2016) Sustainable Development Goals - Guidelines for the use of the SDG logo, including the colour wheel, and 17 icons. United Nations.

The Sustainable Development Agenda (N.D.) http://www.un.org/sustainabledevelopment/development-agenda/. Cited 20-03-2017

United Nations Economic and Social Council (2010) Satatement on the Right to Sanitation. 45th edition. E/C.12/2010/1: 2

United Nations Population Fund (2007) UNFPA state of world population 2007: unleashing the potential of urban growth UNFPA New York.

Vasconcelos A (1988) As cidades satélites de Brasília [The satelite-cities of Brasília] Centro Gráfico do Senado Federal

WHO Health topics - Sanitation (2016) http://www.who.int/topics/sanitation/en/. Cited 19/09/2016

WHO, UNICEF (2000) Global water supply and sanitation assessment 2000 report World Health Organization (WHO).

Winblad U, Simpson-Hebert M, Calvert P (2004) Ecological sanitation, revised and enlarged edition Stockholm Environment Institute, Stockholm

Appendices

Appendix A **Interview Protocols**

Appendix A.1. **Interview type 1: Information on Vila Cauhy**

Session 1 – Getting to know the Organization

- For how long has Vila Cauhy existed?
- For how long has the organization been in existence?
- How long have you been in charge of it?
- What is the function and the main activities developed by this organization?
- How is it organized?
- Do you see sanitation as a priority in the village? Why or why not?
-

Session 2 – Brief background of the village

- How have public agencies dealt with this informal settlement? Did they try to demolish the houses or legalize the land?
- What are the difficulties faced to legalize the land?
- Are any public services accessed in the village? (Water, electricity, sanitation)
- How has the government helped in implementing services?
- Has this organization taken any actions regardless of other public authority? What were the impacts and bottlenecks encountered?
-

Session 3 – Service Chain

1.1 What are the elements that compose the sanitation system in Vila Cauhy?

- How does sanitation work in the village (toilets used, collection, transport, treatment)?
- Are households connected to sewerage pipes?

1.2 In case of emptying a septic tank, where is the sludge taken to be treated? Is the payment done by the dwellers or government?

Session 4 – How people are affected

1.3 Do people in the village have access to improved sanitation?

- Are you aware if there are families without toilets that practice open defecation?
- Are there public toilets in the village? Are that people who rely exclusively on it? In this case, who is responsible for maintenance and cleaning? Is the access restricted or charged?

1.4 Are you aware if people in Villa Cauhy suffer from oral-faecal transmitted diseases? (diarrhea, hookworms, cholera, typhoid, polio, cryptosporidiosis, infectious hepatitis or ascariasis)

1.7 How has Vila Cauhy tried to solve its own sanitation problems?

- What kind of actions were taken by this organization to improve sanitation in the village?
- Sewer lines - I heard there where sewer lines built by the association. How does it work?
- Sewer lines - Why was it implemented?
- Sewer lines – What was the decision process to build it.
- Sewer lines - Is it active?
- Sewer lines - Does it work?
- Sewer lines - Where is the wastewater discharged? Is it treated?
- Sewer lines - Were you personally involved in this project?
- Sewer lines - What were the issues faced?
- Sewer lines - Are you satisfied with the project?
- Sewer lines - What can be improved? (See and take pictures)

1.8 Was there external help to construct the sewer pipes in the village?

1.9 Residents from Vila Cauhy constructed sewer lines to collect the wastewater. Has any authority impaired the village to construct the sewer pipes? Where there any disincentive (fines)?

Session 5 – Decision-making process

2.9 What strategies are in place to implement or increase sanitation service provision in the village?

3.9 Are the stakeholders involved today in the sanitation aspects of Vila Cauhy in accordance with solutions to be implemented? Is there a good interaction between them?

- How is the relationship between the municipality and the community association (AMOVIC)? What are the issues that have been faced?

3.10 Do the people in the village have technical capacity to operate the systems in place today?

- Do you think your community is capable of initiating sanitation projects without the influence of external organizations? [1]

3.17 Does the community participate in the decision-making process?

- Does this organization involve the community members in the decisions that are taken?
- Does this organization communicate to the community members about the decisions that are taken?
- How is the interaction between this organization and the community members?
- Does the community usually agrees with the decisions?

- In your past experience, are the community members usually willing to help with ideas, labor, materials or money?
- Are you satisfied with the level of community participation that is allowed by public agencies during the development of projects in your area? What are the problems? [1]

3.18 Are the sanitary facilities today in accordance with social-cultural acceptance?

- Does the community agree with the sanitation solutions provided for them so far?
- Are you satisfied with the level of sanitation services provided in the village? If not, what are the reasons? [1]

End of Interview type 1

[1]: Adapted from Mulenga (2003)

Appendix A.2. **Interview type 2: Sanitation**

Session 1 – Getting to know the Organization

- What are the activities developed by this organizations regarding sanitation?

Session 2 – Services for informal settlements

1.6 Are sanitation services provided in informal settlements of Brasília? Why / Why not?

2.1 What are the issues in providing sanitation services in informal settlements?

2.7 When a technology is considered for a poor community, is the social/ financial conditions of the residents taken into account?

3.14 Are there any special tariff system for the poor communities? Who is considered poor?[2]

3.13 How are services financed in informal settlements? [1]

3.15 Is the sanitation service tariff system considered sustainable?

2.6 How sustainability of the facilities or services provided is ensured? [1]

3.17 Does the community participate in the decision-making process?

Session 3 – Institutional support

2.2 What strategies are in place to increase sanitation services to the informal settlements of Brasília? [1]

3.1 Are there governmental programs that help informal settlements to have access to safe sanitation?

3.2 Is there support from the government for these communities to find sanitation solutions on their own?

3.8 Which are the national or international policies that are followed for the provision of sanitation services in Brasília? Any law is against decentralization of sanitation?

3.6 To apply a decentralized sanitary solution in an informal settlement, are there regulations applied?

Session 4 – Decentralized sanitation

2.3 Is decentralized sanitation considered as a reliable alternative for informal settlements?

2.4 Is decentralized sanitation considered a formal or informal service?

1.10 Is it possible to get external help to construct a decentralized solution in informal settlements? What are the requirements for that to happen?

3.11 Is it possible to obtain external technical assistance for a village to build their own sanitary system? What are the requirements?

3.12 Is there (possible) financial support to build, operate and maintain a decentralized system?

3.16 In case of using septic tanks, is the service payed by authorities or the dwellers? Is there a different pricing for poor communities?

3.4 Will the sanitation company operate and maintain decentralized systems already in place while it is an informal settlement and when it becomes legal?

2.8 Is there any inspection towards decentralized sanitation in informal settlements?

Session 5 – After the legalization of the land

3.3 If a sanitation decentralized solution is technically correct, will it be kept in place once the land becomes legalized? What are the requirements?

3.5 Will there be any sanitation tariffs applied in a decentralized system that already exists once the land becomes legal?

2.5 Once the area is legalized, how is the decision for implementation of sanitation? What technologies are considered?

Session 5 – Closure

1.9 Residents from Vila Cauhy constructed sewer lines to collect the wastewater. Has any authority impaired the village to construct the sewer pipes? Where there any disincentive (fines)?

5.1 What are your suggestions and recommendations to ensure improvement of sanitation services in informal settlements of Brasília? [1]

End of Interview type 2

[1] Adapted from Muzvidzwa (2014)

[2] Adapted from (Alves, 2015)

Appendix A.3. **Interview type 3: Environment**

Session 1 – Getting to know the Organization

- Considering that lack of sanitation or inappropriate sanitary solutions affect the environment, does this organization has any influence on the decision-making processes of sanitation?

Session 2 – How people are affected

1.9 Residents from Vila Cauhy constructed sewer lines to collect the wastewater. Has any authority impaired the village to construct the sewer pipes? Where there any disincentive (fines)?

Session 3 – Sanitation decision-making process

2.2 What strategies are in place to increase sanitation services to the informal settlements of Brasília? [1]

2.8 Is there any inspection towards decentralized sanitation in informal settlements?

3.2 Is there support from the government for these communities to find solutions on their own?

3.7 Are there any environmental protection laws that impair a decentralized system in Vila Cauhy, even though it is technically appropriate?

Session 4 – Recommendations

5.1 What are your suggestions and recommendations to ensure improvement of sanitation services in informal settlements of Brasília? [1]

End of Interview type 3

[1] Adapted from Muzvidzwa (2014)

Appendix A.4. **Interview type 4: Informal Settlements**

Session 1 – Historical background on informal settlements

4.9 In such a planned city as Brasília, why are there so many non-planned informal settlements in place?

4.1 For how long have informal settlements existed in Brasília?

4.2 Where do people in informal settlements mostly come from? (Rural areas or other urban areas)

4.3 Why do people still come to Brasília and live under these conditions? Is it a problem for the national or federal government?

4.4 When people immigrate to an informal settlement of Brasília, what are they looking for?

4.5 What are the strategies in place to prevent informal settlements from emerging?

4.6 Once informal settlements are in place, what are the strategies - legalize the area or demolish houses?

4.7 Is demolishing houses and expelling the people from the informal settlements a successful action? In this case, where do people go? Are there shelters for these people or they insist on informal settlements somewhere else?

4.8 What are future plans to recover the Federal District fully from this situation?

End of Interview type 4

Appendix A.5. **Interview type 5: Health**

Session 1 – Getting to know the Organization

- Considering that lack of sanitation has a big impact on health, does this organization has any influence on the decision-making processes of sanitation?

Session 2 – How people are affected

1.4 Are people in Villa Cauhy suffering from oral-faecal transmitted diseases? (diarrhea, hookworms, cholera, typhoid, polio, cryptosporidiosis, infectious hepatitis or ascariasis)

1.5 What are the most common oral-faecal diseases reported in the Federal District? Do most people with oral-faecal transmitted diseases live in informal settlements?

Session 3 – Sanitation decision-making process

2.2 What strategies are in place to increase sanitation services to the informal settlements of Brasília? [1]

3.1 Are there governmental programs that help informal settlements to have access to safe sanitation?

3.2 Is there support from the government for these communities to find sanitation solutions on their own?

End of Interview type 5

[1] Adapted from Muzvidzwa (2014)

Appendix B **Survey**

UNESCO-IHE
Institute for Water Education

UNESCO-IHE Institute of Water Education
Sanitary Engineering Master Program
Master of Science Thesis USW-SE 2017-11
Viviane Virgolim

Decentralized sanitation in informal settlements
Survey on Vila Cauhy

Sample number: _____

Date: _____ Household: _____ Time at beginning: _____

Good morning/afternoon, my name is Viviane and I am conducting a research for my master thesis on sanitation. I would like to understand a little bit about the sanitation conditions of Vila Cauhy and for that I would like to ask you a few questions about the sanitation of your household. The information you give me will remain confidential and serves only for academic purposes. This questionnaire will only take a few minutes.

Do you agree to participate? ☐ Yes ☐ No

Circle the location of the household on the map:

Figure 1 - Map of Vila Cauhy - Retrieved from Barbosa (2015)

UNESCO-IHE
Institute for Water Education

UNESCO-IHE Institute of Water Education
Sanitary Engineering Master Program
Master of Science Thesis USW-SE 2017-11
Viviane Virgolim

Session 1 - Information on the household/ Interviewed

1- Who is answering the interview?

☐ Man ☐ Woman ☐ Child/Teenager (under 15)

2- Is there more than one family living in this lot? How many?

☐ Yes ☐ No ☐ If yes, how many? _____

3- How many people live permanently in this household, including yourself? How many of them work?

Total of adults: _____ How many work: _____
Total of children: _____ Total of people: _____

4- What is the occupation of the head of the family? [2]

☐ Formally employed ☐ Unemployed ☐ Self-employed ☐ Other_____

5- What is the educational level of the head of the family? (mark also if it is complete or incomplete)

☐ None ☐ Alphabetized ☐ Basic education (up to 9th grade) ☐ Medium school (High school)
☐ Technical superior degree ☐ University superior degree (collage) ☐ Post-graduation degree (MSc, PhD)
☐ I don't know ☐ **Complete** ☐ **Incomplete**

6- What is the total monthly income of the family? (1 Minimum Wage (MW) in Brazil in 2016 is R$880/month)

☐ Less than 1 MW (R$880) ☐ 1 to 2 MW (R$880 to R$1,760) ☐ 2 to 5 MW (R$1,760 to R$4,400)
☐ 5 to 10MW (R$4,400 to R$8,800) ☐ More than 10MW (R$8,800)

7- How long do you live in Villa Cauhy? [3]

☐ Less than 1 year ☐ 1 to 5 years ☐ 5 to 10 years ☐ 10 to 20 years ☐ More than 20 years

8- Do you own or rent this household? [2]

☐ Own ☐ Rent

9- Where did you live before?

☐ In another informal settlement of Brasília ☐ In another (formal) neighborhood of Brasília
From another region of Brazil: ☐ North ☐ Northeast ☐ South ☐ Southeast ☐ Center-west

10- Why did you move to Brasília

☐ Construction of the new capital ☐ Find better job opportunities ☐ Better health care
☐ Better living standards ☐ Education ☐ Water availability
☐ Other _____

11- Did you find here what you were looking for?

☐ Yes ☐ No Why?_____

12- What area did you use to live before? [3]

☐ Urban area ☐ Peri-urban area ☐ Rural area

13- How would you compare the dwelling you used to live before with the one you live now? [3]

☐ It had better conditions/infrastructure ☐ It had worse conditions/infrastructure ☐ It is the same

14- Are you satisfied with the services and infrastructure of your neighborhood (water, sanitation, electricity)? If not, what are the problems?

☐ Yes ☐ No

☐ No Water or bad water quality ☐ No sanitation services/ lack of toilets ☐ No electricity services
☐ Bad telephone/ internet services ☐ No/bad health care ☐ Bad road infrastructure
☐ Bad organization/administration ☐ No space for social interaction ☐ Bad landscape
Other: _____

15- In your opinion, what investments should be prioritized in the village? (give a number)

___ Water services ___ Sanitation services/facilities ___ Electricity provision
___ Telephone/ internet services ___ Health center ___ Road infrastructure
___ Waste collection

16- Has any member of your family suffered from any of the following diseases in the past 3 months? [3]

☐ Yes ☐ No

☐ Diarrhea ☐ Hookworms ☐ Typhoid ☐ Cholera ☐ Polio
☐ Cryptosporidiosis ☐ Ascariasis ☐ Infectious hepatitis

17- If your answer to the previous question was yes, what do you think caused this disease?

_____

18- When you get sick, to which central care do you go to?

_____
_____

Additional observations:

_____
_____
_____
_____

Session 2 - Information on water and electricity services

19- Do you have water connection at home?

☐ Yes ☐ No

20- How do you get water to drink/ cook/ shower? [2]

☐ Piped water (household connection) ☐ Fetch water from river/stream ☐ Community stand pipe
☐ Buy from independent supplier ☐ Tank truck ☐ Rainwater
☐ Borehole/ unprotected well ☐ Protected dug well ☐ Other _____

21- In case of NO water connection at home - What is the distance to your water source? [2]

☐ 500m ☐ Less than 500m ☐ More than 500m ☐ Not applicable

22- In case of NO water connection at home - How much time do you spend to fetch water? [2]

☐ 10min ☐ 15 min ☐ 30 to 60min ☐ More than 60min ☐ Not applicable

23- Who provides your water? [2]

☐ CAESB ☐ NGO ☐ Government ☐ Local Authority ☐ Self-initiated
☐ Other _____

24- Do you pay for water services? How much per month? If you do pay, do you consider it affordable?

☐ Yes ☐ No ☐ I don't know
Estimative: R$_____/month ☐ I don't know how much ☐ Affordable ☐ Not affordable

25- Are you consulted before water infrastructure/facilities are constructed in your area? How? By Whom? [2]

☐ Yes How?_____
By whom?_____
☐ No

26- Did you participate/contribute in the project of implementation of water facilities for the village? How? [2]

☐ Yes How?_____ ☐ No

27- Do you have electricity connection at home?

☐ Yes ☐ No

28- How do you get electricity?

☐ Provided by CEB (household connection) ☐ Connection to a post ☐ Other _____

29- Do you pay for electricity services? How much per month? If you do pay, do you consider it affordable?

☐ Yes ☐ No ☐ I don't know
Estimative: R$_____/month ☐ I don't know how much ☐ Affordable ☐ Not affordable

Additional observations:

_____

_____

Session 3 - Sanitation facility

30- Do you have a toilet facility inside your household? If not, why not? [2] [3]

☐ Yes ☐ No. Why not? _____

31- If yes, is the toilet: [3]

☐ Separate from the house ☐ Attached to house but entered from outside ☐ Inside the house and entered from inside

32- What kind of toilet is it? [1]

☐ Flush toilet ☐ Pour flush toilet ☐ Buckets
☐ VIP latrine ☐ Pit Latrine with slab ☐ Pit Latrine without slab/Open pit
☐ Open air/ bush ☐ Composting toilet ☐ Other_____

33- In case of flush/pour flush – Where is it flushed to? [1]

☐ Piped sewer system ☐ Septic tank ☐ Pit latrine
☐ Unsealed underground tank ☐ Directly into the streets ☐ I don't know
☐ Elsewhere _____ ☐ Not applicable

34- In case of septic tanks or pit latrines – How is it emptied?

☐ Vacuum trucks ☐ Manually ☐ Other_____ ☐ Not applicable

35- In case of septic tanks or pit latrines – Who is responsible for emptying it (who pays for it)?

☐ Government ☐ Municipality ☐ Community association (AMOVIC)
☐ CAESB ☐ Household owner ☐ Not applicable
☐ Other _____

36- Do you pay for sanitation services? How much? If you do pay, do you consider it affordable?

☐ Yes ☐ No ☐ I don't know
Estimative: R$_____/month ☐ I don't know how much ☐ Affordable ☐ Not affordable

37- Do you share this facility with other households? [1]

☐ Yes ☐ No

How many other households share this toilet?_____

Can any member of the public use this toilet? ☐ Yes ☐ No ☐ I don't know

38- In case of a shared facility – Who provided this facility? [2]

☐ Government ☐ Municipality ☐ Community association (AMOVIC)
☐ CAESB ☐ NGO ☐ Community members
☐ Other _____ ☐ Not applicable

39- In case of a shared facility – How far is it from your household? [2]

☐ 500m ☐ Less than 500m ☐ More than 500m ☐ Not applicable

40- In case of a shared facility – Are the toilets designed for people with disabilities? [2]

☐ Yes ☐ No ☐ Not applicable

41- In case of a shared facility – Are women and children able to use this toilet at night? [2]

☐ Yes ☐ No ☐ Not applicable

42- In case of a shared facility – Who cleans the toilets? [2]

☐ Municipality ☐ Cleaning Company ☐ Users ☐ Other _____ ☐ Not applicable

43- In case of a shared facility – How often are the toilets cleaned? [2]

☐ Daily ☐ Weekly ☐ Every 2 weeks ☐ Monthly ☐ Other _____
☐ Not applicable

44- Are you satisfied with the condition of your communal /household toilet? If not, why not? [3]

☐ Yes ☐ No
☐ Lack of privacy ☐ Smell ☐ Safety ☐ Appropriateness for women/Children
☐ Durability of materials ☐ Location ☐ Cleanness ☐ Other _____

45- Did you participate on the decision of the type of toilet you use? If not, who made this decision and why did you accept it? [3]

☐ Yes ☐ No Who made the decision? _____
Why did you accept it? _____

46- What can be done to improve service delivery for sanitation in your area?

47- Has the government helped to improve sanitation in Vila Cauhy? How?

☐ Yes How? _____ ☐ No

48- Has the community tried to solve sanitation problems?

☐ Yes How? _____ ☐ No

49- Have you ever contributed to the sanitation issues of your neighborhood? How? If not, why not?

☐ Yes How? _____
☐ No Why not? _____

50- Would you be willing to help your community in improving sanitation services in your neighborhood?

☐ Yes ☐ No

51- Are you willing to pay (with labor, cash or construction materials) for having access adequate and improved sanitation and live in a clean neighborhood?

☐ Yes, with labor ☐ Yes, with cash (R$_____) ☐ Yes, with construction materials ☐ No
If no, why not? _____

Additional observations:

_____
_____

End of Interview

Time at the end: _____

Session 4 - Observation on the household

52- Type of house from observation.

☐ Bricks with lining ☐ Bricks with no lining ☐ Wood ☐ steel sheet ☐ Tilt ☐ Mud
☐ Other _____

53- What kind of possessions can be observed from the outside?

☐ Electronic gates ☐ Electrical fence ☐ Satellite cable ☐ Car
☐ Other _____

54- Do you see wastewater on the surroundings of the household?

☐ Yes ☐ No

Additional observations:

_____
_____
_____
_____
_____

Questions adapted from:

[1] UNICEF and WHO (2006)
[2] Muzvidzwa (2014)
[3] Mulenga (2003)

Appendix C **Survey Results**

Session 1 - Information on the household/ Interviewed		
Questions	Total	Percentages
1- Who is answering the interview?		
Man	26	49%
Woman	27	51%
Total of households interviewed	53	100%
2- Is there more than one family living in this lot? How many?		
Yes	14	26%
No	39	74%
How Many?	0	-
3- How many people live permanently in this household, including yourself? How many of them work?		
Adults	149	60%
Children	100	40%
How many work[7]	86	58%
Total of people	249	-
4- What is the occupation of the head of the family? [2]		
Formally employed	26	49%
Unemployed	6	11%
Self-employed	19	36%
Retired	2	4%
5- What is the educational level of the head of the family?		
None	1	2%
Alphabetized	2	4%
Basic education (up to 9th grade) incomplete	18	34%
Basic education (up to 9th grade) complete	7	13%

[7] In 4 cases it was not registered how many adults worked. However, the other registered data show that someone in the household does work (formal or informal job) and there is a registered regular income. Therefore, the criteria was to mark 1 person in the family as a worker.

Medium school (High school) incomplete	10	19%
Medium school (High school) complete	11	21%
Technical superior degree incomplete	0	0%
Technical superior degree complete	0	0%
University superior degree (collage) incomplete	0	0%
University superior degree (collage) complete	2	4%
Post-graduation degree (Specialization, MSc, PhD) incomplete	0	0%
Post-graduation degree (MSc, PhD) complete	2	4%
I don't know	0	0%
6- What is the total monthly income of the family?		
Less than 1 MW (R$937)	12	23%
1 to 2 MW (R$937 to R$1,874)	23	43%
2 to 5 MW (R$1,874 to R$4,685)	13	25%
5 to 10MW (R$4,685 to R$9,370)	1	2%
More than 10MW (R$9,870)	2	4%
I don't know	2	4%
7- How long do you live in Villa Cauhy? [3]		
Less than 1 year	4	8%
1 to 5 years	11	21%
5 to 10 years	10	19%
10 to 20 years	13	25%
More than 20 years	15	28%
8- Do you own or rent this household? [2]		
Own	41	77%
Rent	12	23%
9- Where did you live before?		
Lived in Vila Cauhy the whole life	1	2%
In another informal settlement of Brasília	2	4%
In another (formal) neighborhood of Brasília	22	42%
North	5	9%

Northeast	14	26%
South	0	0%
Southeast	3	6%
Center-west	6	11%
Lived somewhere in Brasília	25	47%
Lived somewhere out of Brasília	28	53%
10- Why did you move to Brasília		
Construction of the new capital	0	0%
Find better job opportunities	18	64%
Better health care	2	7%
Better living standards	12	43%
Education	3	11%
Water availability	1	4%
Family	2	7%
Religion	1	4%
Not applicable	25	-
11- Did you find here what you were looking for?		
Yes	21	75%
No	7	25%
No job opportunities	6	86%
Short time living in Brasilia	1	14%
Not applicable	25	-
12- What area did you use to live before? [3]		
Urban area	37	70%
Peri-urban area	7	13%
Rural area	8	15%
Not applicable	1	2%
13- How would you compare the dwelling you used to live before with the one you live now? [3]		
It had better conditions/infrastructure	32	60%
It had worse conditions/infrastructure	12	23%

It is the same	8	15%
Not applicable	1	2%
had better conditions but now they own their house	26	81%
14- Are you satisfied with the services and infrastructure of your neighborhood (water, sanitation, and electricity)? If not, what are the problems?		
Yes	3	6%
No	50	94%
No sanitation services/ lack of toilets	43	86%
Bad road infrastructure	20	40%
No space for social interaction	12	24%
No/bad health care	9	18%
No Water or bad water quality	8	16%
Bad telephone/ internet services	6	12%
No electricity services	4	8%
Bad landscape	4	8%
Bad organization/administration	3	6%
Solid waste collection	1	2%
15- In your opinion, what investments should be prioritized in the village? (give a number)[8][9]		
Sanitation services/facilities	44	83%
Road infrastructure	34	64%
Waste collection	26	49%
Health center	17	32%
Water services	16	30%
Electricity provision	14	26%
Legalization of the neighborhood[6]	10	19%
Telephone/ internet services	6	11%
Post office services[6]	1	2%

[8] This answer was not originally given on the survey.
[9] When priorities were not numbered, the criteria was to put all items picked by the respondent as number 1 priority. When only a priority 1 was addressed and all the other items picked are the same, the criteria was to put them as priority 2.

space for social interaction[6]	1	2%
Security[6]	1	2%
16- Has any member of your family suffered from any of the following diseases in the past 3 months? [3]		
Yes	10	19%
No	43	81%
Diarrhea	6	60%
Dengue/Zika/Chikungunya	5	50%
Hookworms	1	10%
Fever	1	10%
Malaria	0	0%
Cholera	0	0%
Leptospirosis	0	0%
Hepatitis	0	0%
Polio	0	0%
Yellow fever	0	0%
Typhoid	0	0%
17- If your answer to the previous question was yes, what do you think caused this disease?		
No	43	81%
I don't know	3	30%
Still water next to the house	2	20%
It is normal for children to have diarrhea	2	20%
Warm weather	1	10%
Walk with bare feet	1	10%
The water from the well	1	10%

Session 2 - Information on water and electricity services		
Questions	Total	Percentages
18- Do you have water connection at home?		
Yes	49	92%

No	4	8%
19- How do you get water to drink/ cook/ shower? [2]		
Piped water (household connection - CAESB)	34	64%
Community well	9	17%
Piped water (CAESB) AND Community well	4	8%
Private Borehole/ unprotected well	3	6%
Water from the neighbour	2	4%
Water from river/stream	1	2%
Community stand pipe	0	0%
Buy from independent supplier	0	0%
Tank truck	0	0%
Rainwater	0	0%
Piped water (from the river)	0	0%
20- In case of NO water connection at home - What is the distance to your water source? [2]		
500m	0	0%
Less than 500m	4	8%
More than 500m	0	0%
Not applicable	49	92%
21- In case of NO water connection at home - How much time do you spend to fetch water? [2]		
Less than 10 min	4	8%
10 min	0	0%
15 min	0	0%
30 to 60 min	0	0%
More than 60min	0	0%
Not applicable	49	92%
22- Who provides your water? [2]		
CAESB	38	72%
Local authority	10	19%
Self-initiated	7	13%
NGO	0	0%

Government	0	0%
I don't know	1	2%
23- Do you pay for water services? How much per month? If you do pay, do you consider it affordable?		
Yes	38	72%
No	14	26%
I don't know	1	2%
How much (R$/month)	129	-
yes, but I don't know how much	2	5%
Affordable	19	50%
Not affordable	14	37%
Did not say if it is affordable or not	5	13%
24- Are you consulted before water infrastructure/facilities are constructed in your area? How? By Whom? [2]		
Yes	11	21%
No	40	75%
I don't know	2	4%
Meetings	3	27%
CAESB	4	36%
Communication	4	36%
Local administration/ Municipality	2	18%
Did not say how they were consulted	2	18%
25- Did you participate/contribute in the project of implementation of water facilities for the village? How? [2]		
Yes	10	19%
No	43	81%
With materials (pipes of the village)	1	10%
With labor	3	30%
With money	3	30%
With the Community association	1	10%
26- Do you have electricity connection at home?		
Yes	53	100%
No	0	0%

27- How do you get electricity?		
Provided by CEB (household connection)	41	77%
(Illegal) Connection to a post	11	21%
I don't know	1	2%
Other	0	0%
28- Do you pay for electricity services? How much per month? If you do pay, do you consider it affordable?		
Yes	40	75%
No	12	23%
I don't know	1	2%
How much (R$/month)	147	-
yes, but I don't know how much	3	8%
Affordable	14	35%
Not affordable	21	53%
Did not say if it is affordable or not	5	13%

Session 3 - Sanitation facility		
Questions	Total	Percentages
29- Do you have a toilet facility inside your household? If not, why not? [2] [3]		
Yes	52	98%
No	1	2%
30- If yes, is the toilet: [3]		
Inside the house and entered from inside	51	96%
Attached to house but entered from outside	1	2%
Not applicable	1	2%
Separate from the house	0	0%
31- What kind of toilet is it? [1]		
Flush toilet	52	98%
Pour flush toilet	0	0%
Buckets	0	0%
VIP latrine	0	0%

Pit Latrine with slab	0	0%
Pit Latrine without slab/Open pit	0	0%
Open air/ bush	1	2%
Composting toilet	0	0%
32- In case of flush/pour flush – Where is it flushed to? [1]		
Septic tank	15	28%
Pipelines of the Village - To the stream	15	28%
Unsealed underground tank	12	23%
I don't know	9	17%
Directly into the streets	1	2%
Directly to the stream	1	2%
Piped sewer system (CAESB)	0	0%
Pit latrine	0	0%
Elsewhere	0	0%
Not applicable	0	0%
33- In case of septic tanks or pit latrines – How is it emptied?		
Vacuum trucks	15	56%
Manually	1	4%
Not applicable	26	49%
Does not clean it (overflows)	2	7%
Overflows to the pipes of the village (to the stream)	4	15%
I don't know	5	19%
Other	0	0%
34- In case of septic tanks or pit latrines – Who is responsible for emptying it (who pays for it)?		
Not applicable	26	49%
Household owner	20	74%
I don't know	7	26%
Government	0	0%
Municipality	0	0%
Community association (AMOVIC)	0	0%

CAESB	0	0%
35- Do you pay for sanitation services? How much? If you do pay, do you consider it affordable?		
Yes	13	25%
No	40	75%
I don't know	0	0%
How much (R$/time)	109	-
How many times per year	2	-
yes, but I don't know how much	2	15%
Affordable	8	62%
Not affordable	2	15%
Did not say if it is affordable or not	3	23%
36- Do you share this facility with other households? [1]		
Yes	3	6%
No	50	94%
How many other households share this toilet	1	-
Can any member of the public use this toilet?		
Yes	0	0%
No	2	4%
I don't know	1	2%
37- In case of a shared facility – Who provided this facility? [2]		
Government	0	0%
Municipality	0	0%
Community association (AMOVIC)	0	0%
CAESB	0	0%
NGO	0	0%
Community members	1	2%
Household owner	1	2%
Not applicable	51	96%
38- In case of a shared facility – How far is it from your household? [2]		
500m	0	0%

Less than 500m	2	4%
More than 500m	0	0%
Not applicable	51	96%
39- In case of a shared facility – Are the toilets designed for people with disabilities? [2]		
Yes	0	0%
No	2	4%
Not applicable	51	96%
40- In case of a shared facility – Are women and children able to use this toilet at night? [2]		
Yes	2	4%
No	0	0%
Not applicable	51	96%
41- In case of a shared facility – Who cleans the toilets? [2]		
Municipality	0	0%
Cleaning Company	0	0%
Users	2	4%
Not applicable	51	96%
42- In case of a shared facility – How often are the toilets cleaned? [2]		
Daily	2	4%
Weekly	0	0%
Every 2 weeks	0	0%
Monthly	0	0%
Never	0	0%
Not applicable	51	96%
43- Are you satisfied with the condition of your communal /household toilet? If not, why not? [3]		
Yes	42	79%
No	11	21%
Smell	3	27%
Appropriateness for women/Children	3	27%
Durability of materials	2	18%
Toilet clogs	2	18%

Lack of privacy	1	9%
Safety	1	9%
No sink inside the bathroom	1	9%
Location	0	0%
Cleanness	0	0%
44- Did you participate on the decision of the type of toilet you use? If not, who made this decision and why did you accept it? [3]		
Yes	40	75%
No	13	25%
Decision by the owner	10	77%
No conditions	1	8%
45- What can be done to improve service delivery for sanitation in your area?		
Improve collection	25	47%
Include wastewater treatment	13	25%
Have services formally provided by CAESB/government	30	57%
I don't know	1	2%
46- Has the government helped to improve sanitation in Vila Cauhy? How?		
Yes	2	4%
No	51	96%
Giving construction material to the pipes of the village	1	-
47- Has the community tried to solve sanitation problems?		
Yes	40	75%
No	9	17%
I don't know	4	8%
Yes, Implementing pipes in the village (to the stream)	24	60%
Yes, but did not solve the issue	10	25%
yes, Trying to legalize the village	1	3%
yes, Unclogging/fixing the sewerage	2	5%
yes, Covering the open sewer	1	3%
No, they tried but did not solve the problem.	1	11%
48- Have you ever contributed to the sanitation issues of your neighborhood? How? If not, why not?		

Yes	22	42%
Implementing pipes in the village (to the stream)	14	64%
Going to the meetings and helps with suggestions	1	5%
Giving money	7	32%
Attracting investments	2	9%
Unclogging the sewerage	1	5%
Cleaning the streets	1	5%
No	31	58%
No specific reason	3	10%
There was no need for me to help	1	3%
Because No one asked me to/ they did not involve me	10	32%
Because I didn't live at the village at that time	5	16%
Not available	2	6%
I cannot give any money	1	3%
I was too young back then	1	3%
49- Would you be willing to help your community in improving sanitation services in your neighborhood?		
Yes	52	98%
No	0	0%
Maybe	1	2%
50- Are you willing to pay (with labor, cash or construction materials) for having access adequate and improved sanitation and live in a clean neighborhood?		
Yes, with labor	34	64%
Yes, with cash (amount)	23	43%
Yes, with construction materials	15	28%
Yes, other	1	2%
No	2	4%
Government should do it	1	2%

Session 4 - Observation on the household		
Questions	Total	Percentages

51- Type of house from observation.		
Bricks with lining	34	64%
Bricks with no lining	12	23%
Wood	5	9%
steel sheet	2	4%
Tilt	0	0%
Mud	0	0%
Other	0	0%
No answer	1	2%
52- What kind of possessions can be observed from the outside?		
Electronic gates	2	4%
Electrical fence	1	2%
Satellite cable	13	25%
Car	12	23%
Washing machine	1	2%
House with nice glasses	1	2%
None of the above	29	55%
TV	1	2%
Inside floor covered with fancy material	1	2%
No answer	1	2%
53- Do you see wastewater on the surroundings of the household?		
Yes	25	47%
No	26	49%
No answer	1	2%

Combined results

Questions	Total	Percentages
Combined results – sanitary infrastructure, collection and treatment		
Households with non-shared flush toilet, septic tank emptied with vacuum truck	14	26%
Households with non-shared flush toilet, unsealed trench emptied with vacuum truck	3	6%

Open defecation/ Plastic bags	1	2%
Shared Flushed toilet	3	6%
Non-shared Flushed toilet with wastewater going elsewhere	24	45%
Householder does not know how the wastewater is collected	8	15%
Households with improved sanitation compared with income and educational level		
Total More than 5MW/month	3	6%
total Less than 5MW, medium school complete or incomplete	21	40%
total Less than 5MW, basic education complete or incomplete	23	43%
Households with improved sanitation (non-shared flush toilet, septic tank emptied with vacuum truck)	14	26%
Improved sanitation More than 5MW/month	3	100%
Improved sanitation Less than 5MW, medium school complete or incomplete	6	29%
Improved sanitation Less than 5MW, basic education complete or incomplete	4	17%