Evaluation of low-cost technology options for sustainable water supply and sanitation in two peri-urban areas of Lusaka, Zambia: Opportunities and constraints

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ABSTRACT

Presently, at least 70% of the total urban population in Zambia resides in peri-urban areas. Peri-urban settlements are characterized by high population growth, high poverty levels and inadequate access to water and sanitation which often result in increased prevalence of diseases. The situation is even made worse because of the position that many local authorities have taken regarding the implementation of infrastructure and service development in these settlements. Local authorities in developing countries have continuously focused on implementation of traditional and unsustainable technologies for service provision to meet the demand despite the technologies' inability to serve the rapidly growing peri-urban areas. These technologies have high costs, lack proper operation and maintenance, and are not affordable to majority of peri-urban residents. Therefore, this study was set out to identify and evaluate the existing and possible low-cost technology options for sustainable water supply and sanitation in two selected peri-urban areas of Lusaka, Zambia, namely Kanyama and Chazanga. This was achieved through a household survey conducted in the selected communities. Questionnaires and focus group discussions were held in the respective areas to obtain baseline data on the current water supply and sanitation situation, the type of technologies used, challenges faced regarding water and sanitation technologies, and to get the communities perceptions and preferences of different technology options. Thereafter, a Multi-Criterion Analysis methodological approach was used to assess the selected technologies by the communities, taking into consideration of the economic, socio-cultural, technical, institutional and environmental aspects.

Results from the study revealed that a few low-cost water supply and sanitation technologies are feasible for peri-urban areas. For Chazanga, communal taps, boreholes, protected wells, and rain water harvesting were found to be feasible for water supply. For sanitation, on-site sanitation services such as compost toilets, dry toilets, as well as Ventilated Improved Pits (VIP) and Pour-flush, Fossa Alterna and the Urine Diversion Dry Toilet (UDDT) are some of the low-cost technologies that can be implemented in the area. The VIP is suitable for households that rely on water from communal taps for their use. As majority of households in the area have taps on their plots, the Pour-flush can be an alternative. The Fossa Alterna and the Urine Diversion Dry Toilet (UDDT) have low initial cost and can accommodate different households.

Additionally, the area has a lower household size and majority of the residents in the area landlords, which makes it easy to teach users how the toilet operates as well as its maintenance. For Kanyama, feasible and sustainable low-cost water supply facilities include boreholes and communal taps. Kanyama has limited plot sizes thereby causing the challenge of implementing infrastructure such as rainwater harvesting. Additionally, continuous increase in urban population in the area, coupled with the construction of unregulated households and sanitation facilities, renders protected wells not feasible to implement in Kanyama. In terms of sanitation, wet on-site sanitation facilities such as Ventilated Improved Pit (VIP) latrines are accepted by the community. The VIP does not require water for use and if properly constructed can be used as a bathroom. The Pour-flush toilet is also another alternative for provision of sanitation in the area. However, the latrine can be expensive to construct for majority of the residents. Dry sanitation such as the Urine Diversion Dry Toilet (UDDT) is not feasible for Kanyama. The UDDT requires continuous awareness on its use especially in rented households where tenants are constantly changing.

The method of evaluating appropriate technology options for peri-urban areas and thereafter letting the users from the communities choose from the proposed technologies ensures a participatory approach. Results from Multi-Criterion Analysis (MCA) showed that stakeholders' influence is essential for the selection of sustainable technology options. However, it is important that the implementation process of any technology in peri-urban areas consider different aspects including the local environmental, socio-cultural, economic, technical, and institutional conditions. Finally, the outcome of this study will not only provide baseline data for successful implementation of appropriate low-cost water supply and sanitation technology options in Chazanga and Kanyama, but also other peri-urban communities in Zambia.

DEDICATION

I dedicate this thesis to my family for their continuous support and encouragement throughout my studies at Rhodes University.

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LIST OF ACRONYMS

ARI	Acute Respiratory Infection
AWD	Acute Watery Diarrhoea
CBD	Central Business District
CSO	Central Statistics Office
CU	Commercial Utility
DTF	Devolution Trust Fund
FGD	Focus Group Discussion
FSM	Faecal Sludge Management
LCC	Lusaka City Council
LWSC	Lusaka Water and Sewerage Company
MCA	Multi-Criterion Analysis
MDG	Millennium Development Goal
MoH	Ministry of Health
MLGH	Ministry of Local Government and Housing
NGO	Non-Governmental Organisation
NWASCO	National Water Supply and Sanitation Council
PF	Pour-flush
PUA	Peri-urban Area
PVC	Polyvinyl Chloride
SuSanA	Sustainable Sanitation Alliance
UBSUP	Upscaling Basic Sanitation for the Urban Poor
UDDT	Urine Diversion Dry Toilet

UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
VIP	Ventilated Improved Pit
VWZ	Village Water Zambia
WASAZA	Water and Sanitation Association of Zambia
WDC	Ward Development Committee
WHO	World Health Organisation
WSUP	Water and Sanitation for the Urban Poor
WSTF	Water Services Trust Fund
WT	Water Trust
ZMW	Zambian Kwacha

CHAPTER ONE: LITERATURE REVIEW

1.1. Background

Access to improved water and sanitation are important components to people's well-being (Bain *et al*., 2014; Ballint, 1999; Norström, 2007; von Münch and Mayumbelo, 2007; Whitford *et al*., 2010). For example, globally, 2-5 million deaths are associated with inadequate water and sanitation (Gleick, 2002). It has been reported that improved access to water and sanitation have shown to reduce diseases associated with lack of water and sanitation (Butala *et al*., 2010). Yet, globally, over 700 million people have no access to improved water sources and 2.5 billion people lack access to improved sanitation facilities (Alagidede & Alagidede, 2016; Santiago *et al*., 2015). Awuah *et al*. (2009) define 'improved' sanitation as facilities that hygienically separate human excreta from human contact. Improved water sources, when constructed, are protected from outside contamination, in particular, that of faecal matter (Hubbard *et al*., 2011) (Table 1.1). In addition to the 2.5 billion people lacking access to sanitation, over 850 million people in urban areas do not only lack access to improved sanitation, but also access to adequate sanitation. 'Adequate' sanitation is defined as access to sanitation facilities that not only eliminate contact with human excreta, but is also convenient for all household members and are affordable (Mara, 2012).

Table 1.1: Overview of improved and unimproved drinking water sources and sanitation facilities (after: WHO/UNICEF 2012)

	Drinking water	**Sanitation**
Improved	• Piped water into dwelling, yard or plot • Tube well or borehole • Protected spring • Protected dug well • Rainwater collection	• Flush or pour flush toilet to: ✓ Piped sewer system ✓ Septic tank ✓ Pit latrine • Ventilated improved pit (VIP) latrine • Pit latrine with slab • Composting toilet
Unimproved	• Unprotected dug well • Unprotected spring • Cart with small tank or drum • Tanker truck • Surface water (river, dam, lake, pond, stream, canal, irrigation channel	• Flush or Pour-flush toilet to elsewhere. i.e. not to piped sewer system, septic tank or pit latrine) • Pit latrine without slab, or open pit • Bucket • Shared or public facilities of any type • Open defecation

One of the factors contributing to the lack of access to improved water and adequate sanitation facilities is the rate at which urban populations are increasing, especially in developing countries (Khatri, 2009). It is reported that currently more than 50% of the world's population reside in urban areas and this population is projected to rise even more in the future (Grimm *et al.*, 2008). Urbanisation is a challenge for the local authority to provide services to keep up with the ever-increasing urban population growth (Mwanza, 2001). As a result of this development, comes along an unprecedented growth and expansion of unplanned settlements, often referred to as peri-urban area, for shelter (Alabaster, 2016; Niemczynowicz, 1999). An estimated 62% of the urban population in developing countries is currently living in these areas (Schouten & Mathenge, 2010). Peri-urban areas have high population growth without accompanying improvements in infrastructure service provision. One might, therefore, expect more demand for service provision within these settlements. The situation is worsened as majority of households and individuals in these areas are financially constrained (Evans, 2007; UN-Habitat, 2007). Further, lack of water and sanitation services have been influenced by the position that many governments have taken against infrastructure and service development in peri-urban areas (Mwanza, 2001).

Governments in developing countries have continuously focused on implementation of centralised technologies for service provision to meet the demand despite the technologies inability to serve the rapidly growing unplanned peri-urban areas (Bouabid & Louis, 2015; Montgomery & Elimelech, 2007; Putri & Wardiha, 2013). However, most of these technologies are 'inappropriate' in that they have high costs, lack proper operation and maintenance, not affordable, as well as not meeting the socio-cultural expectations of the intended people (Mwanza, 2001). Given these challenges, there is need to explore a variety of innovative approaches such as low-cost technologies, especially in peri-urban areas where majority of the peri-urban population lacks access to service provision such as adequate water and sanitation (Werner *et al.*, 2009).

1.2. Consequences of inadequacies in water supply and sanitation infrastructure

Rapid growth of peri-urban areas and lack of adequate water and sanitation have been identified as contributors to the increased risk of waterborne diseases (Butala *et al.*, 2010; Moore *et al.*, 2003). Overcrowding in peri-urban areas increases the use of unimproved facilities such as pit latrines and shallow wells (Graham & Polizzotto, 2013).

Peri-urban areas, are characterised by overcrowding, high poverty levels, inadequate access to water supply and sanitation, among others (Kulabako *et al*., 2010; Prüss *et al*., 2002; Tumwebaze *et al*., 2012; World Bank, 2002). The close proximity of people in peri-urban areas causes limited space (Moore *et al*., 2003). Houses in these areas are closely built that a systematic layout of water supply and sanitation infrastructure is simply impossible (Bruggen *et al*., 2010; Perez *et al*., 1993). The average plot size in peri-urban areas decreases because of continuous construction of houses within one plot, which increases the potential for spread of diseases (Isunju *et al*., 2011). Diseases transmitted through faecal-oral routes are more frequent in situations involving overcrowding due to high population (Moore *et al*., 2003). Due to limited space, sanitation facilities such as pit latrines and water sources (i.e. water wells) are often located close to one another; and the water sources get contaminated with faecal matter as a result (Bruggen *et al.*, 2010). Faecally contaminated water sources can cause outbkreak of water-borne diseases (Carter *et al*., 1999; Keswick & Gerba, 1980). Figure 1.1 graphically represents multiple means of transmission of pathogens found in faeces to humans. The arrows show the different routes of pathogen transmission, whereas the crossing bars represent practices that can be used to prevent the spread of pathogens. The absence of these practices promotes the spread of a variety of diseases such as diarrhoea, cholera and dysentery (Mandal *et al*., 2011). This shows the importance of interventions such as the safe disposal of excreta, water for hand washing and safe water in preventing disease transmission (Gajurel & Wendland, 2007; Mara *et al.*, 2010).

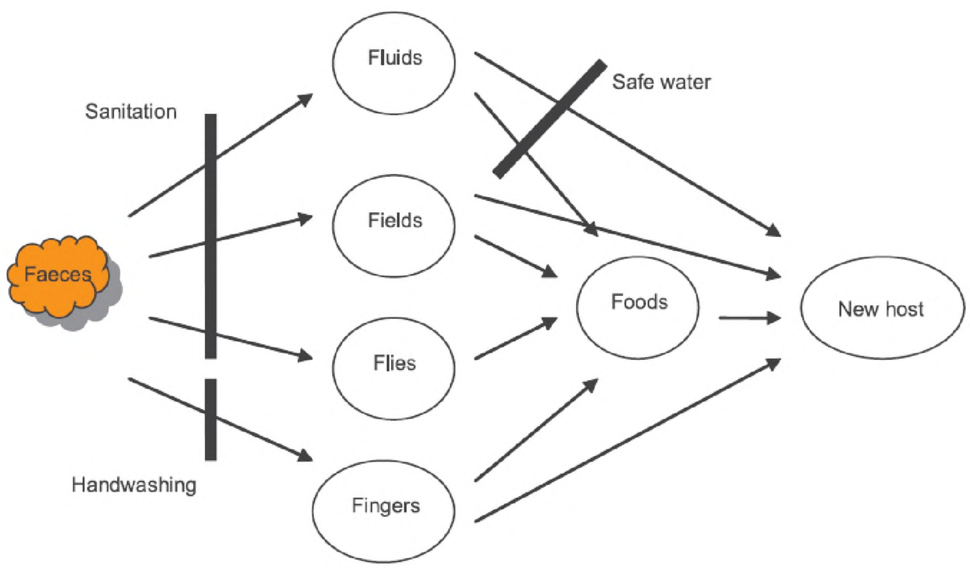

Figure 1.1: The F diagram model showing the multiple route of transmission of pathogens and practices (i.e. sanitation, handwashing and safe water) that can prevent them (source; Mara *et al.* 2010)

On the other hand, inadequacies in water and sanitation services pose separate, but linked problems. However, the immediate problems impact directly on the well-being of people (Carter *et al*., 1999). For instance, inadequacies in access to water have an impact on mostly children and women, as they spend much time and energy fetching water (Table 1.2). As a result, this decreases the per capita water consumption per day. Chenoweth *et al.* (2016) suggests that 85 litres per capita per day can be sufficient for maintaining a high quality of life. Low per capita consumption reduces the well-being of children in particular due to use of insufficient water (Basani *et al*., 2008).

Table 1.2: Summary of linked consequences of inadequacies in water supply and sanitation facilities (source: Carter *et al.* 1999)

Aspect	Immediate problem	Consequences
Water supply	Distant sources	• Much time and energy spent by women and children collecting water • Low levels of water consumption resulting in water-related diseases
	Inadequate or poorly managed source Cost of water Faecally contaminated sources	• Much time is spent queuing or seeking alternative sources • Use of shallow wells • Waterborne diseases
Sanitation	Lack of facilities for the disposal of excreta	• Contamination of soils, surface and ground water • Open defaecation

Similarly, inadequacies in sanitation facilities force peri-urban residents to practice unimproved methods such as use of unlined shared pit latrines and ‘flying toilets’ (people defecate in polyethene bags, which are then thrown into the surrounding environment and open spaces) (Curtis *et al*., 2011; Schouten & Mathenge, 2010). As a result, peri-urban environments are polluted by human excreta resulting from inadequate sanitation (Shayo & Chaggu, 2004). Left untreated, human excreta contain bacteria, worm eggs, parasites and other pathogens that can cause diseases such as cholera, dysentery and diarrhoea (Haq and Cambridge, 2012). Also, the predominant use of unlined pit latrines in peri-urban areas with high water table and flooding in the rainy season increase the risk of polluting groundwater and thus, promoting the spreading of water-related diseases (Bruggen *et al.*, 2010; Katukiza, 2013; O’Neill, 2011).

Nearly 60% of infant mortality in sub-Saharan Africa is linked to infectious diseases, most of them water and sanitation related (Bartlett, 2003; Checkley *et al*., 2008; Fink *et al*., 2011; Montgomery and Elimelech, 2007).

Diarrhoea is the most common disease associated with unsafe disposal of excreta and lack of adequate water, followed by malaria (Manase *et al*., 2001). The Culex mosquito, which transmits filariasis and avian malaria, breeds in stagnant water, septic tanks and flooded latrines (Hunt, 2001). Most cases of diarrhoea are transmitted through faecal-oral route agents such as contaminated food and drink, person-to-person (hand-to-mouth) contact, contact with contaminated objects, and flies either through contaminating food and utensils or resting on children (Root, 2001). Diarrhoea is a major problem because it is a leading cause of illness and death in children (Young & Briscoe, 1988). Diarrhoeal related disease claims over 1.6 million deaths globally per year (Mara *et al*., 2010), of which 580,000 are children below the age of five due to lack of adequate water and sanitation facilities (Burki, 2015). This implies that these unfortunate deaths can be prevented by providing proper water and sanitation facilities. Access to adequate water and sanitation facilities can generally aid prevention of disease and deaths (Bartram and Cairncross, 2010; Bresee & Hayden, 2013). Esrey *et al*. (1991) (In: Hunt, 2001) estimated the expected reductions in diarrhoeal disease through a range of interventions (Table 1.3). For example, practice of good sanitation can lower the rate of diarrhoeal diseases by 36% and promotion of good hygiene by 33%.

Table 1.3: Expected reduction in diarrhoeal disease morbidity from improvement in one or more components of water and sanitation (adapted from Hunt 2001)

	All studies		Rigorous studies	
	n(a/b)	Reduction %	n(a/b)	Reduction %
Water and sanitation	7/11	20	2/3	30
Sanitation	11/30	22	5/8	36
Water quality and quantity	22/43	16	2/22	17
Water quality	7/16	17	4/7	15
Water quantity	7/16	27	5/10	20
Hygiene and promotion	6/6	33	6/6	33

[a] *the number of studies for which morbidity reduction calculations could be made*, [b] *the total number of studies that relate the type of facility to diarrhoeal morbidity, nutrition and mortality studies*

Efforts to prevent deaths from diarrhoea or to reduce the burden of water related diseases are doomed to fail unless those who currently lack access to adequate water and basic sanitation are provided with these basic needs (WHO/UNICEF, 2006). Importantly, appropriate intervention to prevent water-related diseases is not only providing enough drinking water, but also adequate quantities of water for basic household activities such as washing hands, laundry, bathing and food preparation. Bradley (1977) argued that the health implications associated with inadequate water and sanitation can be reduced by providing adequate water because water-related diseases are actually water washed as reported by Dezuane (1997). This is because increase in water availability and quantity reduces faecal contamination of hands (Esrey *et al.*, 1985).

1.2.1. Status of water supply and sanitation in Zambia

In sub-Saharan Africa, high rates of urbanisation has created a situation whereby two-thirds of the urban population, reside in peri-urban areas (Freire *et al.*, 2014; Ruth Kennedy-Walker *et al.*, 2015). Adell (1999) defined a peri-urban area as a transitional zone between urban and rural, often not described as a separate area, but as a diffuse area identified by combinations of features (agriculture and manufacture and service based areas) and occurrences (populated areas). For example, countries in Southern Africa such as South Africa and Zimbabwe are experiencing high rates of urbanisation. In South Africa, 62% of the over 50 million population live in urban areas, with a three-quarter of this population living in peri-urban areas (Turok, 2012). On the other hand, Chinyama *et al.* (2012) reported that 37% of Zimbabwe's population (i.e., 13 724 million) live in urban areas. Further, only 52% of Zimbabwe's urban population uses improved sanitation, while 97% uses improved water sources (WHO/UNICEF, 2014). Consequently, the increase in peri-urban populations creates increased demand on existing infrastructure services such as improved water and adequate sanitation services. In most instances, access to these basic services in peri-urban areas is inadequate (Murphy *et al.*, 2009; Sigel *et al.*, 2012).

Zambia is among the countries in Southern Africa experiencing urban growth (Chileshe *et al.*, 2005; Wragg & Lim, 2015). During the last population census conducted in 2010, Zambia was reported to have an estimated population of 13 million people (Table 1.4), over 50% of whom lived in urban areas (CSO, 2012; Phiri, 2000). As a result, Zambia, like many other developing countries, is faced with the challenge of inadequate water supply and sanitation services especially to the urban poor (Nakagiri *et al.*, 2015).

According to Giles *et al.* (1997), a comparison of definitions used in seven countries by the World Bank indicates that no universally accepted definition of the urban poor exists. However, an understanding of the nature of the urban poor can be described as those persons living in low-income zones such as peri-urban areas and whose income does not permit them access to adequate basic services such as water and sanitation.

Table 1.4: Water supply and sanitation coverage in Zambia (after: NWASCO 2013)

Zambia			
Total	**2000**	**2010**	**2012**
Population	9,885,591	13,046,508	14,075,000
Urban Population	3,400,797	4,793,876	5,571,909
Access to improved water sources (%)	87.1	85.2	83.3
Access to sanitation facilities (%)	58.8	56.8	56.4

It can be seen in Table 1.4 that due to increase in urbanisation, there is a decrease in percentage of coverage of both water supply and sanitation for the urban population in Zambia. Zambia was one of the countries that committed to meeting target 10 of the Millennium Development Goals (MDGs), which aimed to cut by half the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015 (Bartram *et al*., 2005; Gutierrez, 2007). The MDG target for water and sanitation was fairly on schedule, nonetheless, when the number of people without improved water sources or sanitation facilities was considered, the total number hardly decreased. This is due to the fact that the Millennium Development Goal (MDG) on water and sanitation referred to proportions, whereas the population in absolute numbers keeps increasing rapidly (Bruggen *et al*., 2010). Approximately, 2 million Zambians lack access to improved sanitation facilities and more than one third of the population lack access to safe water (UNDP, 2013).

Urban areas in Zambia are characterized by a sharp divide between the fully planned and established areas and the peri-urban areas. While the former are served by reticulated water supplies and waterborne sewerage systems, the latter have a mix of communal standpipes, shallow wells, boreholes, as well as various types of on-site sanitation facilities (Akbar *et al*., 2007). Peri-urban areas in Zambia experience serious inadequacies with at least 56% of the population lacking access to safe water supply and as much as 90% not having access to proper sanitation facilities (Robinson, 2002).

Typically, peri-urban settlements in Zambia have a high population density due to internal population growth and rural-urban migration in search of better livelihoods. Consequently, majority of peri-urban residents cannot access benefits from piped water services. Existing water supply sources are in most cases inadequate for the level of demand, which makes peri-urban residents to purchase water from more expensive vendors or fetching from shallow wells (Kayaga and Kadimba-Mwanamwambwa, 2006). Peri-urban residents spend twice as much on water compared to urban residents that have piped water managed by the Commercial Utility (CU). The average monthly expenditure for water per household in peri-urban areas in Zambia often vary between 60 to 150 Zambian Kwacha (ZMW) (UNDP, 2013).

This is a challenge to majority of residents beecause they are financially constrained or informally employed in small enterprises. Kay (2011) defined informal employment is any business or firm that is not registered with the state. The majority of people working in the informal sector are self-employed, mostly involved in trading activities, ranging from street vending to trading in the city's central markets and markets in their residential areas (Mulenga, 2013). The high cost of water, coupled with lack of finances, compels households to use alternative sources of water such as shallow wells, which are limited in quantity and quality (Aertgeerts, 2009; Kayaga and Kadimba-Mwanamwambwa, 2006; Shivendra and Ramaraju, 2013). Consequently, the urban poor have a low life expectancy and a high infant mortality rate (Bradley *et al*., 1992). The Zambia Demographic and Health Survey Report (2014) stated that inadequate access to water and sanitation facilities accompanied by poor hygiene are associated with Acute Respiratory Infections (ARIs) and diarrhoea diseases. ARIs and diarrhoea diseases are among the leading causes of child mortality in Zambia (CSO *et al*., 2014). Additionally, the sanitation situation in peri-urban areas remains poor (Alirol *et al*., 2011; O'Neill, 2011). Traditional pit latrines are very common sanitation facilities used in peri-urban areas, but Ventilated Improved Pit (VIP) latrines and Pour-flush toilets connected to septic tanks are also used to a lesser extent. Open defecation is also practised (Montgomery & Elimelech, 2007; Thye *et al*., 2011), but many of these facilities are poorly maintained (Lüthi *et al*., 2011). Poorly maintained sanitation facilities can leave communities in environmental squalor and ultimately lead to periodic outbreak of water-related diseases (Knappett *et al*., 2011; Lyinto *et al*., 2007; Seleman & Bhat, 2016).

1.2.2. Challenges of service provision in peri-urban areas in Lusaka

High population growth, poverty and lack of sustainable housing policy have led to the mushrooming of peri-urban settlements in Lusaka City. Peri-urban areas have become a source of shelter for the majority of low-income urban residents due to the government's inefficiency of guiding urban developments, availability of land at a relatively low value. Urbanisation leads to peri-urban areas due to increasing demand for land by urban dwellers (Adam, 2014; Cobbinah *et al.*, 2015). Lusaka City has over thirty (30) peri-urban areas (Dagdeviren, 2008) whose population accounts for an estimated 70% of the total city population (DTF, 2013; UN Habitat, 2012). The World Bank (2002) reported that less than 45% of the residents in peri-urban settlements in Zambia own their houses, as majority of the residents are tenants. The World Bank further stated that informal employment stands at 65% in peri-urban areas.Lusaka Water and Sewerage Company (LWSC), the licensed Commercial Utility (CU) in Lusaka has the responsibility for the provision of water and sewerage services in the City. LWSC only provides water supply to 22 of the over 30 peri-urban areas (Katooka, 2007). Therefore, additional water supply services are currently provided by private community-based water operations known as Water Trust (WT), which operates under license from the LWSC (Kennedy-Walker *et al.*, 2015).

Nonetheless, rapid increase in population in peri-urban areas puts enormous pressure on the local authorities, to provide the desirable level of services in the city (LCC & ECZ, 2008; WSUP, 2014). Lack of services to certain areas, and the inability to pay water bills for operation and maintenance due to high poverty levels causes the majority of peri-urban residents to have access to water supply (Santiago *et al.*, 2015; WSUP, 2013). Kayaga and Franceys, (2008) reported that in 2005, 65% and 72% of peri-urban residents of Lusaka did not have access to adequate service levels of water and sanitation, respectively. Use of communal water sources and on-site sanitation facilities such as traditional pits latrines for peri-urban areas are the norm (Lüthi *et al.*, 2010). Many peri-urban residents spend a lot of time fetching water, especially children and women (Kayaga and Franceys, 2008), and 90% use shared poorly constructed pit latrines. The pit latrines when full are emptied by households themselves and indiscriminately dump the sludge into the environment. As a result, water borne diseases such as diarrhoea and cholera are common occurrences in peri-urban areas of Lusaka (Kennedy-Walker *et al.*, 2015). However, despite these conditions (i.e., lack of adequate housing, water and sanitation), many peri-urban dwellers continue to live in such disease-prone areas because of poverty (Okurut & Charles, 2014). Godfrey and Julien (2005) pointed out that one way to reduce urban health risks in developing countries is by providing adequate water and sanitation infrastructure.

However, burden in population, high poverty levels and high demand for services contribute against the provision of improved adequate water supply and sanitation. Under such circumstances, there is need for local authorities to implement not only adequate water and sanitation, but sustainable facilities encompassing the circumstances experienced.

1.3. Sustainable water supply and sanitation facilities

In developing countries including Zambia, a significant number of water and sanitation services are not sustainable (Carter *et al.*, 1999). Service provisions are not sustainable due to the implementation of services that do not take into account the specific conditions of the areas in which they are implemented, services that are barely financially viable for local authorities and affordable for the urban poor (Diener *et al.*, 2014). For example, provision of sanitation services without considering the local conditions of areas may result in the facilities being abandoned, misused or never used at all (Okurut & Charles, 2014). Local authorities often do not consider the different specific demand attributes of the communities. Specific demand attributes may include demographic characteristics, availability, reliability, cost, convenience, household situation and attitudes, household awareness, as well as understanding of technical limitations such as operational and maintenance, tenancy and geophysical settings (Okurut & Charles, 2014; Tinoco *et al.*, 2014). More often than not, communities and households are never made aware of the reason for them to have access to new facilities (Carter *et al.*, 1999). Moreover, the lack of interest in investing in sanitation facilities by residents, who are in most cases tenants rather than landlords, is another challenge (Katukiza *et al.*, 2012).

Providing sustainable water and sanitation services will require appropriate technically sound sustainable technological solutions, among other things (Feachem, 1980; Moe and Rheingans, 2006). Mara *et al.* (2007) stated that a sustainable water supply and sanitation systems provision should be managed at the lowest technical level. Likewise, communities benefiting from the provision of these facilities must be involved in the planning, implementation and, where appropriate, operation and maintenance. The technologies should be affordable, economically viable for the households using them, protect human health, and minimize environmental degradation (Murphy *et al.*, 2009; Bolaane and Ikgopoleng, 2011). This implies that sanitation systems need to comprise of the safe disposal and treatment of human excreta, as well as the safe re-use of the end products, and should be acceptable to the users (Katukiza *et al.*, 2012).

A technology is considered appropriate when it is compatible with socio-cultural, institutional, environmental and economic conditions of the communities in which it is used (Hazeltine and Bull, 2003). Other local conditions such as population density, settlement pattern, space available in plots for installing facilities, ground water table, water availability, household income and social-cultural aspects are factors to consider when providing water and sanitation facilities to a community (Katukiza *et al.*, 2012; Schouten & Mathenge, 2010). Improper considerations of these factors in the provision of water and sanitation services in peri-urban areas can lead to their unsustainable use, which increases the risk of water-borne diseases (von Münch and Mayumbelo, 2007).

1.4. Low-cost water supply and sanitation technologies

It is imperative that existing and possible low-cost water supply and sanitation options be assessed for service provision in peri-urban areas of developing countries such as Zambia. Provision of water supply and sanitation infrastructure to peri-urban areas need to be affordable and sustainable to the people (Pickford, 1980). One approach of achieving this is the implementation of low-cost technologies. Low-cost technologies offer a means of addressing water and sanitation needs in a more sustainable manner and can provide the same health benefits and user convenience as conventional technologies (Montgomery and Elimelech, 2007; Paterson *et al.*, 2007). In regions were water quantity is a problem, alternative technologies that require no or low water should be used. Simple and acceptable low-cost interventions at the household and community levels are capable of improving the quality of water and reducing the risks of diarrhoeal diseases and ill health in populations in developing countries (Hecht, 2004). However, despite the benefits offered by low-cost technologies, little research is put into the evaluation of the feasibility of these technologies by the local authorities. Local authorities are more focused on the implementation of the conventional centralised technologies.

Despite the fact that majority of urban population in developing countries uses on-site sanitation, much of the focus for policy makers is still on network-sewerage and centralized systems (Lüthi *et al.*, 2010). In most parts of the world, two options exist with the handling of sanitation problems: “drop and store” and “flush and forget” (Langergraber and Muellegger, 2005). A flush and forget sanitation system is based on the premise that excreta is waste, and that waste should be disposed of. The cistern-flush toilet is the most familiar type of excreta disposal system. However, it is neither the only available nor appropriate system for low-income communities such as peri-urban areas.

The system uses large amounts of water for excreta disposal. In addition, the construction, operation and maintenance of the necessary hardware for the “flush and forget” options are a heavy financial burden (Langergraber and Muellegger, 2005). Most peri-urban communities in developing countries do not have high level of water supply system. Instead they often rely on hand carried supplies from shallow wells, standpipes or surface water (Mara, 1996). The “drop and store” is used for the conventional pit latrines, however, in densely populated areas; the system is not viable due to lack of space for digging a new pit when the old one gets full (Werner et al., 2009).

1.5. Types of sanitation options

Generally, there are two types of sanitation systems; dry and wet sanitation. Both can be on-site or off-site. In wet systems, water is used to flush the excreta away. In the dry systems, the excreta drop through a hole into a pit or chamber (Cairncross, 1987). Additionally, in dry systems, there are two distinct technical approaches; dehydration, were urine and faeces are managed separately, and decomposition (composting), where bacteria, worms, or other organisms are used to break organic matter down to produce compost (Peasey, 2000). Figure 1.2 shows the common types of sanitation systems for both on-site and off-site.

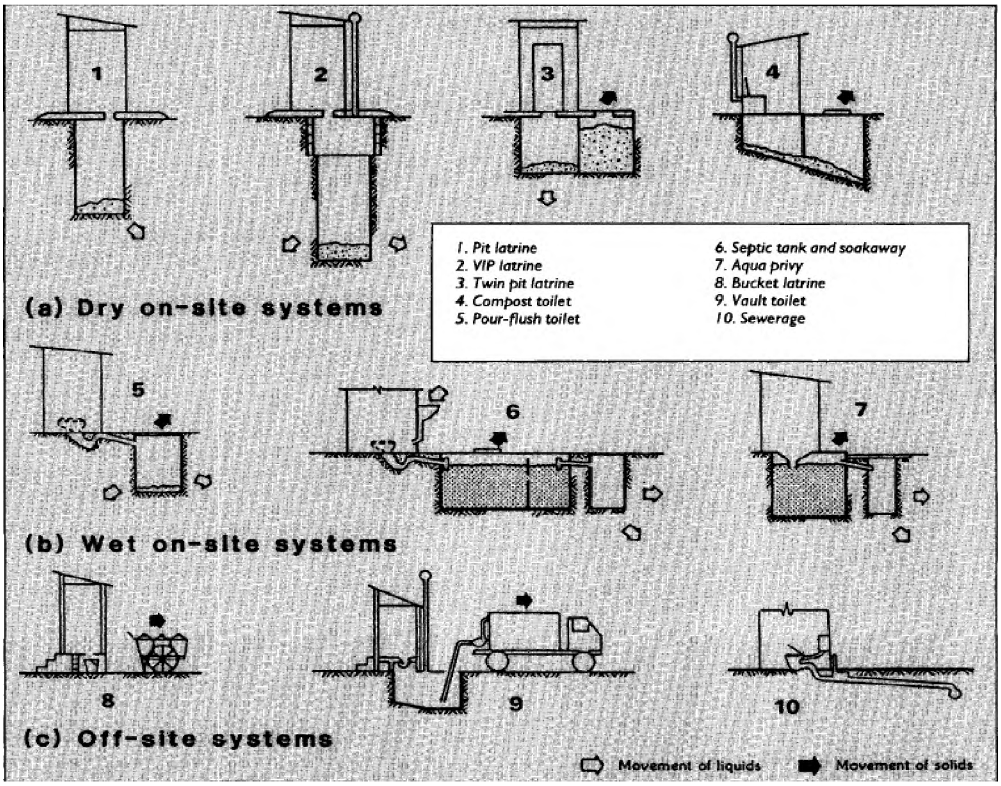

Figure 1.2: Common sanitation systems in their categories (source: Cairncross 1987)

1.5.1. On-site dry and wet sanitation

1.5.1.1. Improved Traditional pit latrine

Improved traditional pit latrines are a very common sanitation facility in many developing countries. Pit latrines have been adopted because of their low cost, simplicity of construction and ease of operation and maintenance (Nakagiri *et al*., 2015). Pit latrines consist of a single pit covered by a slab with a drop hole and a superstructure (Figure 1.3). Human excreta are collected in a chamber below the slab. The depth of the pit depends on the soil and groundwater conditions of the areas. In areas where water table levels are high or where the soil is too hard to dig, the pit latrine may be raised above ground level (Brikké & Bredero, 2003). Traditional pit latrines however have disadvantages including bad smell and breeding of disease-carrying insects.

Additionally, they are all too often poorly constructed, with the result that pit collapses are common (Mara, 1984). The toilet is constructed with a squatting hole and this can be difficult for elderly people. Alternatively, the toilet can be constructed with a toilet pedestal to make it more accessible to the elderly, as well as people that cannot squat. Further, if the slab is not constructed with suitable material, it can crack. The cracks provide a habitat for parasites (Brikké & Bredero, 2003).

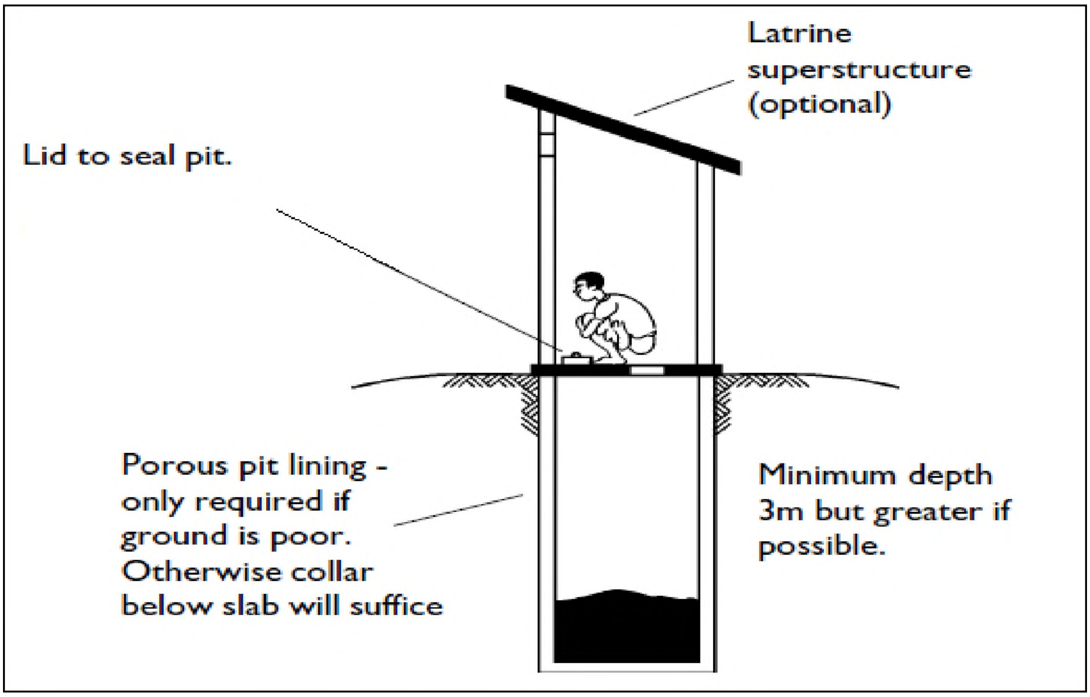

Figure 1.3: A schematic drawing of a traditional Improved pit latrine (source: Cotton, Franceys, Pickford, & Saywell, 1995)

1.5.1.2. Sanitation Platform (SanPlat latrines)

The SanPlat latrine is a pit latrine fitted with concrete cover slab. The SanPlat has low construction costs, it is hygienic (i.e., it has a washable floor with a concrete lid to keep flies and bad odour away), the slab can easily be moved to other places, and it is safe for children to use. The SanPlat is a good solution when combined with a strong superstructure. It is easy to construct, and can be adapted according to environmental and geographical circumstances. SanPlat latrines are similar to improved traditional pit latrines and are used in most developing countries (Mara *et al.*, 2007). However, the latrine does not prevent the possibility of groundwater pollution for areas that have high water table and does not address latrine pit walls' stability (Shayo & Chaggu, 2004). Further, the SanPlat can be difficult to access by the elderly as it is fitted with squatting slab.

SanPlat latrines have been implemented in Tanzania. Tanzania faces high rates of disease resulting from inadequacies in sanitation services. To improve sanitation in the country, a Non-Governmental Organisation (NGO), took the initiative of devising appropriate measures and technologies that was acceptable to the people, cost effective and contributed to the improvement of health. The SanPlat was introduced in various districts of the country, in peri-urban and rural areas. Community members from the districts including artisans were trained on the production of the SanPlat latrine, as well as installation and use (Figure 1.4). The project provided improvements in sanitation situation in the districts and at the same time created jobs and income for small scale artisans (Shayo & Chaggu, 2004).

Figure 1.4: (A) A traditional pit latrine fitted with a SanPlat slab and (B) artisans making the slabs (source: Shayo & Chaggu 2004)

1.5.1.3. *Ventilated Improved Pit (VIP) latrine*

Ventilated Improved Pit (VIP) is a pit latrines designed to remove bad odour and insects from the pit using a vent pipe. It consists of a pit, a slab covering the pit, a squatting hole and a superstructure including, a roof as well as a screened ventilation pipe which extends from the pit to eliminate odour and flies (Figure 1.5 A: Paterson *et al*., 2007). A VIP works by containing the solids within the pit and leaching the urine and any wash water into the surrounding soil. Odours generated in the pit are ventilated into the atmosphere using a vent pipe (Cairncross, 1987). The pit is protected against collapse by a collar at its rim, made from mortar or bricks (Chimbunde and Morgan, 1982). In areas where there is not enough space to dig or re-dig sufficient pits whenever it is full, latrines can be built with two pits. This type of latrine is known as the alternating VIP latrine (Figure 1.5 B: Mara, 2008). One disadvantage of the VIP is that it can be expensive to construct for some households that are financially constrained.

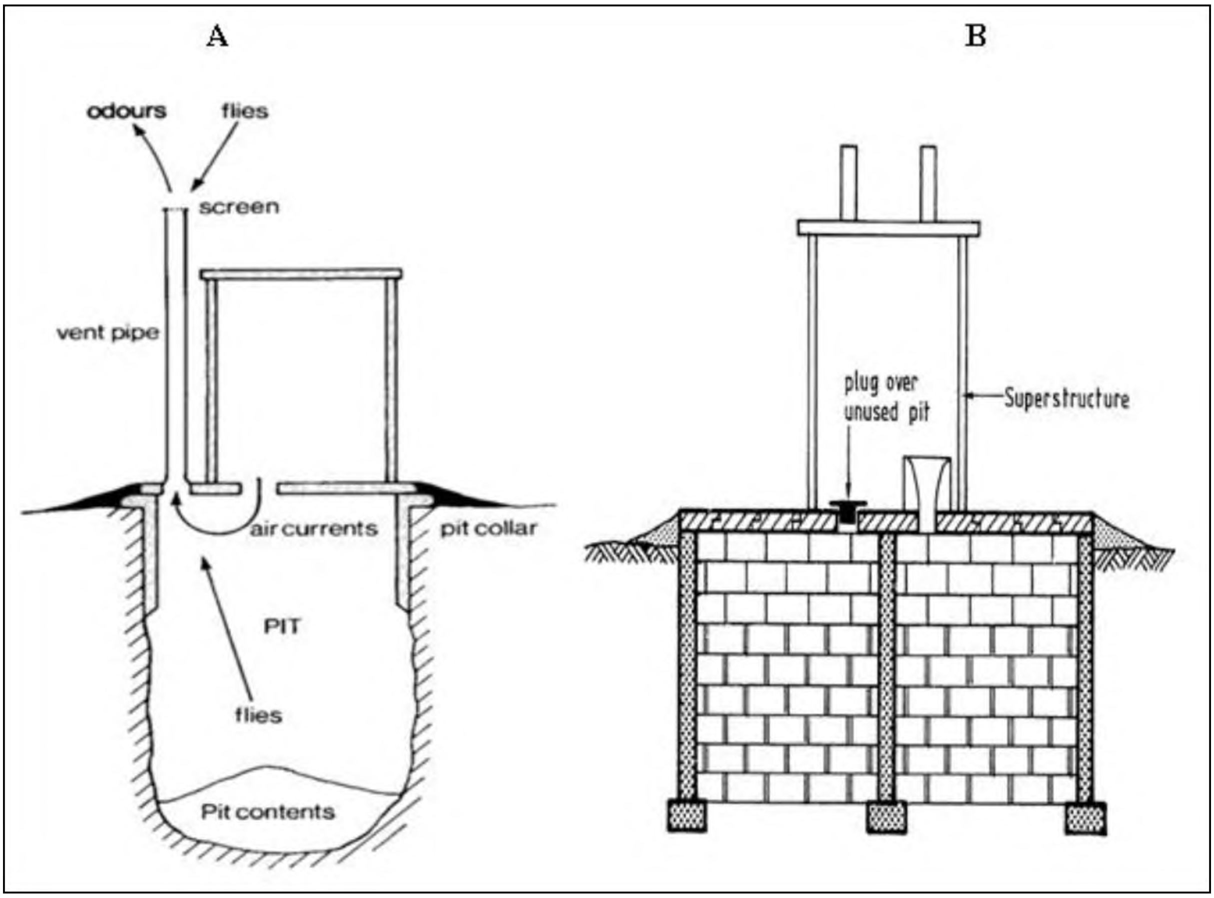

Figure 1.5: (A) Schematic drawing of the functioning of a VIP and (B) Alternating VIP (source: Cairncross 1987 and Ryan & Mara 1983)

Alternating VIP latrines are widely used in peri-urban areas of Botswana, where they are known as "Revised Earth Closet Type II latrines". Each pit is lined in open-joint concrete blockwork supported on reinforced concrete footings. A dividing wall is built at mid-length and is similarly supported. This is designed for the removal of the pit contents at regular intervals; this alternating cycle can be repeated indefinitely (Mara, 1984). The most important factors governing the ventilation rate of the VIP latrines are the local wind speed and its direction. All the latrines studied in Botswana were completely free of faecal odours. Only a few households had slight odour of ammonia from urine splashed onto the squatting plate (Ryan & Mara, 1983).

1.5.1.4. Pour flush

A Pour-flush (PF) is a pit for excreta disposal fitted with a special pan that has a shallow U-pipe (Figure 1.6) (Paterson *et al*., 2007). When well designed, excreta deposited on the pan are flushed by a low volume (1-3 litres) of hand poured water through the water seal and connecting pipe into the pit or connecting septic tank (Cairncross, 1987). Advantages of PF are that they reduce odours and flies, are easily cleaned and are safe for use by children. In areas that have limited space, a PF toilet can be built with two pits so that the toilet does not have to be moved when a pit fills up, rather the excreta would be diverted to the second pit through the connecting pipe (Mara, 1985). A disadvantage of the Pour-flush toilet is that it can be expensive to construct. In households that have elderly people, the toilet can be constructed with a pedestal to make it more accessible.

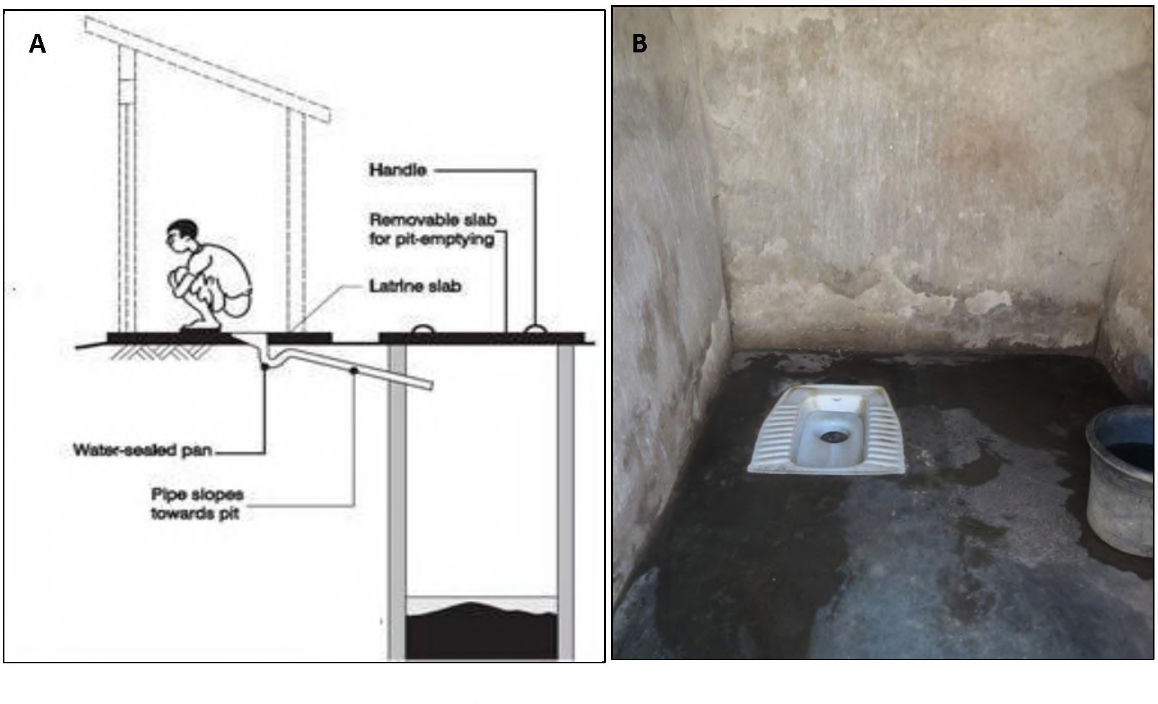

Figure 1.6: (A) Schematic drawing of a Pour-flush toilet and (B), Pour-flush pan

1.5.1.5. Septic tanks

A septic tank is a large watertight tank that helps to separate the solid matter. Some of the solids sink to the bottom of the tank where they undergo anaerobic digestion to form sludge. The sludge accumulating in the tank needs to be emptied from time to time (Mara *et al.*, 2007). Septic tanks can be connected to flushing toilets or Pour-flush toilets. One disadvantage with a septic tank is space. Septic tanks are not feasible in areas that have limited space.

In Kenya, a project called Upscaling Basic Sanitation for the Urban Poor (UBSUP) was implemented in 2011 by the Water Services Trust Fund (WSTF), which aimed at providing access to basic household sanitation across all Kenyan peri-urban areas. Kenya has a population of 39.5 million (Ngusale *et al.*, 2014), of which an estimated 40 % is urban (Karekezi *et al.*, 2008). The technologies implemented by UBSUP included Pour-flush toilets connected to septic tanks, flush toilets connected to sewers and Urine Diversion Dry Toilets (UDDTs). The most popular toilets in the project are the Pour-flush connected to septic tanks. To date, 4,800 Pour-flush toilets have been constructed across the different peri-urban areas. The septic tanks are emptied by exhauster pump trucks operated and maintained by the utilities companies. Responsibilities for operation and maintenance of the toilets rest with the users. Social marketers visit households from time to time, offering advice to landlords and tenants on proper maintenance of the toilets (Schröder, 2016).

1.5.1.6. Urine Diversion Dry Toilet (UDDT)

A Urine Diversion Dry Toilet (UDDT) is a toilet that separates urine and faecal matter. Urine-diverting toilets use a special pedestal or squat plate (Figure 1.7, 2) in which the urine enters the front part of the pedestal and is then diverted through a pipe. Thus, the urine gets separated from the excreta which fall directly downwards into a vault. Lime, soil and ash are added to the excreta after every visit, with the aim to kill pathogen and reduce the volume of the waste. With time, the excreta becomes completely composted (Morgan, 2007). Urine-diverting toilets can be built with single or double vaults (Figure 1.7, 5). The double vaults compost latrine consists of two vaults for excreta collection, which are rotated. When the first vault is almost full, it is completely filled with soil, sealed and the contents allowed to decompose anaerobically; the second vault is then used. After a suitable retention time, the contents of the vaults can be emptied and used as fertiliser (Figure 1.7, 6). In rocky or high water-table areas, the vaults can be placed above ground, which can avoid contamination of groundwater and soil (Brikké & Bredero, 2003). Collected urine can be applied to plants; composted excreta and organic wastes are used as soil conditioner.

Other advantages of this type of sanitation facility is that it saves space because the pits can be emptied when full, has a very long system lifetime and low recurring cost of emptying, and requires no water to flush away human waste (Patinet, 2010). However, the toilet requires continuous awareness on its operation and maintenance. Incorrect usage and maintenance of the toilet can result in pathogens surviving in the end products which could lead to the spread of disease (Peasey, 2000).

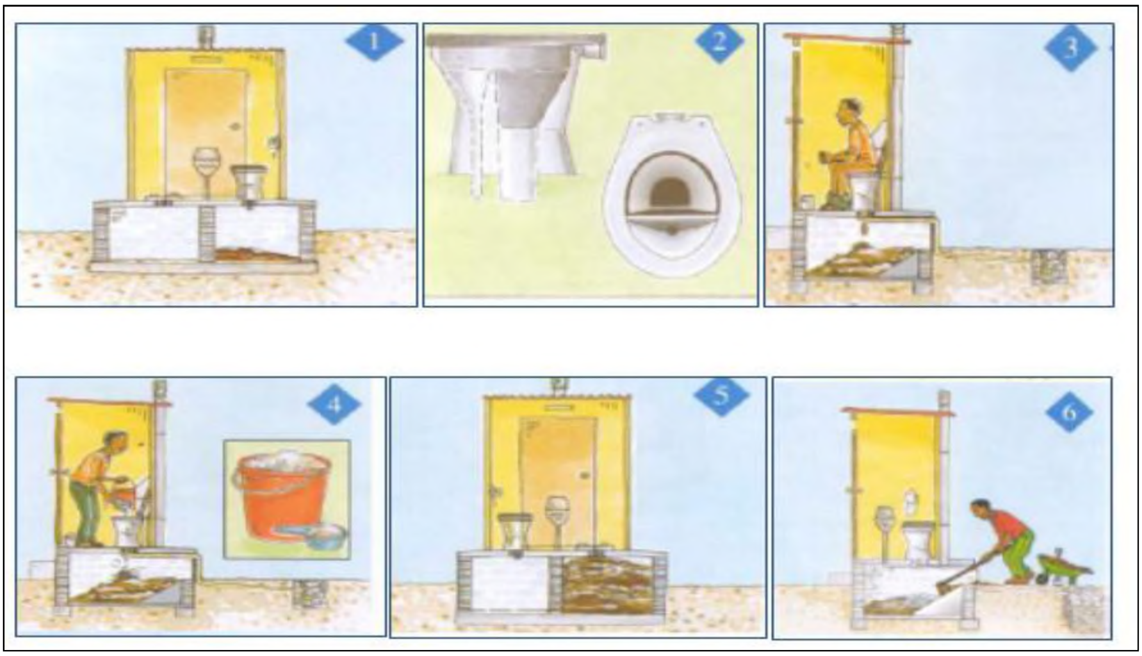

Figure 1.7: Illustrations of the operation of a Urine Diversion Dry Toilet (source: EMS 2005)

Urine Diversion Dry Toilets (UDDTs) were implemented in Arusha, Tanzania. Three peri-urban areas namely Daraja II, Lemara and Sokon I were selected for the project. The three (3) areas account for 26% of the Arusha's population and are characterised by high population density. Majority of the people in the areas are informally employed. The Urine Diversion Dry Toilet (UDDT) was chosen for the area because it offers a permanent structure and has a possibility of using products from the toilet for agricultural purposes. In addition, the toilet reduces odour and flies as a result of separating urine and faeces. A total of eight (8) UDDTs were constructed; 5 double vaults and 3 single vaults. The toilets were estimated to take 3-5 years for one vault to fill up with an average household size of 4-6 persons. Household users received training on the use of the toilets and reuse of the UDDTs products. Experiences from the project revealed that proper understanding of the use of the toilets as well as transportation and re-use of the products for agriculture purposes from the UDDTs is a crucial to the success of the system (Senzia, 2011).

1.5.1.7. Arborloo

An arborloo is a simple pit compost toilet made up of 3 parts: a shallow pit of about 1-1.5m, a concrete slab, and a portable superstructure (Mara, 2012). The pit fills up with a mix of excreta, together with soil, ash or leaves which are added after every use. The daily addition of soil or ash helps to reduce flies and smells. When the pit is full, the parts of the toilet are moved to another place, rebuilt and used in the same way again. Urine is not separated from faeces in this type of toilet. The full pit is filled with soil and a young tree is planted in this soil. The content will decompose by different biological processes over time and utilized by the planted tree (Figure 1.8).

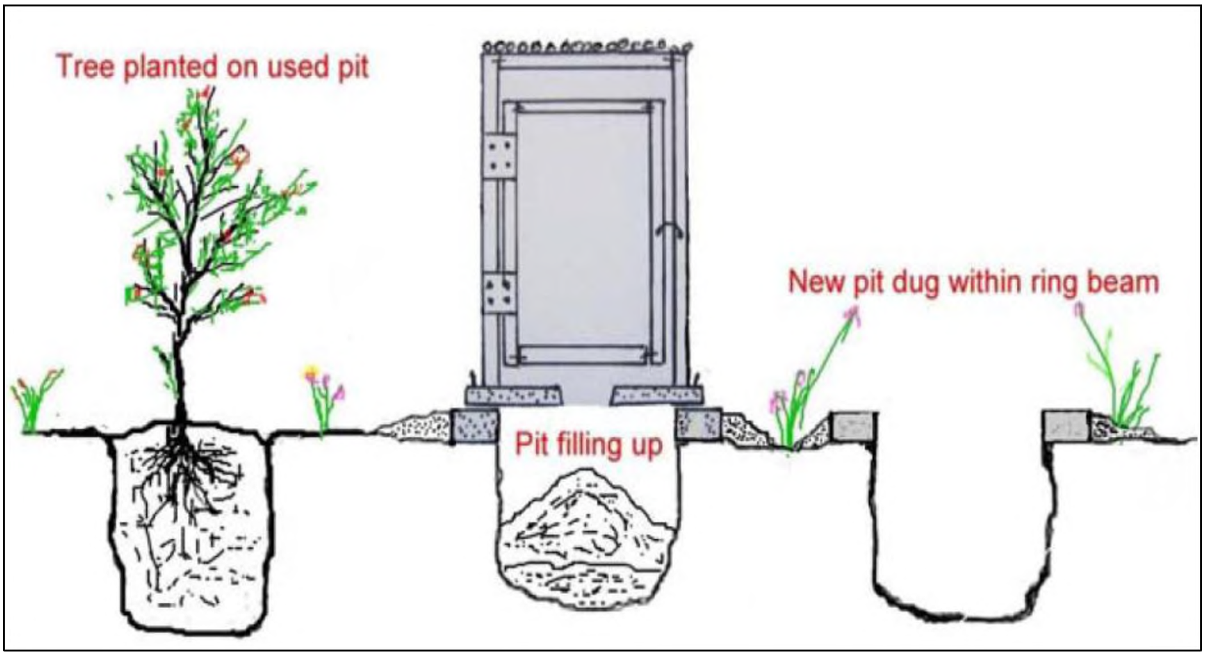

Figure 1.8: Schematic diagram of a single pit compost toilet, the Arborloo (source: Morgan 2007)

The Arborloo was implemented in Ethiopia by the Sustainable Sanitation Alliance (SuSanA). The toilets were introduced in the City of Arba Minch, one of the fast growing towns in Ethiopia, with a total population of 75,000 and annual growth rate of 4.5%. The city experiences a wide range of sanitation problems due to rapid population. A total of 9 Arborloos were constructed during the period 2006-2010. Some of the toilets were constructed in areas of the city that have congested settlements, which causes lack of available space for digging pits. The operation and maintenance of the Arborloo is simple and can be carried out by the users. Although most users of the Arborloo implemented in Arba Minch accepted them, some users did not like the toilets because of its fast filling rate due to small volumetric capacity of the pits. People are more interested in toilets that can last for two years and more (Shewa and Geleta, 2010).

Arborloo has a disadvantage of a shallow pit which fills up quickly in peri-urban areas where the user load is high.

1.5.1.8. Fossa Alterna

The Fossa alterna, similar to an arborloo, is a sanitation option that is a double pit compost toilet and is made up of six parts, two pits, two ring beams to protect the pits, a single concrete slab, and a toilet house (Morgan, 2007). The two pits are used interchangeably. During the first season, when the first pit fills up with a mix of excreta, soil, ash or leaves which are added after every use, the second pit is unused. Depending on the number of users, the first pit will get filled after one or two years. Soil is placed over the contents of the first pit and left to compost. The second pit is then put to use while the contents of the first pit are composting. When the second pit gets filled, the first pit will be ready for emptying the compost of the pit. The toilet slab and structure can be placed back again over the empty pit and the recently filled pit is covered with soil and left to compost. This changing of the pits can continue for many years in the same site. The Fossa alterna is one sanitation option which is easy and affordable for many populations. It can be constructed to provide improved sanitation in places facing problems with rocky ground and pits collapsing, as well as areas that have a high water table (Figure 1.9A and B). In such cases, the Fossa alterna can be constructed above ground. However, the toilet can have disadvantage in terms of acceptability. In some areas, the handling of end products from the toilet is considered unhygienic and this can be challenging to service providers.

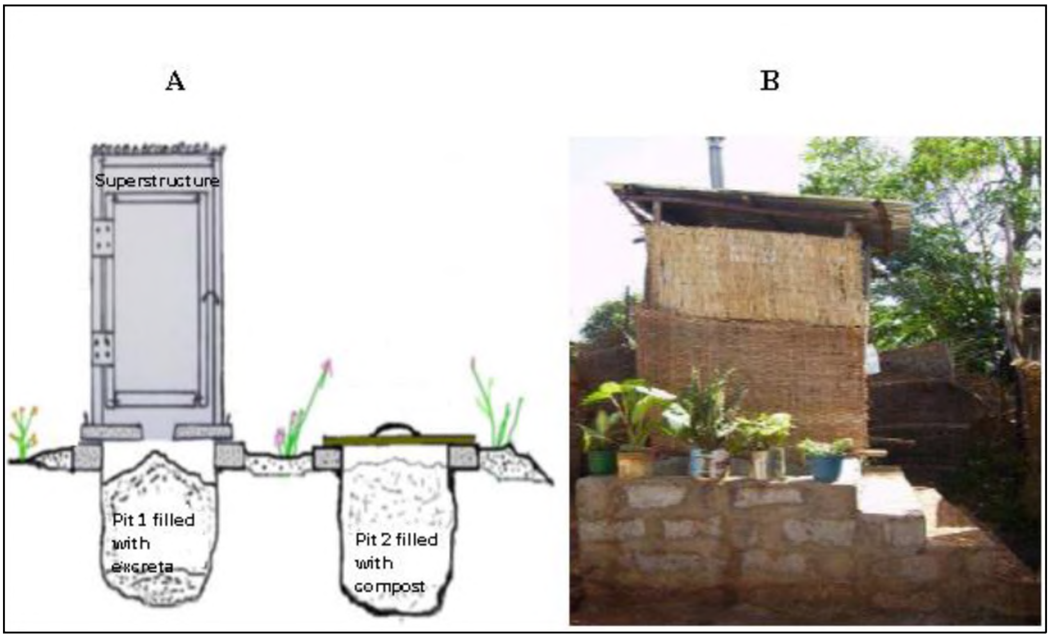

Figure 1.9: (A) Functioning of a Fossa Alterna and (B), an elevated Fossa Alterna (source: Morgan 2007)

A total of 30 Fossa Alternas were constructed during the period 2007-2009 in Arba Munch, Ethiopia by the Sustainable Sanitation Alliance (SuSanA). The Fossa Alterna had a portable superstructure made of local material called 'Karta' (woven bamboo), canvas or corrugated iron sheet. The cost for constructing a Fossa Alterna in the areas was ZMW 940.99. The Fossa Alterna was accepted by the users' because of the similarity of the toilet to a traditional toilet. In terms of sustainability, strong emphasis of the toilet was put on the treatment of waste from the pit latrines, transport, re-use, robustness, adaptability and affordability of the system (von Münch and Ingle, 2012).

1.5.2. Off-site wet sanitation

1.5.2.1. Simplified sewerage

Simplified sewerage is a sewerage system designed to receive unsettled domestic waste i.e. sewage that has not been pre-treated in the settling tank prior to being discharged into the sewer (Jean-Marie *et al.*, 2014). The design of simplified sewerage is based on the same hydraulic principles as those used for the design of conventional sewers. However, simplified sewerage uses small-diameter sewer pipes laid at shallow depths to convey the sewage.

The sewers may be laid inside housing blocks or outside housing blocks (Figure 1.10). Simplified sewerage is most appropriate in high-density low-income because the technical design according to Jean-Marie *et al.* (2014) can be simplified which in turn reduces costs. However, simplified sewage requires households to have an on-plot level of water supply (Mara, 1996).

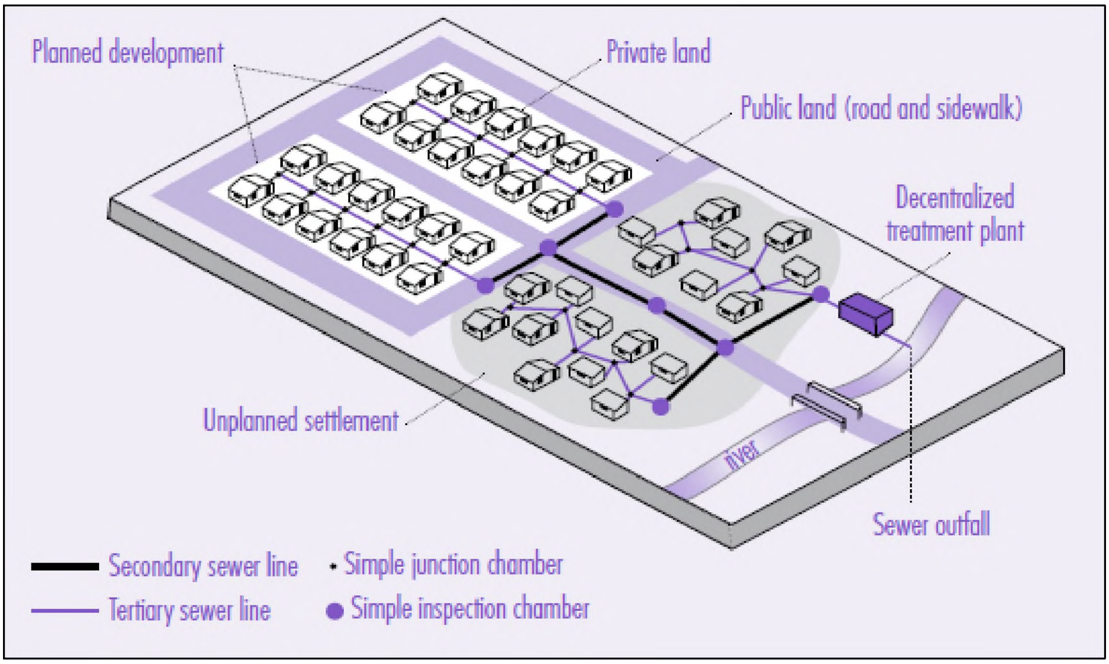

Figure 1.10: Overview of simplified sewerage layout for planned settlement and unplanned settlement (source: Jean-Marie *et al*. 2014)

The project of simplified sewerage was carried out in 1984 aimed at improving the living conditions of the people of Karachi, Pakistan. At the time of the project, 40% of Karachi's population lived in peri-urban areas with Orangi as the largest peri-urban urban in Karachi. Infant mortality and incidence of infections related to lack of access to sanitation were high. Water supply in Orangi was supplied through communal taps. On average 20-30 litres of water were used by each household member each day. Simplified sewers laid in the service lanes, received household domestic wastewater. Following the first success of the project, by 1996, 750,000 people in Orangi were served by simplified sewerage (Mara, 1996).

1.5.2.2. Faecal Sludge Management (FSM)

Sludge from on-site sanitation options such as traditional pit latrines, VIP latrines, pour flush toilets and septic tanks need to be removed from the pit from time to time. Two options exist when a latrine is full: if there is enough space in the yard, a latrine can be buried, and a new latrine constructed or the latrine can be emptied (Thye *et al*., 2011). A Faecal Sludge Management (FSM) system is a sanitation practice that includes adequate desludging of sanitation facilities, safe handling, transport, treatment, and safe disposal or re-use of sludge. FSM helps reduce public health and environmental impacts caused by indiscriminate dumping and overflow of septic tanks full pit latrines, among others (Opel, 2012).

In addition, organic waste from FSM can be processed into useful products (Figure 1.11 B and F). In other cases, FSM systems can have a bio-digester, a closed airtight medium in which anaerobic fermentation generates methane or biogas and at the same time the waste is sanitised and transformed into high quality semi-liquid fertilizer (slurry) (Mara *et al*., 2007). Biogas generated during the fermentation process can be used directly for in-house cooking and /or lighting. Dried slurry from an FSM plant is used as fertiliser or soil conditioner on the fields. One disadvantage of FSM is the cost of emptying by households in low-income areas. Additionally, some toilets in peri-urban areas are not constructed well that can allow for desludging which is a challenge (African Development Bank Group, 2015) .

Figure 1.11: FSM stages (A) bio-digester, (B) gas pipe, (C) drying beds, (D) wet slurry in drying beds, (E) dried slurry and, (F) packaged dried slurry ready to sell

Bangladesh is experiencing a rapid urbanisation. Approximately 46 million people are currently living in the urban areas (Opel *et al.*, 2012). Three cities namely, Dhaka, Khulna and Faridpur were analysed of the use of Faecal Sludge Management (FSM). Dhaka accommodates more than one-third of the total urban population. Khulna is the third largest city in Bangladesh.

Khulna had an estimated population of 1.2 million in 2009. Faridpur had a population of 135, 837 people and is considered to be a high density area. A total of 467 households from Dhaka, 395 from Faridpur and 358 households from Khulna were selected for the survey. Majority of the households in the 3 areas relied on simple pit latrines, VIPs and septic tanks and practiced manual emptying. The sanitation facilities were shared among the households. An average of 7.6 households in Dhaka shared a latrine, 3.4 in Faridpur and 5.7 households in Khulna. In all 3 areas, most households emptied their tanks or pits at least once per year according to the number of users per latrine. The cost of manual emptying was provided by a non-profit organisation at a subsidised fare. Majority of the people in the 3 cities were willing to pay to improve the prevailing situation of FSM (Opel, 2012).

1.6. Types of water supply options

In developing countries, the most common water supply options for peri-urban areas include boreholes and communal standpipes. These water facilities are in most cases constructed for the community by Non-Governmental Organisations (NGOs) and donors (Dagdeviren, 2008). The following are some of the common water sources found in peri-urban areas of developing countries.

1.6.1. Protected wells

Protected wells are wells consisting of the following main parts: a concrete apron (provides a hard standing area for users); a headwall (prevents spilt water, rainfall, runoff, debris, people and animals from entering or falling into the well); a lining (prevents the well from collapsing), and a drain (guides spilt water farther away from the well, usually towards a soakaway) (Brikké & Bredero, 2003). A soakaway is a pit or trench filled with rubble such as stones or broken bricks where the water can infiltrate back into the ground, or evaporate from the stone surfaces at a safe distance from the well (Cairncross, 1987). Most poor peri-urban households rely on water from other sources in cases where a centralized water supply is not available or the quantity is limited. Protected wells are often the preferred solution, as the distance to them may be shorter and they may be easily accessed (Peter-Varbanets *et al.,* 2009). However, they need to be constructed not close to pit latrine to prevent cross contamination of human waste and water.

1.6.2. Boreholes

Boreholes are similar to traditional protected dug wells except that their diameter is generally smaller than that of traditional wells. Boreholes consist mainly of three parts: a concrete apron around the borehole; a lining below the ground, which is usually a pipe, with the material made of either Polyvinyl Chloride (PVC) or galvanized iron; and a slotted pipe below water level, which allows groundwater to enter the borehole. In cases that the borehole is not constructed correctly, soil particles can enter the borehole. Therefore, it is important that the borehole is built with adequate screens to prevent soil particle being found in water (Brikké & Bredero, 2003).

1.6.3. Communal taps

A public stand tap is a centralised water source, and distributes water from one or more taps to many users (Figure 1.12). It consists of a service connection to the supplying water pipeline, a supporting column or wall made of concrete, and one or more taps, as well as a concrete apron under the taps. Because a stand pipe is used by many people, and if not conveniently located, operation and maintenance of the taps often become a challenge. Further, hours of access of the communal taps is limited and taps located at the end of a main pipe system often have insufficient water pressure (Brikké & Bredero, 2003).

Figure 1.12: A public stand pipe (communal tap)

1.6.4. Rooftop rainwater harvesting

Rainwater harvesting is the collection of rainfall water from rooftops. Rainwater falling from the roof surfaces is collected through gutters and led to storage tanks after rainfall events (Guzha *et al.*, 2007). Rainwater harvesting provides water at the point of use and family members have full control of their own systems, which reduces operation and maintenance difficulties. However, the disadvantages of rainwater harvesting are the tanks may develop leaks and rust problems, uncertainty of rainfall, and also the unreliable water quality due to infection and growth of bacteria during storage (Peter-Varbanets *et al.*, 2009).

1.7. Relationship between water supply and sanitation

It is apparent from the discourse so far that availability of water is very important in providing adequate sanitation for communities. However, other systems which use much less water or none at all can be equally hygienic (Cairncross, 1987). Composting toilets are one example that require little to no water (Anand and Apul, 2014). Simple and low-cost sanitation systems such as VIP latrines are effective in reducing the spread of faecal pathogens through the environment, and have low infrastructure investments (Rheingans, Dreibelbis, & Freeman, 2006). Pit latrine can be designed in a way as to be free of flies and smells, as well as clean and safe to use (Cairncross, 1987).

1.8. Justification, aim and objectives of the study

1.8.1. Justification of the study

The foregoing literature review has highlighted the need for proper and adequate water and sanitation services to improve health and reduce the burden among peri-urban populations. Given that most of the urban population growth is occurring in peri-urban areas, this will be a challenge especially for local authorities to put up with the growing demands in sanitation and water supply (Kariuki *et al.,* 2003). This notwithstanding, it is important that any technology intended to be used by people living in peri-urban communities are subjected to sustainability analysis in order to ensure maximum benefit of the technology (Lehmann *et al.*, 2013).

Local authorities need to evaluate different technologies such as low-cost technologies, which comply with the aspects of sustainability highlighted in the literature and are affordable to majority of the residents. Lack of knowledge and non-awareness of the residents with regard to new technologies is a barrier to their acceptance and sustainability (Anand & Apul, 2014; Cordova & Knuth, 2005; McConville, 2003). Therefore, understanding conditions such as socio-economics, perceptions, preferences, population size, technical, environmental and institutional aspects of the intended recipient communities will help local authorities plan for water and sanitation facilities that are sustainable (Avvannavar & Mani, 2008; Mara *et al.*, 2007; Paterson *et al.*, 2007). In the absence of these aspects, it is possible for local authorities and implementers to provide services that are not sustainable because the intended users may misuse or not use them at all (Remigios, 2011). It is important that such situations are prevented so as to avert wasting of the already meagre resources available for developmental projects in peri-urban communities. This study sought to provide a baseline data for successful implementation of appropriate low-cost water supply and sanitation technology options for peri-urban communities in Zambia.

1.8.2. Aim and objectives of the study

Based on the literature review and the justification, this study was set out to identify and evaluate the existing and possible low-cost technology options for sustainable water supply and sanitation in Kanyama and Chazanga, two peri-urban areas of Zambia.

The specific objectives are:

- Identify and evaluate the viability of selected low-cost technologies in Kanyama and Chazanga using criteria that consider socio-cultural, economic, technical, environmental and institutional appropriateness

- Suggest possible low-cost technologies that can be useful for the provision of water supply and sanitation in Kanyama and Chazanga peri-urban areas.

1.9. Thesis outline

The thesis consists of five chapters. This first chapter gives an introduction and literature review of the study and presents the possible low-cost technologies that are used or have the potential for use in peri-urban areas of Zambia. Chapter 2 presents methods employed in the research. Chapter 3 presents results and analysis of the household survey and Focus Group Discussion conducted in the two case study communities i.e. Kanyama and Chazanga peri-urban areas. Chapter 4 presents results from the key expert interviews and analysis of the evaluation of the feasibility of the selected low–cost technologies presented through ranking using a Multi-Criterion Analysis (MCA). Chapter 5 consists of general discussion, limitations to the study, conclusions and recommendations for future research.

CHAPTER TWO: METHODOLOGY

2.1. Introduction

This chapter presents the description of the study area and different methods that were used in an attempt to fulfil the objectives of the research. The study used tiered approach executed in four phases (Figure 2.1). The first phase involved a desktop study to review literature and concepts from previous studies focusing on peri-urban settlements with regard to provision of low-cost water supply and sanitation technologies. Thereafter, a technology analysis was conducted to determine the applicability of the previously selected technologies for the selected peri-urban settlements. The second phase involved development of tools for data collection. Data collection was achieved through a household survey in Kanyama and Chazanga, two peri-urban areas of Lusaka city. Information obtained included current water supply and sanitation status, and practices/preferences of technologies. Further, Focus Group Discussions (FGDs) were conducted to have an in depth overview of the current water and sanitation status in the two communities. The third phase involved interviews and technology ranking through a Multi-Criterion Analysis (MCA) with key experts. The fourth and final phase involved the analysis of data collected during the household survey, FGDs, key expert interviews, and finally, ranking by experts. The diagram below shows the four-phased methodology tiered approach used in this study.

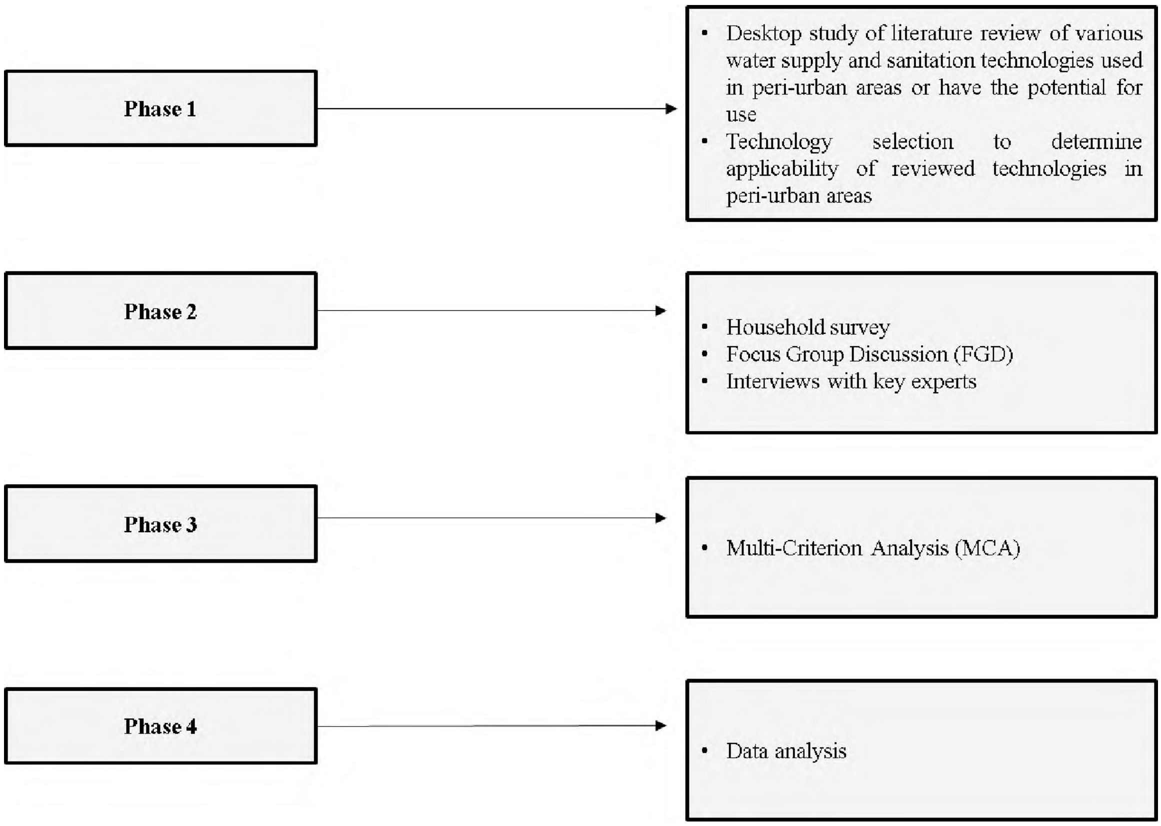

Figure 2.1: Flow chart of the methodological framework used in the study

2.2. Description of study communities

Zambia is divided into 10 provinces. It's fastest growing and most urbanised province is Lusaka which covers an area of 424km^2 of mostly flat land and has a population of 2,198,996 (Van Asperen, 2014). Out of the total population, men account for 49.4% whereas women account for 50.6%. The province has a total of 444,418 households of which 79.6% are male headed and 20.4% female headed. Poverty incidence for the province lies at 24.4% and is highest among households with lower education, the unemployed and non-farming communities (UNDP, 2013). The province is made up of four districts, namely Kafue, Luangwa, Chongwe and Lusaka City (Figure 2.2). Luangwa and Chongwe form Lusaka rural area. From the total population, 15.3% live in rural areas whilst 84.7% live in urban areas of Lusaka province (UNDP, 2013).

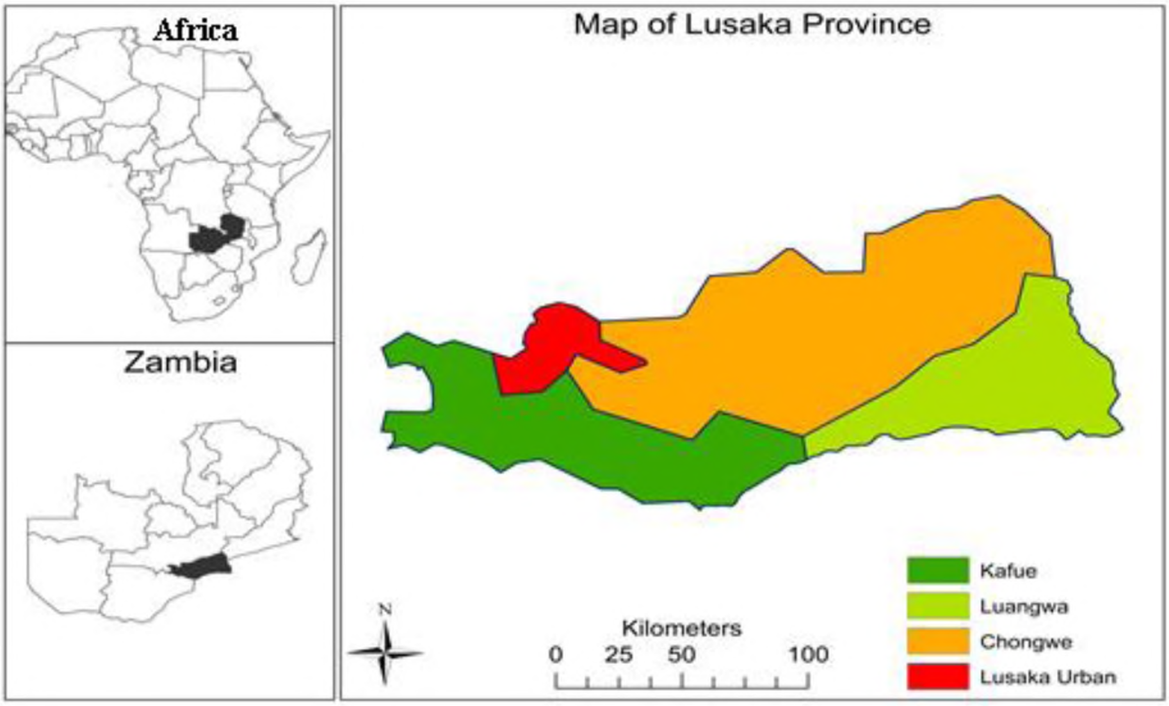

Figure 2.2: Map of Lusaka Province showing the four districts

Lusaka City is experiencing an increase in population and expansion of peri-urban areas. Unprecedented urban growth has seen a rise in the population of Lusaka City from 123,146 in 1963 to approximately 1.8 million in 2010 (Figure 2.3) (Wragg & Lim, 2015). The unprecedented urban population growth is due to high levels of immigration into Lusaka because of the city's diversified economy (UN-Habitat, 2007). More than 70% of the urban total population resides in peri-urban areas. 56% of the peri-urban residents in Lusaka lack access to improved water sources and an estimated 90% lack access to improved sanitation facilities (CSO, 2011).

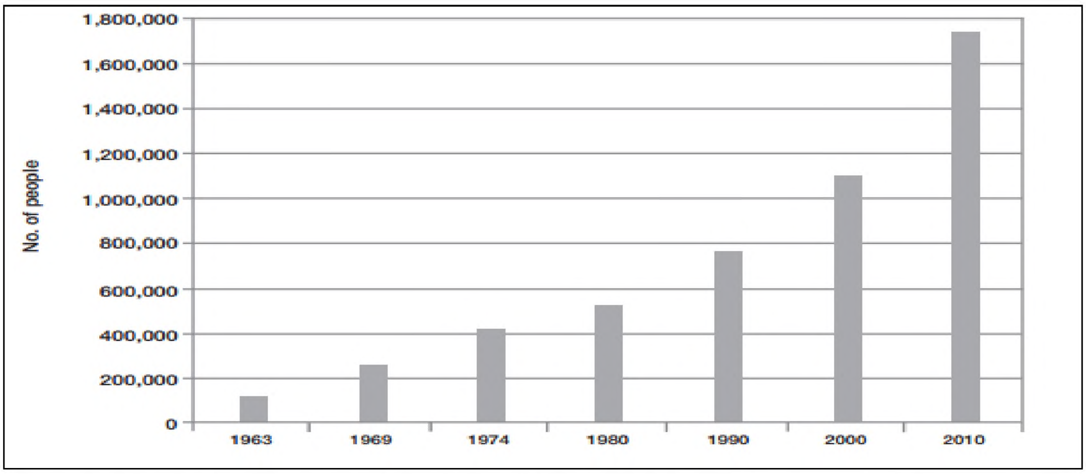

Figure 2.3: Growth of Lusaka City from 1963-2010 (source: Mulenga 2013)

2.2.1. **Case study areas:** Kanyama and Chazanga

This study focused on peri-urbans Kanyama (15°20′14.84″S, 28°14′06.88″E) and Chazanga (15°20′07.69″S, 28°18′36.79″E). Both areas are located in the outskirts of Lusaka City. Kanyama area is divided into 5 branches namely, Northern, Western, North western, Central and Southern branches. The area is characterised by high population growth, informal layout of infrastructure, and high density conditions with most of the population being in the low-income groups (Katooka, 2007). Informal layout of houses in the area makes provision of basic water and sanitation services difficult. The area has a chronic history of Cholera and Acute Watery Diarrhoea (AWD) (UNICEF, 2016). In total, 364,655 people are estimated to live in the area (Holm *et al*., 2015). In addition, Kanyama area is vulnerable to flooding in rainy seasons due to its topographical conditions. The area is generally rocky and has a high water table, which also makes it difficult to construct pit latrines. The area is not on the sewerage reticulation system and water supply is mainly by Lusaka water and Sewerage Company (LWSC). Water supply for this area is abstracted from boreholes, and the level of service consists of both individual connections and communal taps.

On the other hand, Chazanga is a rapidly growing settlement, situated about 9 km from Lusaka's Central Business District (CBD). Until 1999, the area was not officially recognized as a settlement by the government of Zambia. The estimated population of the area is 57 600. The geology of the area comprises an ancient basement complex of limestone and dolomite. Porous and soluble characteristics of these rocks render them susceptible to pollution (DTF, 2013). The population of Chazanga is growing fast due to high birth rates and immigration of people from other settlements. Like Kanyama, Chazanga is not on the sewerage reticulation system but rely on pit latrines (Yasini, 2007). Chazanga is subdivided into 30 zones (Van Asperen, 2014). It operates under the Ward Development Committee (WDC), whose major role is to facilitate development and implement development projects in the area (Yasini, 2007). Both Kanyama and Chazanga have a low coverage of piped water, in most cases communal stand pipes, and residents rely on a combination of shallow wells and standpipes for the supply of water (UNICEF, 2016). The figure below shows the map of Lusaka with the location of Kanyama and Chazanga, and the existing conventional sewerage network lines in the City.

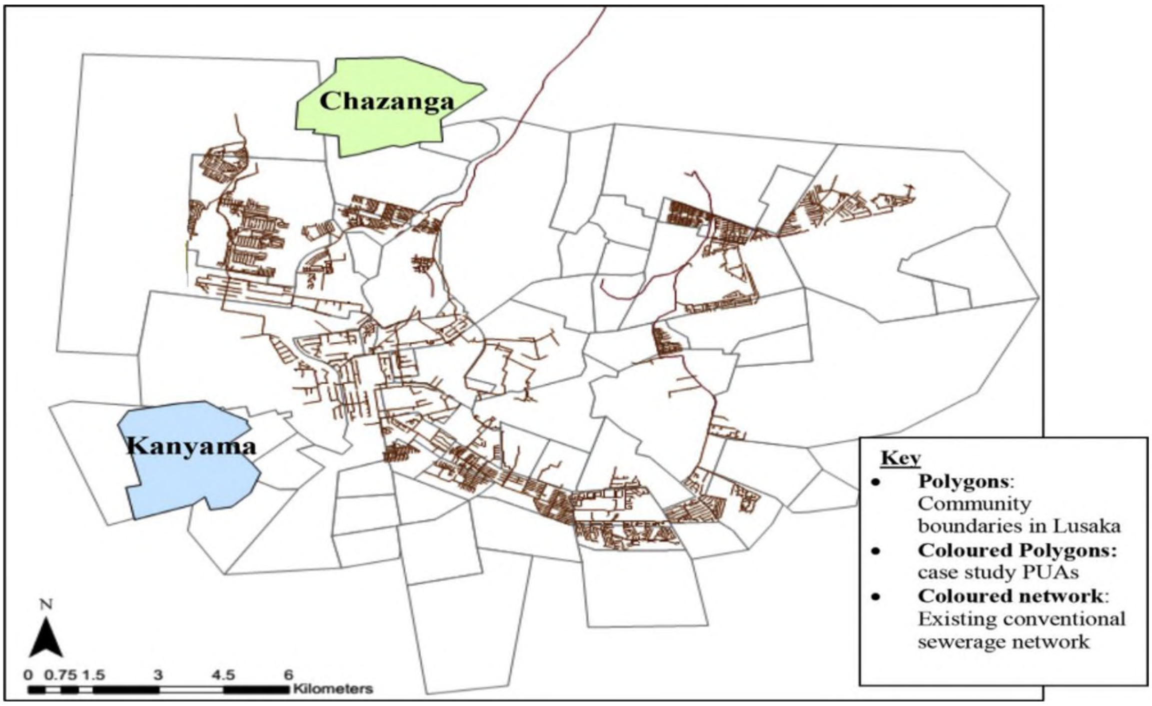

Figure 2.4: Map of Lusaka city showing the case study peri-urban areas and existing conventional sewerage network (source: Kennedy-Walker *et al*. 2015)

2.3. Study approach

2.3.1. Phase one: Literature review

2.3.1.1. Desktop study and technology selection

A desktop literature review of the various low-cost water supply and sanitation technologies was undertaken in order to get an explanatory and comprehensive view of the status quo in developing countries. A number of technologies were considered based on whether they are currently used in developing countries (Katukiza *et al*., 2010), then narrowed down to studies that focused on peri-urban settlements using an adapted descriptive comparison analysis theory from John *et al*. (1980) and Cairncross (1987). The descriptive comparison analysis (Table 2.1) is a common approach to making comparisons of sanitation technologies on a technical basis (John *et al*., 1980). The technologies reviewed were assessed compared using a set of criteria on different given situations to assess their suitability and/or applicability in peri-urban areas. The analysis aided in eliminating non feasible technologies for specific conditions for peri-urban settings.

Table 2.1: Descriptive comparison of some of the feasible sanitation technologies for peri-urban settings (adapted from: John *et al.* 1980 and Cairncross 1987)

Sanitation technology	Population density where suitable	Construction cost	Operating cost	Ease of construction	Water requirement	Required soil conditions	Complimentary off-site investment	Re-use	Health benefits	Institutional requirements
Arborloo	L/M	L	L	easy	none	Stable permeable soils	none	H	good	L
Fossa alterna	L/M/H	L	L	easy	none	Permeable soils/can be built above ground	none	H	good	L
Pour flush	L/M/H	L	L	easy	minimal water near toilet	Stable permeable soils	desludging cost	L	Very good	L
VIP	L/M/H	M	L	easy unless in rocky areas	none	Stable permeable soils	desludging cost	L	good	L
SanPlat	L/M/H	L	L	easy	none	Stable permeable soils	none	L	good	L
Traditional pit latrine	L/M	L	L	easy	none	Stable permeable soils	none	L	low	L
UDDT	L/M/H	M	L	requires skilled labour	none	none	none	H	Very good	M
Simplified sewerage	L/M/H	L	M	requires skilled labour/engineers	on-plot connections	none	sewer	none	Very good	VH
FSM	L/M/H	H	M	requires skilled labour	none	Stable permeable soils	desludging cost	L	Very good	H
Septic tank	L/M	H	H	easy	multiple taps	Stable permeable soils	desludging cost	L	Very good	H

Note: *L=low, M=medium, H=high, VH=veryhigh*

Once the different sanitation technologies had been compared on a technical basis, feasible options for peri-urban settings were then subjected to a sanitation selection algorithm adapted from John *et al.* (1980) and Mara *et al.* (2007) (Figure 2.5-2.7). The algorithm was used as a guide to the selection of the most appropriate sanitation technologies for the specific study areas. The technologies subjected to the algorithm analysis included Pour-flush, UDDT, arborloo, fossa alterna, improved traditional pit latrine, VIP, septic tanks, SanPlat, FSM and simplified sewerage. The parameters considered included conditions such as topography, soil stability, water table variations, vulnerability of the area to flooding, and suitability of the technology in relation to population density, water supply availability, and socio-cultural beliefs.

The algorithm was divided into 3 stages. The first stage commences with the question if the subjected technology requires water for the conveyance of human waste. The answer determines whether sewerage/septic tank toilets can be considered. If neither sewerage nor septic tanks can be used, then the second stage algorithm commences. If water is required, then the assessment of the technology within the first algorithm continues. The second stage of the algorithm commences by asking if there is lack of interest in or strong socio-cultural objections for reusing human wastes. If there are no strong socio-cultural beliefs to the re-use of human waste, then the choice is among urine diversion dry toilet (UDDT), Arborloo or Fossa Alterna. However, if the composting and dehydrating toilets cannot be used, then the third stage of the algorithm commences. Therefore, the choice lies among Pour-flush, Ventilated Improved Pit latrine VIP, Sanitation Platform (SanPlat), Traditional pit latrine and FSM. If the water table was high, then the recommended choices will be VIP and Pour-flush toilets. If the soil is insufficiently permeable or the area is prone to flooding, then the SanPlat and Traditional pit latrine cannot be feasible. If there is a municipal or private system for emptying latrines and users can afford paying for the services, Faecal Sludge Management (FSM) can be an option (Figure 2.3).

In terms of water supply, the technologies subjected to the descriptive analysis theory were found to be the most feasible options for peri-urban areas. This was due to the fact that there are limited feasible options available for water supply that are affordable while reaching a large number of beneficiaries for peri-urban settings. Therefore, the water supply technologies were not subjected to an algorithm analysis.

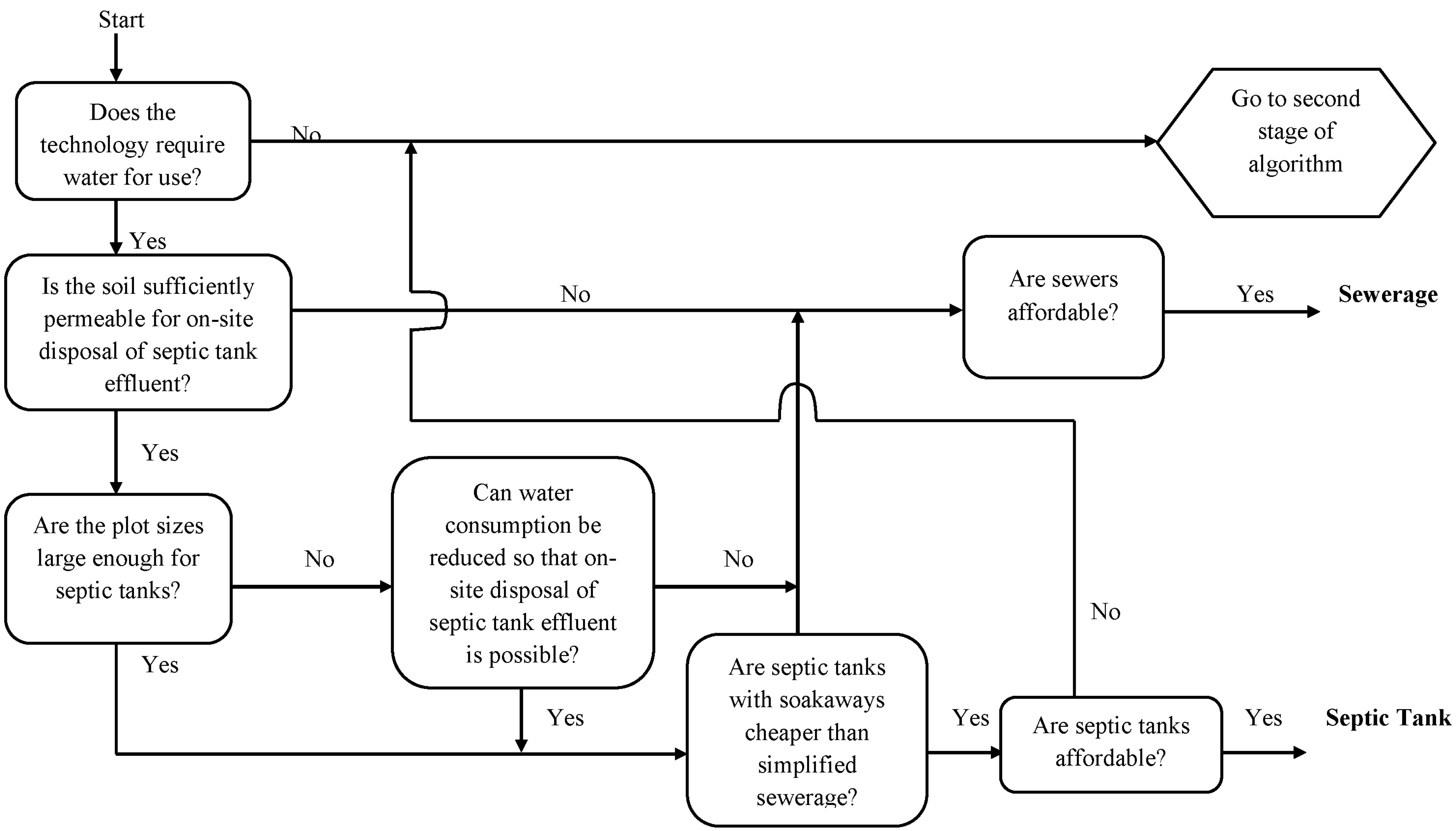

Figure 2.5: First stage Algorithm for the selection of sanitation technology (adapted from John *et al*. 1980 and Mara *et al*. 2007)

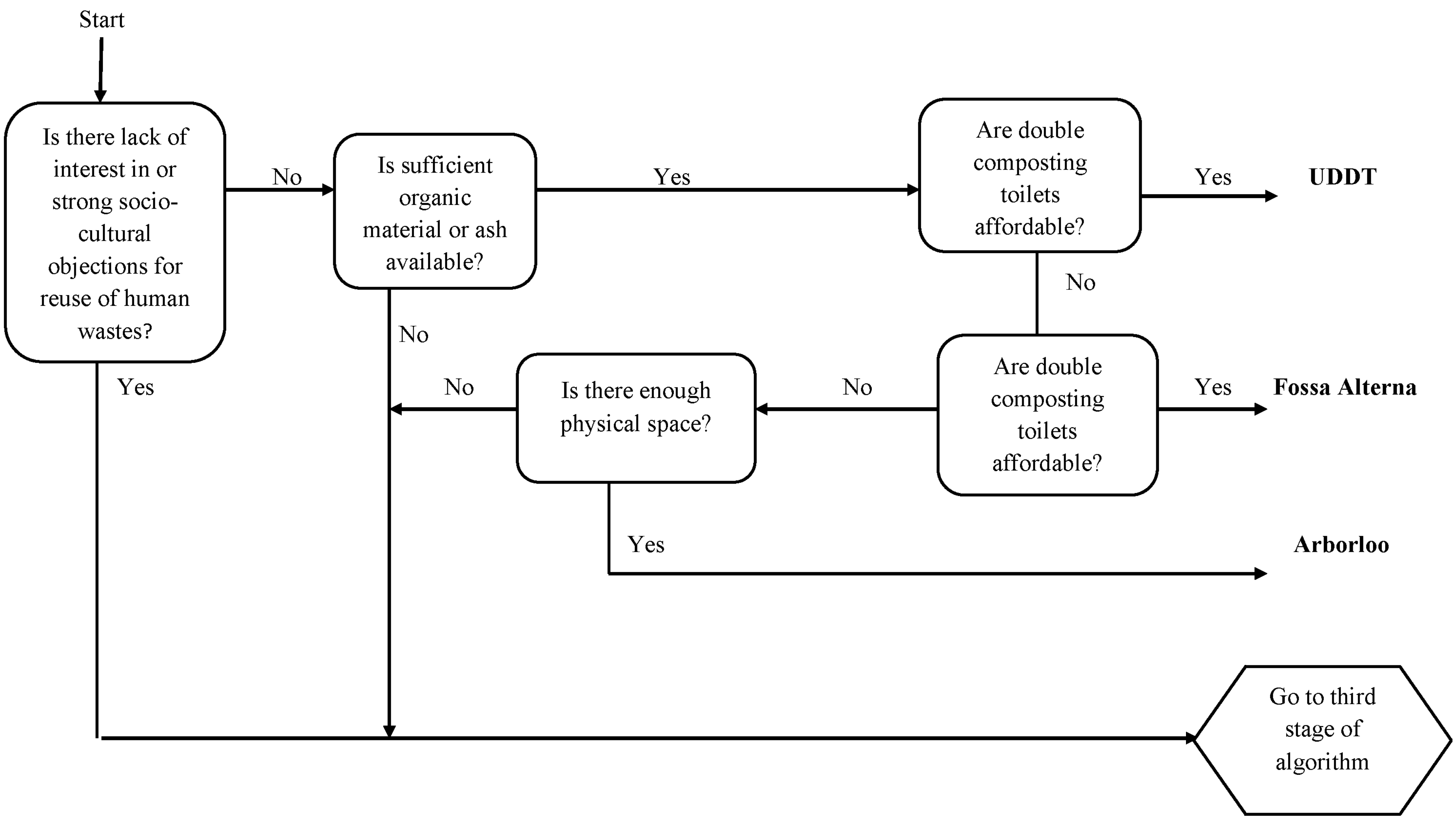

Figure 2.6: Second stage Algorithm for the selection of sanitation technology (adapted from John *et al*. 1980 and Mara *et al*. 2007)

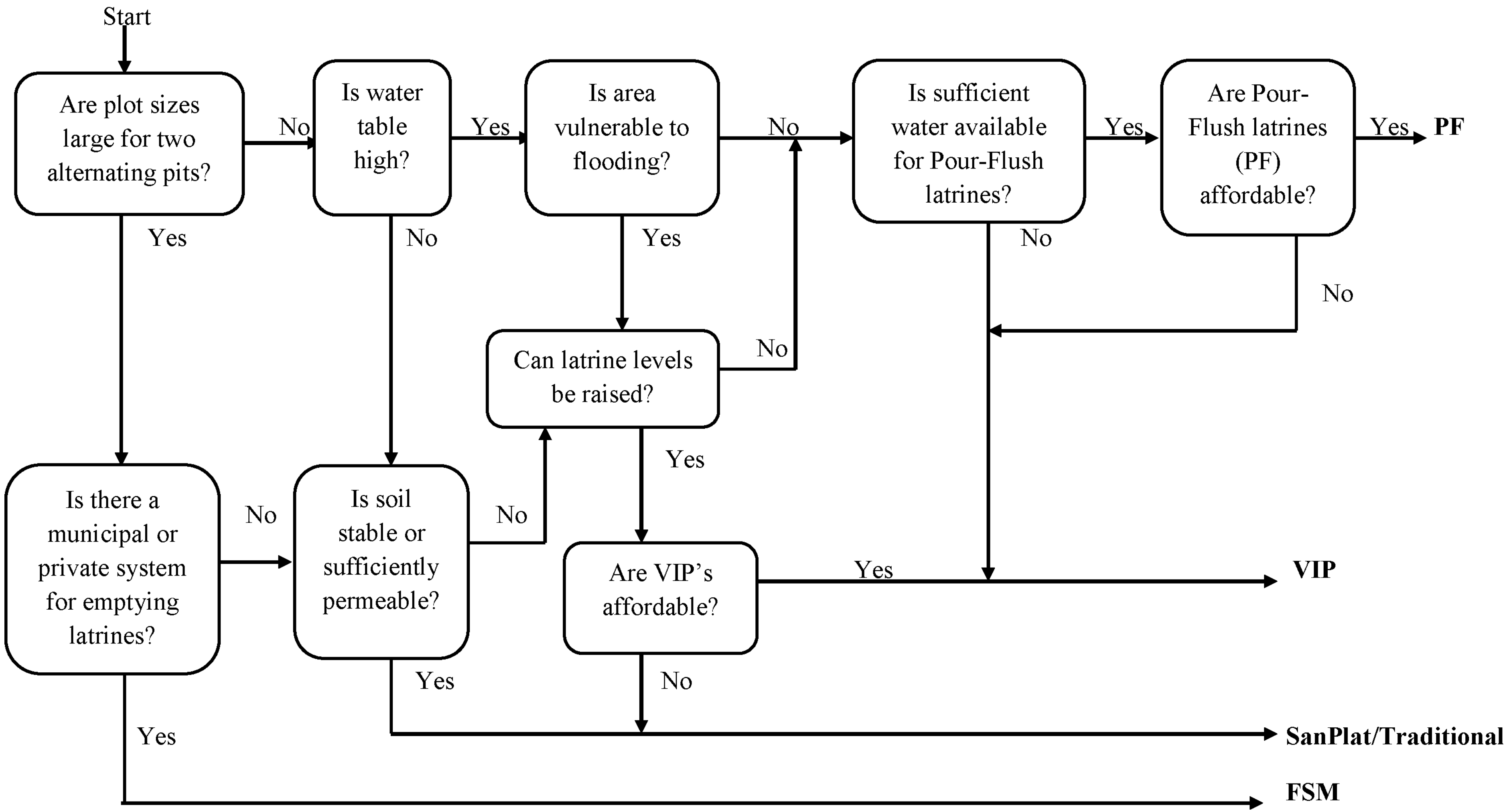

Figure 2.7: Third stage Algorithm for the selection of sanitation technology (adapted from John *et al*. 1980 and Mara *et al*. 2007)

2.3.2. Phase two: Field survey

2.3.2.1. Data collection and sampling

The field survey was carried out in May-June 2015 in Lusaka City, Zambia. The common goal of a survey is to collect data representative of a population (Bartlett *et al.*, 2001). However, cost and time constraints as well as variability of the population could be used to determine the sample size (Hertzog, 2008). Therefore, the final selection of an appropriate approach depends on the aim of the study (Marshall, 1996). A mixed method approach was used for this study. A mixed method approach involves the collection and integration of both qualitative and quantitative data in a study (Creswell, 2014). The final decision on the sample size selected and their location took into consideration the actual situation on the ground such as the size and accessibility of the areas, the type of water supply and sanitation facilities used, through consultations with the representatives from the Lusaka City Council (LCC), Water Trust (WT) and Ward Development Committees (WDC). Ward Development Committee (WDC) consists of elected representatives from zones and branches. A zone or branch is a section under the peri-urban areas consisting of more than 150 households, and is defined by physical infrastructure such as roads (Yasini, 2007). The major role of the WDC is to facilitate and implement developmental projects in the areas (DTF, 2013). Kanyama has about 46,250 households which are subdivided in 5 areas referred to as "branches". Chazanga has approximately 11,300 households, which are subdivided into 30 areas referred to as "zones" (Van Asperen, 2011). The sampled zones/branches and households were chosen based on the cost and time constraints. In Kanyama, households from different branches were selected for the survey. In Chazanga, households from seven (7) zones were sampled. Households in the sampled zones/branches were selected based on the fact that they were not far from each other, thereby reducing traveling time due to few personnel conducting the survey. In addition, the survey was carried out during weekdays between 10am to 4pm. Therefore, the sampled households were selected based on availability of people to participate in the survey. Care was taken to ensure that the respondents were a representative sample of households across Kanyama and Chazanga.

During the household survey and Focused Groups Discussions (FGDs), questionnaires with structured, semi-structured and unstructured questions were used. The questionnaire was first piloted to 10 randomly chosen households representing 5% of the total (i.e. 200) households to be interviewed. The sampled households were not included in the final survey. Thereafter, the questionnaire was refined for final administering.

A stratified random sampling approach (Cohen *et al.*, 2011) was adopted for this study as the most suitable and appropriate method. Stratified random sampling is a method in which the population is divided into subgroups or 'strata', and a random sample is then selected from each subgroup (Latham, 2007). Stratified sampling are easy to implement and more economical especially in urban areas because they minimize travel time and finances. However, due to lack of necessary information with which to create a 'strata', stratified random sampling can have an attempt of sampling error (Breakwell *et al*, 2000). A total of 200 household questionnaires were administered (Kanyama=100, and Chazanga=100). Three people including the Principal Investigator per area carried out the research. A total of 159 respondents interviewed were females and 41 were males. Females were available at homes during the times the survey was conducted. The information collected during the household survey focused on gaining an understanding of the current water supply and sanitation situation, types of facilities used in the areas, people's perception of basic service provision, and their preferences of technologies. Questionnaire is presented in Appendix A.

Additionally, in each study community, a Focus Group Discussion (FGD) was conducted with a select group of households for more assessment of the specific areas with regard to water supply and sanitation (Appendix A). The aim of the FGDs was to generate and evaluate data from different sub-groups of the populations, gather qualitative data, and gather data on the participants' opinions, perceptions and preferences in the technology selection (Cohen *et al.*, 2011). The FGD composed of 6-11 participants in each area. The durations for the FGD were 1 hour 30 minutes to 2 hours long. In Chazanga, the FGD was made up of 11 participants, 4 males and 7 females. In Kanyama, the FGD was made up of 9 participants, 6 males and 3 females. The feasible technologies for the areas analysed during the literature review were presented to the community during the survey and the FGD using pictures, which were explained to the participants how each technology works, its advantages and disadvantages. This helped gather information about participants' perceptions and preferences regarding the proposed sanitation technologies.

2.3.3. Phase three: Multi-Criterion Analysis

2.3.3.1. Expert interviews and ranking of technologies

A Multi-Criterion Analysis (MCA) is a form of decision support system that deals with decision making problems across a range of different criteria and indicators (Pohekar & Ramachandran, 2004; Sheppard & Meitner, 2005). Criteria are principles by which something is evaluated on and indicators are any variable or component that are used to reach a final decision of each criteria (Table 2.2) (Mendoza & Macoun, 1999). An MCA focuses on applying weights and scores to alternatives and to determine a preferred outcome (Akadiri, 2011). In this study, a multiple criteria approach was used in an attempt to encompass different points of views (i.e. the experts as well as the local people's points of view) quantitatively in the decision making process (Karagiannidis & Perkoulidis, 2009).

A total of 7 interviews were conducted with various key informants using a snowball sampling methodology (Cohen *et al*., 2011). This was achieved through a questionnaire that was made up of semi-structured and unstructured questions. Key experts working in government institutions such as the National Water Supply and Sanitation Council (NWASCO), Ministry of Local Government and Housing (MGLH), Lusaka Water and Sewerage Company (LWSC), Lusaka City Council (LCC) and Non-Governmental Organisations (NGOs) including WaterAid Zambia, Water and Sanitation for the Urban Poor (WSUP), Water and Sanitation Association of Zambia (WASAZA), and Village Water Zambia (VWZ) were interviewed. The aim of the key expert interviews was to obtain information on: (i) the present water supply and sanitation situation in peri-urban areas (ii) the type of technologies implemented, if the organisations are involved in the implementation of low-cost technologies (iii) community involvement in planning, selection, implementation of technologies and willingness to pay for technologies (iv) challenges faced with regard to introduction of new technologies in peri-urban communities, and (v) sustainability of water supply and sanitation technologies for Kanyama and Chazanga.

2.3.4. Ethical practice

This research followed ethical practice at all times. Prior to conducting the survey in both areas, meetings were held with managers from the Water Trusts (WTs') in each respective area. At these meetings, the aim and objectives of the study were explained and consent sought.

During the survey, informed consent was sought from respondents by agreeing verbally at the start of each survey to participate in the survey. Respondents were made to understand and agree to participate in the research (Anthropology Southern Africa, 2005). In addition, the respondents had the right to withdraw their consent at any time in the research process (Babbie, 2011). Before questionnaire or interview administration had begun, voluntary participation from the respondents was obtained. Right of privacy was observed as certain kinds of information are more personal than others. Respondents had the right to not take part in the research, answer questions, and have their homes intruded (Cohen *et al.*, 2011). Respondents were guaranteed confidentiality and anonymity through a coding system for each questionnaire (Yin, 2011).

2.3.5. Phase four: Data analysis

2.3.5.1. Descriptive statistics and content analysis

Household survey results were quantified, coded, captured and analysed using Microsoft Excel Spreadsheet. Descriptive statistics were used to describe the characteristics of the study participants (Cohen *et al.*, 2011). The qualitative data collected during the FGDs and key expert interviews were copied into Microsoft word. This was done by writing the analysis directly from the audio recordings and selecting the important materials from the source. The data were then coded according to categories that were frequently coming out of the analysis and further organised by themes and research questions. The data were then analysed using content analysis technique (Cohen *et al.*, 2011). Content analysis classifies written, verbal or visual communication messages, reducing it to more relevant and manageable bits of data (Elo & Kyngäs, 2008). Content analysis is used for analysing both qualitative and quantitative data.

2.3.5.2. Ranking of technologies using a Multi-Criterion Analysis (MCA)

Preferred technologies from the field survey and Focus Group Discussions (FGDs) were subjected to ranking, using a Multi-Criterion Analysis (MCA) (Table 2.2). Five aspects of sustainability, namely technical, environmental, institutional, socio-cultural and economic aspects were considered.

The experts included engineers, environmental health scientists and social development specialists. Regular ranking with a scale of 1-5 (1 being the least important and 5 the most important), based on sustainability indicators, was used to estimate scores for the selected criteria for each options (Mendoza & Macoun, 1999) through the following steps:

- Step 1: The sum of ranking votes for each criterion by each expert was calculated to get the total criterion ranking.

- Step 2: A total criterion ranking of each technology was calculated using the sum of total criterion ranking and the total number of criterion.

- Step 3: The average weighted scores was calculated from using the total criterion for each technology.

- Step 4: The sum of the average weighted scores (i.e. for each technology) was used to arrive at the total ranking score per sustainability aspect.

Based on the preferences of the community survey respondents and Focus group discussion (FGD) participants, three sanitation options, including Ventilated Improved Pit (VIP) latrine, Pour-flush and Fossa Alterna, were presented to the experts for ranking. The Fossa Alterna was included on the ranking as it was the highest preferred composting option by the community members. The flushing toilet was also highly preferred by the community. However, it was not presented to the experts for ranking as it was economically not feasible to the majority of the community members. Water supply technologies were not presented for ranking as all four (i.e., rainwater harvesting, boreholes, protected wells and communal standpipes) were found to be applicable technologies for peri-urban areas. Ranking of the sanitation technologies by the experts determined the most sustainable and suitable options for peri-urban settings such as Chazanga and Kanyama.

Table 2.2: Sustainability aspects used in ranking of technology (after: Katukiza *et al.* 2010 and Mara *et al.* 2007)

Criteria	Indicator
Technical	• availability of construction material and labour • demand • compatibility with local conditions of the area
Environmental	• risk of emission of pollutants to the environment • risk of pollutants on the environment and human health • safe reuse of treated waste • protection of the source against contamination • accessibility, availability and reliability of technology
Institutional	• adoptability of the technology by users • involvement of users in planning, decision making, implementation and maintenance of technology • management of technology at lowest appropriate level
Socio-cultural	• acceptance of technology by the users • perception of the technology by the users • involvement of users in operation and maintenance • ease of use of facility by the users
Economic	• initial costs • flexibility of the technology to accommodate different household incomes and material availability • resources for operation and maintenance

2.4. Conclusion

This chapter presented the methodological approach for the study. Factors such as age of interviewee, sex, level of education attainment, household income, household size, and availability of services, among others, were used to describe the characteristics of the study participants and analysis of Chapter 3. The sampling method was determined by random stratified sampling through semi-structured questionnaires during the filed survey (household survey and Focus Group Discussions (FGDs) in Kanyama and Chazanga peri-urban areas. During the Key expert interviews, a snowball sampling approach was implored. Data collected was quantified, coded, captured and analysed using Microsoft Excel Spreadsheet and content analysis. Further, a Multi-Criterion Analysis (MCA) aided in ranking of feasible sanitation technologies by the Key experts using sustainability criteria.

CHAPTER THREE: RESULTS AND DISCUSSION

3.1. Introduction

This chapter presents the results of the analysed data collected during the field survey in Kanyama and Chazanga. The results include socio-economic and demographic status of the sample population, current water and sanitation situations of the areas, the type of technologies used and communities' preferences on the proposed sanitation technologies.

3.2. Household survey

3.2.1. Socio-economic and demographic characteristic of Kanyama and Chazanga

3.2.1.1. Characteristics of Kanyama and Chazanga and the sampled population

A total of n=200 households were surveyed for the study; 100 households each from Kanyama and Chazanga. Table 3.1 gives an overview of the characteristics of the two study communities.

Table 3.1: Key characteristics of the case study areas (after: CSO 2012; DTF 2013 and von Münch 2007; Lusaka District Health Office)

Characteristic	Kanyama	Chazanga
Approximate population	364,655	57,600
Number of households	46,250	11,300
Typical number of household per plot	7.0	6.0
Under-five diarrhoea cases for a period of 5 years (2010-2015)	4,443	2,636

Note: *A plot is a small piece of land the size of which can occupy a house and a small yard.. Diarrhoea is the most frequent disease suffered in peri-urban areas annually.*

3.2.1.2. Gender, age distribution and religion of respondents

Majority of the respondents in both study communities were female 79.5% (Figure 3.1), and the average age group of the respondents observed was 25≤34 years old (Figure 3.2).

Other age groups interviewed included respondents above 55 years (7.5%). The majority of the interviewed were female because the survey was conducted during the times men were away for work. The survey was conducted during weekdays between the times 10:00am to 4:00pm. However, 77% of the interviewed households were male headed, whereas, 23% were female headed.

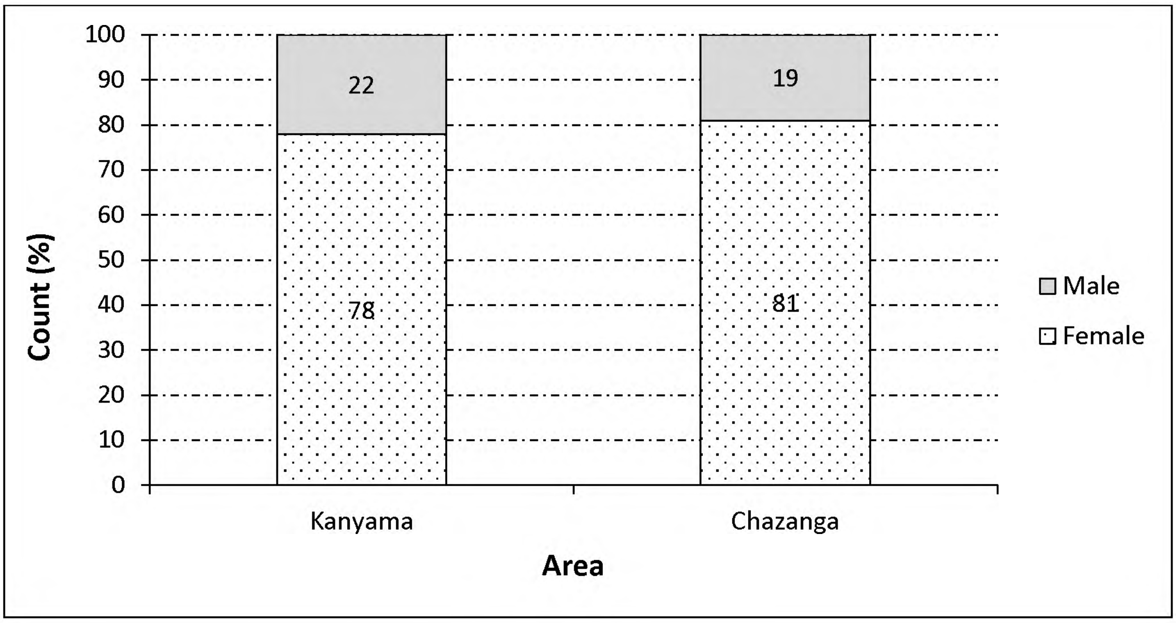

Figure 3.1: Gender of respondents' per area

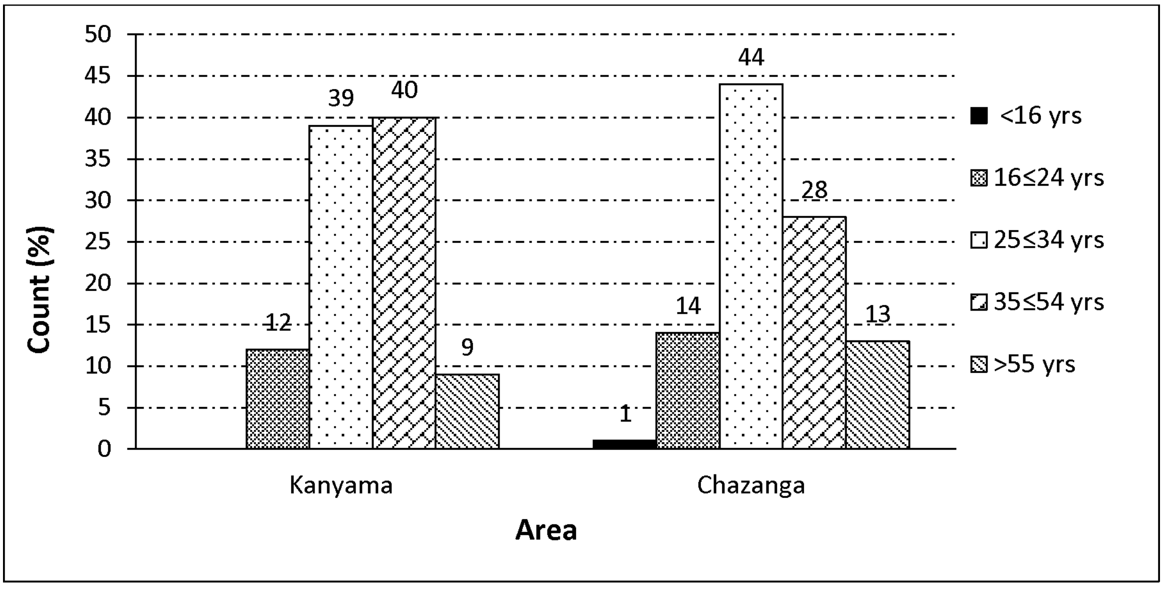

Figure 3.2: Age distribution of respondents' per area

3.2.1.3. Marital status, religion and family size of households of respondents

Seventy-seven percent (77%) of the respondents interviewed from both study communities were married. The most predominant religion was Christianity (96%), and respondents of other religious background, mostly Islam, Traditional religions and Christianity/Traditional, were in the minority.

The average household size of the respondents in the survey was 6-10 persons (total household population-home and away) per household (Table 3.2), although the households ranged from 1-12 household members. According to the report by Zambia Central Statistics Office (CSO) (2013), the average household size in Lusaka is 5 members.

Table 3.2: Marital status, religion and household size among the sample population

Variable	Chazanga	Kanyama
Marital status		**(%)**
Married	72	82
Single	10	6
Divorced/ separated	7	3
Widowed	11	9
Total	**100**	**100**
Religion		**(%)**
Christianity	95	97
Other	5	3
Total	**100**	**100**
Household size		**(%)**
1-5 person	49	43
6-10 persons	47	50
More than10 persons	4	7
Total	**100**	**100**

3.2.1.4. Migration data and duration of stay in areas

Peri-urban settlements are made up of people migrating from various areas. It is evident from Figure 3.3 that a mean of 40% of the surveyed households from both study communities (34% and 46% in Kanyama and Chazanga, respectively) migrated from areas within Lusaka city to settle in the study communities. However, the results also showed that 40% of the households in Kanyama came from outside Lusaka.

In Kanyama, 53% of the surveyed households had lived in the area for a period of over 10 years, whereas in Chazanga, 34% of the surveyed households had lived in the area for 2-5 years.

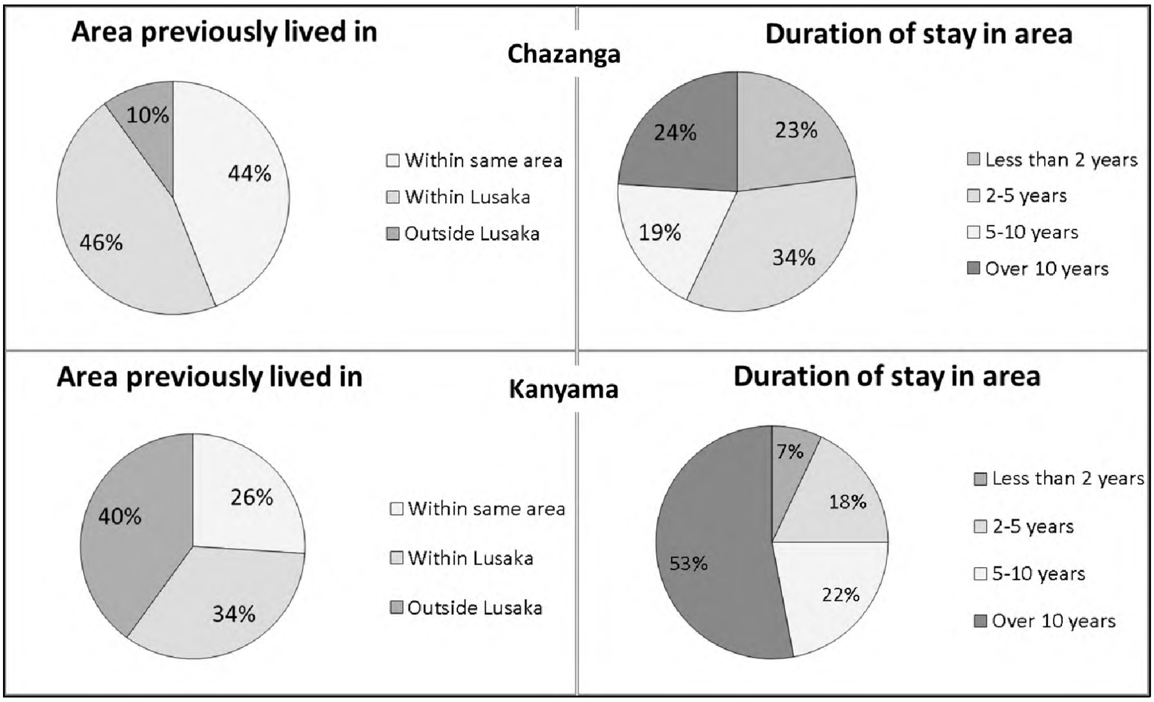

Figure 3.3: Duration of stay of respondents' in the area and previously area lived in for Kanyama and Chazanga

3.2.1.5. Literacy levels of the sampled population

Fifty-five percent (55%) of the respondents from both study communities had achieved some secondary school level of education. 36% had achieved some primary school level, and 3.5% had no form of formal education (Figure 3.4).

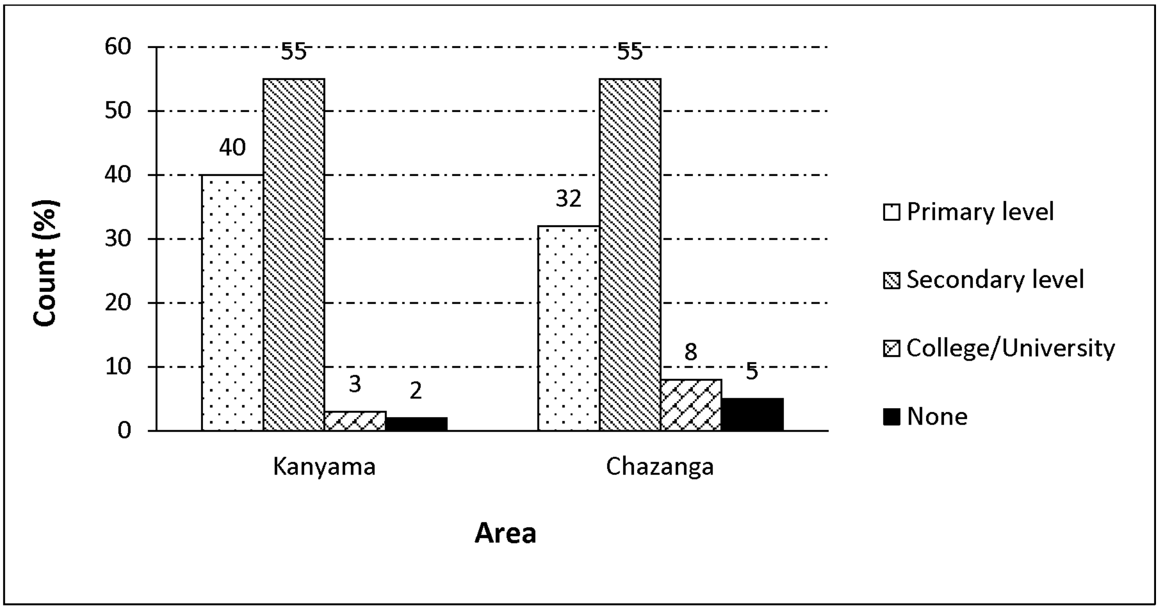

Figure 3.4: Literacy levels of the respondents'

3.2.1.6. Monthly income, income source and priority of monthly expenditure

The results showed that 47% of the respondents' household monthly income in both areas was between ZMW 1, 000 to ZMW 1, 999. This was distributed among various household expenditures such as food, rent and other utilities. Monthly income was through both informal and formal employment and it was observed that households had several sources of income. Majority (66%) of the respondents' income source in both areas was through some kind of entrepreneurial activity. These activities ranged from domestic vendors of foodstuffs, subsistence farmers, carpenters, and real estate owners (rented part of the rooms in their houses), among others. Chazanga had the highest number of households employed in a formal occupation, working for either the Government or private institutions (Table 3.3). Analysis of the average monthly household expenditure showed that, in Chazanga, the average monthly expenditure for households (ZMW 1,336) was higher than that of households in Kanyama (ZMW 1,153). According to the 2015 Living Conditions Monitoring Survey for Zambia, the monthly household expenditure for urban areas in 2015 was ZMW 2,680 (CSO, 2015). Respondents of households in Kanyama spend ZMW 826 on food and ZMW 326 on non-food items such as housing, water and electricity, while in Chazanga, households spend ZMW 900 and ZMW 436 on food and non-food items, respectively, as seen in Table 3.3.

In terms of priority of order of monthly expenditure (repondents most to least expenditure), sanitation was the least important monthly expenditure. The order of priority of monthly expenditure was housing, food (this includes bread, oil, meat, maize meal among others), water, electricity and sanitation. Housing was highly prioritised in both study communities as respondents reported that it is important to have shelter over their heads. Sanitation was least prioritised as respondents highlighted that they can use other means such as accessing their neighbours toilets, public toilets or practice open defecation.

Table 3.3: Monthly income and source of household income in the sample population

Variable	Kanyama	Chazanga
Monthly household income	**(%)**	
ZMW 0-999	31	17
ZMW 1,000-1,999	44	50
ZMW 2,000-2,999	11	15
ZMW 3,000-3,999	10	10
Over 4,000	4	8
Total	**100**	**100**
Income source	**(%)**	
Formal	23	30
Private	20	23
Government	3	7
Informal	70	62
Self-employed	32	40
Rent	11	8
Occasional jobs	7	8
Self-employed and rent	20	6
Total	**100**	**100**
Average monthly household expenditure	**(ZMW)**	
Total monthly household expenditure	1,153	1,336
Food	826	900
Housing (tenants)	200	300
Electricity	58	70
Water	68	66
Sanitation	-	-

3.2.1.7. Comparative figures between Chazanga and Kanyama in terms of socio and economic aspects

Similar socio and economic aspects were observed in both study communities. It was observed that in Kanyama, the average monthly amount spent on rent is ZMW 200 with ZMW 500 being the highest amount paid and ZMW 100 being the lowest. In Chazanga, the lowest amount paid for rent was also noticed to be ZMW 100, with the highest being ZMW 900. The average amount paid for rent was ZMW 300. From this observation, it can be see that accommodation in Chazanga is slightly more expensive than Kanyama. In both areas, the average number of people per household ranged between 6-10 persons. In Kanyama, the highest number of persons per household interviewed was 12, whereas, in Chazanga, it was 11 household members. The order of priority of monthly expenditure in Kanyama was rent, food, water and electricity. However, in Chazanga, the order of priority of monthly expenditure was rent, food and water. Sanitation and electricity were ranked lowest as majority of the respondents pointed out that they can live in a house without electricity and use other means of sanitation facilities. The use of charcoal for cooking and use of neighbour's sanitation facilities was observed among people that had no electricity or sanitation facility within premises.

3.2.2. Current water supply situation

3.2.2.1. Types of water sources

The most predominant type of water supply facility for both study communities was the communal tap. Forty-two percent (42%) of the respondents accessed their water from communal taps. Figure 3.5 illustrates a comparison of service levels to residents in the two study communities. In Kanyama, 30% of the population accessed water from both communal taps and shallow wells. In Chazanga, 35% access water through communal taps while 34% get water through individual water connections in their yard. In Kanyama area, only 19% of the respondents had individual piped water connections. It was observed that in Kanyama, the cost of connecting an individual pipe in the one's yard was high due to the rocky conditions of the area as opposed to Chazanga, which has loose soils that allows for easy laying of pipes. Laying of individual yard water connections is provided by the staff from the Water Trusts (WTs') under license from the Commercial Utility (CU), Lusaka Water and Sewerage Company (LWSC).

It was observed that 77% of the respondents preferred piped water, i.e. water from communal taps and individual connection to homes because they felt the quality of water was better than other sources. Piped water was used mostly for cooking and drinking. However, the cost of connecting individual water to homes, as well as affordability is a limiting factor for majority of the people, especially in Kanyama, for having piped water.

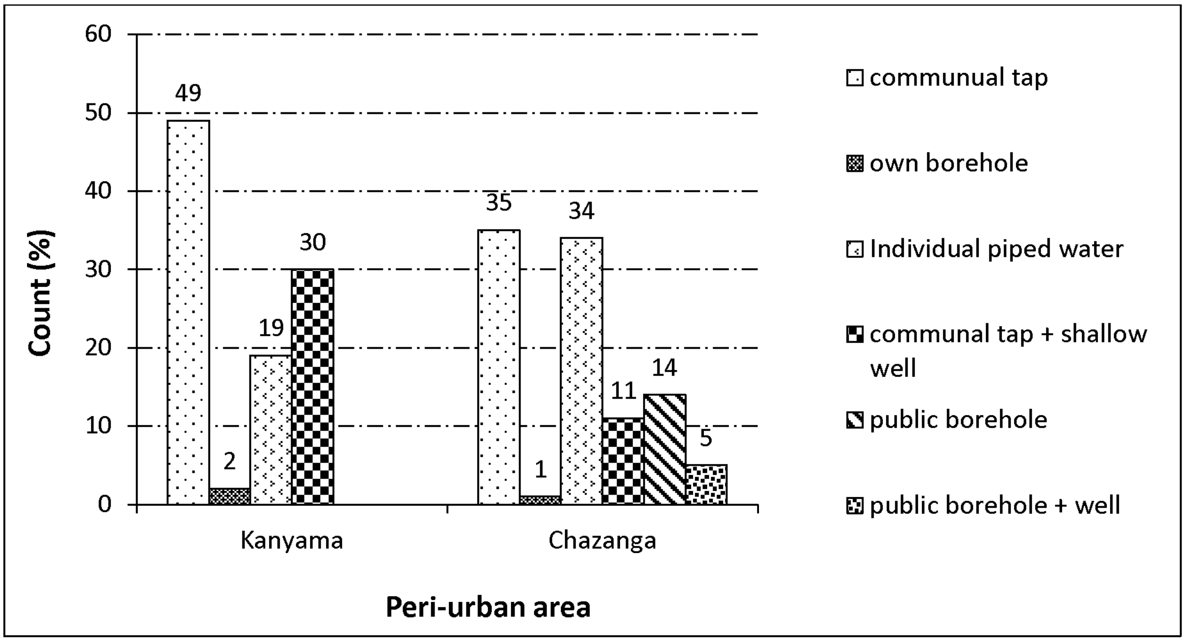

Figure 3.5: Levels of water services available in Kanyama and Chazanga

3.2.2.2. Affordability of water

The range of cost of water starts from 5 ngwee for a 5-litre container to ZMW 5 for a 200-litre drum. Majority of the residents in Kanyama and Chazanga fetch water in 20-litre containers. The cost of, for example a 20-litre container, is not standardised across all peri-urban areas in Lusaka. Within Chazanga and Kanyama areas, it was noted that the cost of a 20-litre container water from communal taps managed by Lusaka water and Sewerage Company (LWSC) was ZMW 10ngwee, which was half the cost of that managed by private water providers. Water at communal taps and kiosks are metered and water is sold by prepayment method. Each communal tap or water kiosk has an attendant who collects money from residents that come to fetch water. A water kiosk differs from a communal standpipe in terms of the way they are built. A communal standpipe is open (Figure 3.6C), whereas, a kiosk has a shelter (Figure 3.6 B and D). A water kiosk is built with a shelter so that kiosk operators supplement their income by selling various other items of daily need. The operator then submits the money to the water providers. Receipts are not issued to the residents, but rather each communal tap is metered and at the end of each supply period, the attendant checks the amount of litres of water sold.

In most cases, the attendants are members of the community as seen in Figure 3.6C. Therefore, the recommended litres of different containers provide an accurate measure to the communal taps attendants of determining water volumes.

Respondents in both communities had mixed views with regard to affordability of water. In Kanyama, 47% of the respondents felt the cost of water is high, and 53% felt the cost is fair. The average monthly cost of water for households that accessed water from communal taps in Kanyama was ZMW 56. For households with individual connections, the average amount spent per month was ZMW 172. In Chazanga, 75% of the respondents felt the cost of water is fair, whereas, 24% felt the cost is high. The average cost of water per month for households was ZMW 61 for accessing water from communal taps and ZMW 85 for accessing water through individual connections, respectively.Households that said the cost of waster was fair reported to have been fetching water from communal taps managed by Lusaka Water and Sewerage Company (LWSC). In both study communities, respondents felt the cost of water is high due to irregular and low levels of household income and intermittent water supplies for individual connections. The findings of affordability of water were similar to the study findings by Mwandawande (2005), which revealed that consumers in peri-urban communities perceived the cost of water as being too high based on intermittent water supply for individual connections which is proportional to the amount paid per month.

Figure 3.6: (A) 20 litre containers used for fetching water at the communal taps (notice the communal tap attendants in (B)), (C) residents fetching water from communal tap and (D) kiosk (source: SusanA Secretariat 2010).

3.2.2.3. Water consumption

In both study communities, 56.3% of the interviewed households made an average of three trips per day to fetch water, and majority (72%) of the people involved in water fetching were female. 20 litre plastic containers were commonly used to fetch water in both peri-urban areas (Figure 3.6 A). Other containers used for fetching water included 5, 10, 30, 40 and 50-litre containers as well as 200-litre plastic drums. 40 and 50-litre containers were carried on wheelbarrows, whereas 200-litre drums were carried using gravity by rolling them.

For households that accessed water from communal taps, an average of 5,800 litres of water is collected per household per month in both study communities. With an average household size of 8 persons, the estimated daily per capita consumption per day is 24 litres. The results observed were similar to findings of a study conducted in four peri-urban communities of Mumbai City, India. Household from the four communities fetched water from communal taps and with low water consumptions patterns of less than 40 litres per capita per day (Kumar & Harada, 2002).

3.2.2.4. Adequacy and reliability of water sources

In both study communities, households are not restricted to the amount of litres of water they should fetch from a communal tap. Households are allowed to fetch as much water as they want for use as long as they have money to pay for the amount of water fetched. Several payment methods were observed depending on where one fetched water. Households with piped water connections within their premises allowed other neighbours to fetch water from them for a fee. The numbers of households that fetch water from the tap divide the monthly water bill. Water bills are issued on a monthly basis to the customers. Settlement of the bill by the customer is due 2 weeks after collection of the bill (Katooka, 2007). Majority of the respondents found this system cheaper than fetching water from the communal taps. However, this practise is illegal against the water providers. Some respondents who daily buy water from communal taps also used water from shallow wells since they could not afford to buy sufficient water for all their household needs. The supplementary water from the wells was used for activities such as bathing and cooking. In both study communities, respondents reported that households with heads who are more than 60 years of age and accessed water from communal taps are entitled to 40 litres of water for free per day.

3.2.2.5. Challenges in water supply

Figure 3.7 shows the distribution of challenges faced by the sample population with communal taps in Kanyama. In Kanyama, 39% of the respondents that accessed water from communal taps complained of rationing of taps. Most peri-urban areas in Lusaka City receive intermittent supply of water for 5 to 8 hours (Katooka, 2007). Communal taps were opened for a period of 3-8hrs. Twenty-three percent (23%) of the respondents complained of congestion especially in the dry season. Another challenge highlighted in Kanyama was distance to communal taps. The average distance from the resident's homes to a communal tap in Kanyama was 300 to 600 meters.
Additionally, the cost of connecting an individual tap was reported to be high by the respondents, as residents are required to procure all the material for installation.

Therefore, the cost associated with individual connections is prohibitive to the residents in these settlements resulting in use of alternative sources such as shallow wells (Kulabako *et al*., 2010). The shallow wells are constructed not far from the pit latrines due to lack of space per plot as seen in Figure 3.8 (A). This contributes to periodic outbreaks of diarrhoea related diseases in the area.

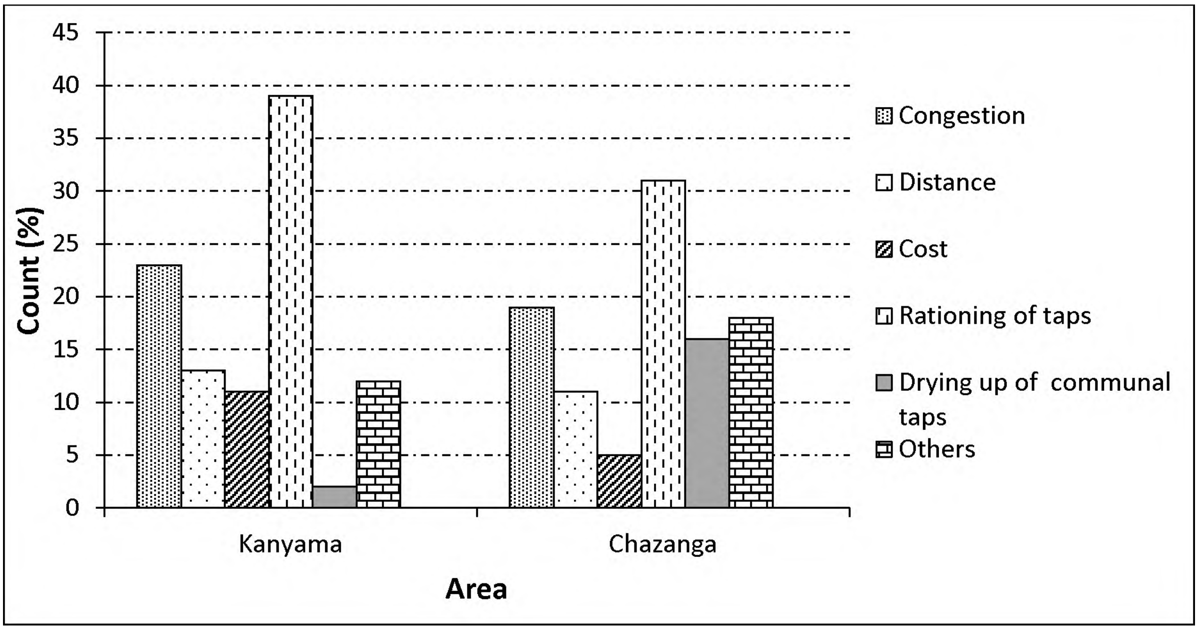

Figure 3.7: Distribution of challenges faced by the respondent families that accessed water from communal taps in both communities

Chazanga area faced similar challenges like Kanyama with regards to water supply. 31% of the respondents complained of rationing of water at communal taps. The taps in the area were opened for a period of 3-8 hours per day. The supply hours of water at communal taps are constant throughout the year. Challenges highlighted included poor quality of water, especially during rainy seasons and interim drying of some communal taps, especially in dry seasons. The dry taps are not attended to or repaired by water providers. As a result, this lead to congestion, particularly at the available communal taps. In Chazanga, the average distance from the houses to the communal taps was 150-300 meters. As a result, residents that did not have nearby communal taps accessed water from other sources such as privately owned boreholes at a cost. This excluded the poorer households who could not afford to fetch water from the boreholes, thereby resorting fetching water from shallow wells. Other challenges experienced in both study communities were lack of water when there is no electricity, high charges of water during power interruptions and unkempt water sources.

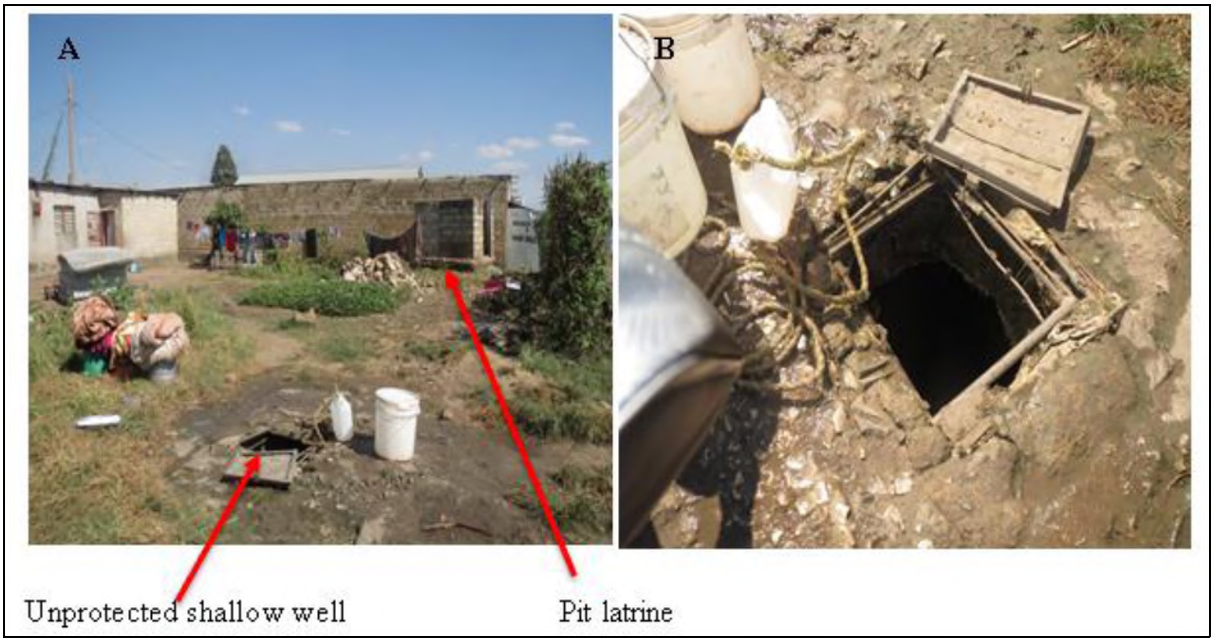

Figure 3.8: Photographs illustrating unprotected shallow wells found in the study areas

3.2.2.6. Community recommendation

Most of the residents indicated preference for a higher level of services such as having many water points. Reasons given included reducing congestion at the communal taps and time devoted to fetching water especially by women and children (53%), as well as to decrease the probability of infection from a disease outbreak in the areas (32.14%). However, respondents also stated that they do not take any action to contribute to water projects due to lack of funds in addition to living in rented houses. As a result, they feel no need of installing water connections in houses that are not theirs.

3.2.3. Current sanitation situation

3.2.3.1. Types of sanitation facilities

The sanitation facilities found in Kanyama and Chazanga ranged from traditional pit latrines to flush toilets. Eighty-four percent (84%) of the respondents in both study communities used traditional pit latrines with or without a slab for excreta disposal. Figure 3.9 shows the contrast in sanitation facilities in both Kanyama and Chazanga among residents.

Figure 3.9: Contrast in sanitation technologies within Kanyama and Chazanga. (A) Unimproved pit latrine with a superstructure made from plastics, (B) unimproved pit latrines also used as a bathroom in Kanyama and (C), a VIP latrine in Chazanga

Majority (57.5%) of the responding households in both study communities were tenants. It was observed that an average of 4-6 households shared one sanitation facility. Kanyama had the highest number of responding households who were tenants (71%), whereas in Chazanga 44% of the responding households were tenants. From Figure 3.10, it is evident that responding households, especially among tenants in both study communities, sometimes wait to access the shared sanitation facility. This is due to the fact that, in most cases, sanitation facilities, especially pit latrines, are also used as bathrooms.

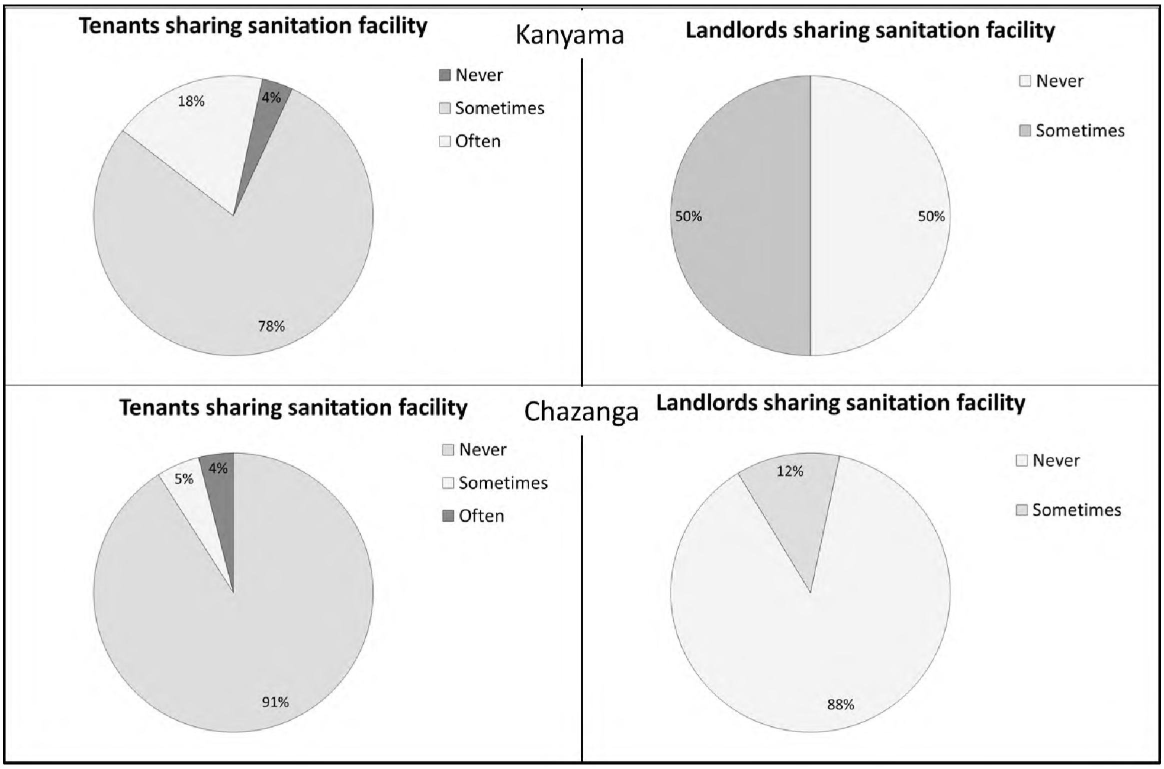

Figure 3.10: Frequency of waiting to access sanitation facility by the sample population in both study communities

In terms of satisfaction with the current sanitation situation, 58.5% of the respondents were satisfied with the current sanitation situation. Levels of satisfaction differed between tenants and house owners. Majority of the house owners that used shared sanitation facilities with their tenants complained of improper use of toilets and high filling rates. However, respondents that used private toilets were only dissatisfied with general cleanliness of the area and lack of waste management. Determinants used for satisfaction with the current sanitation situation in both Kanyama and Chazanga included the general cleanliness of the surroundings, type of toilet facilities used and their cleanliness, and the number of households sharing a sanitation facility. Reasons for the respondents' dissatisfaction included frequent outbreaks of diseases, flooding of the areas, unregulated construction of poor toilets, fast filling rate of toilets, improper use of the toilets due to use by many households, lack of proper waste management handling, and not emptying full toilets. However, in Kanyama, 72% of the respondents were dissatisfied with the current sanitation situation (Figure 3.11); of which majority were respondents that used shared sanitation facilities. Reasons for the respondent's dissatisfaction included fast filling rate of toilets and improper use of the toilets due to use by many households. Ninety-nine percent (99%) of responding households in Kanyama and Chazanga claimed to have access to a sanitation facility.

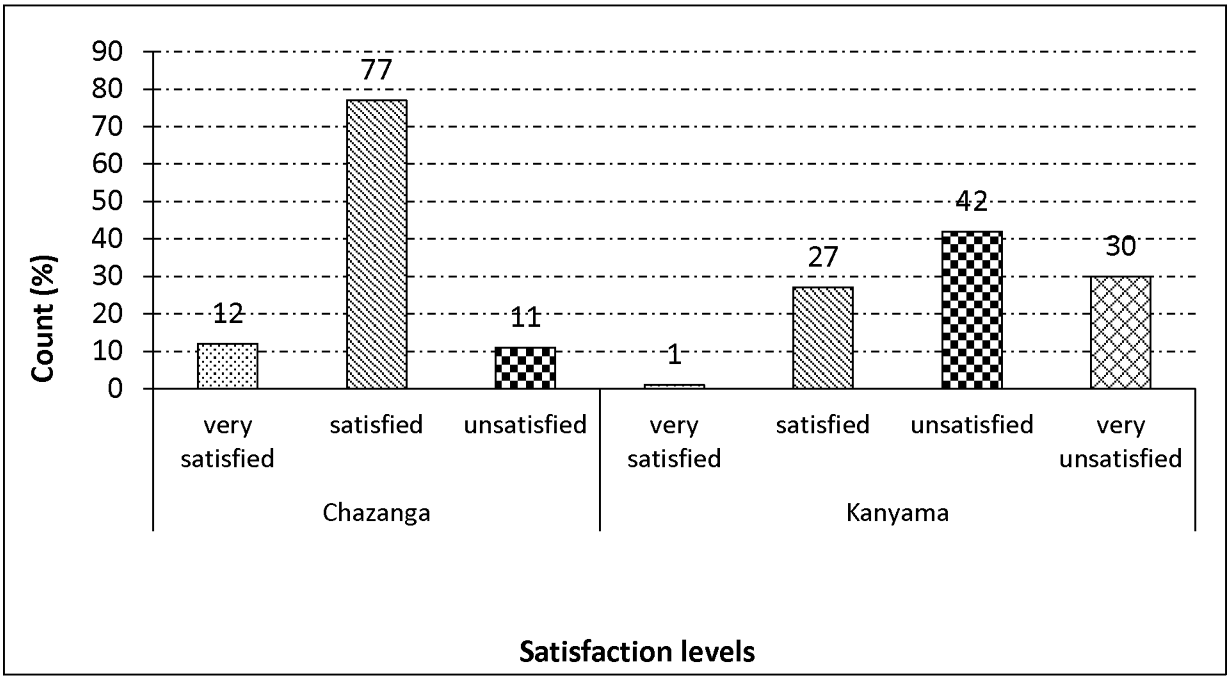

Figure 3.11: Users' perceptions of current sanitation situation

3.2.3.2. Current sanitation situation in Kanyama

Eighty-one percent (81%) of the residents in Kanyama used traditional pit latrines for excreta disposal. Kanyama often experiences flooding every rainy season due to the high water table and rocky conditions of the area. Figure 3.12 shows pits (A and B), which were initially constructed for use as pit latrines. However, due to the high water table, they were abandoned. Due to the high water table, most of the pit latrines in the area are elevated as shown in Figure 3.12C.

Figure 3.12: (A and B) Pit latrines (just dug out, not elevated) and (C) an elevated pit latrine in Kanyama

Other sanitation facilities used included Urine Diversion Dry Toilets (UDDTs), Ventilated Improved Pit (VIP) latrines, Pour-flush toilets and flushing toilets connected to septic tanks. Figure 3.13 gives the percentage of users to different types of sanitation facilities found in the Kanyama and Figure 3.14 shows pictures of a Pour-flush (A) latrine and a UDDT (B). However, the most predominant sanitation facility is the traditional pit latrine.

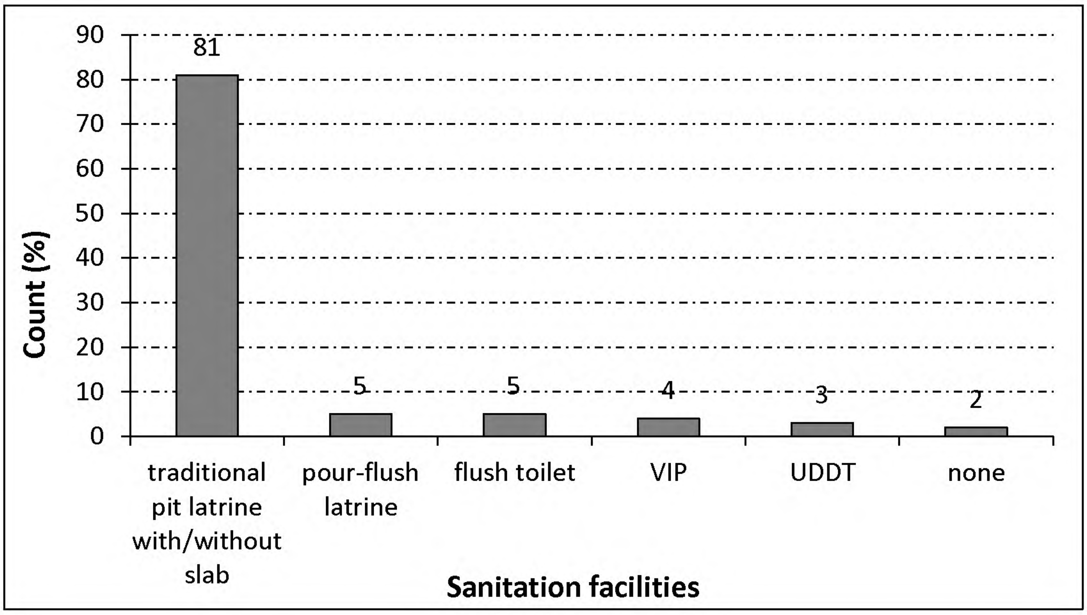

Figure 3.13: Sanitation facilities in Kanyama and percentage of users of the technologies

Figure 3.14: Photos of (A) Pour-flush and (B) Urine Diversion Dry Toilet (UDDT)

The average number of sanitation facilities per premises in Kanyama was one (1). In most instances, the sanitation facilities were shared by an average of six (6) households. This means 1 sanitation facility is used by 6 households. However, it was observed that in some cases, the number of households sharing a sanitation facility was 12 households per toilet. Maintenance of the sanitation facilities was the responsibility of the landlords, but in most cases, the tenants had the responsibility of maintaining a sanitation facility. However, this was a challenge as majority of the tenants were not willing to maintain a sanitation facility that did not belong to them. Cleaning of the shared sanitation facility was divided among the different users. However it was noted that in other instances, cleaning of the sanitation facility was dependant on the person using the toilet at that moment. Figure 3.15 outlines some of the challenges experienced with shared sanitation facilities. Fifty-five percent (55%) of the respondents in Kanyama complained of improper use of sanitation facilities as well as the difficulties in cleaning of shared sanitation facilities as seen in Figure 3.16.

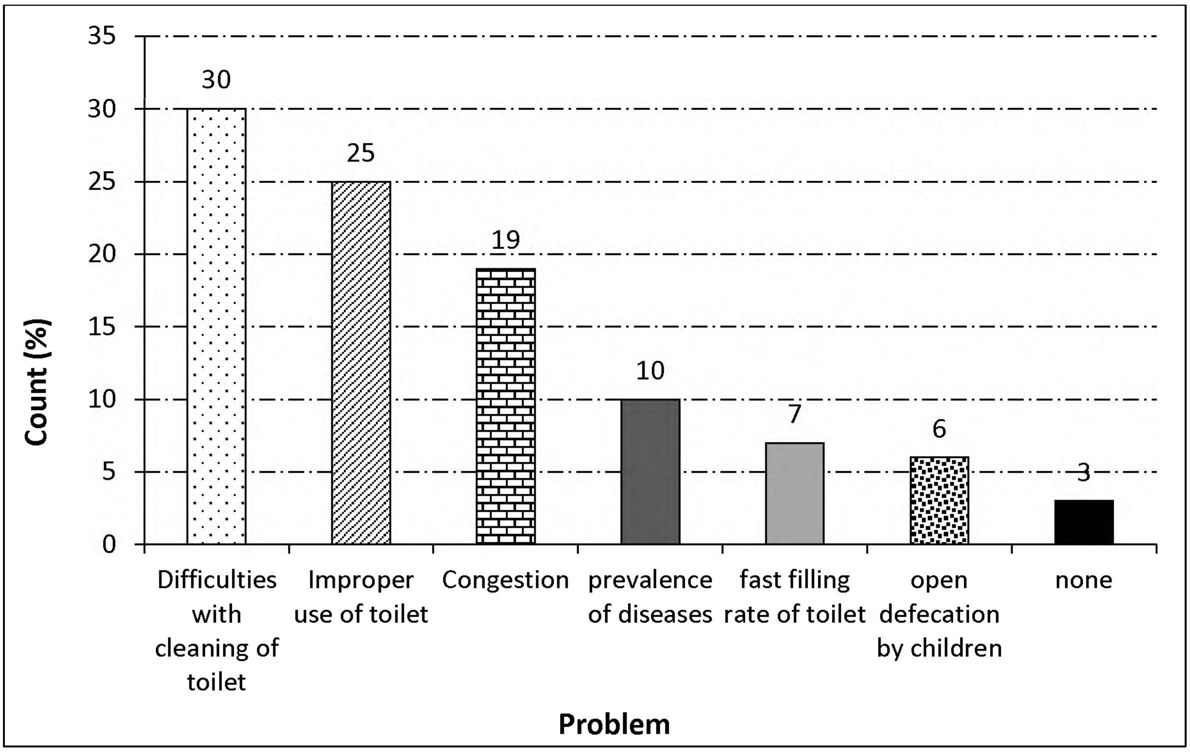

Figure 3.15: Problems associated with sharing a sanitation facility

Figure 3.16: (A and B) improperly used toilets and (C).almost filled pit latrine

Due to high user load and disposal of non-degradable solids, the filling rate for the toilets is high. 31% of the respondents' toilets get filled in less than a year. However, of the 100 respondents interviewed, only 13% engage legal pit emptiers to empty their latrines. The rest of the respondents abandon their toilets and dig new ones, or engage illegal pit emptiers. Illegal pit emptiers charge less than legal pit emptiers. The cost for legal pit emptying varies; the cheapest is 12 barrels for a cost of ZMW 250. In most cases, when the toilet was very full, the number of barrels emptied is more. Figure 3.17 shows the type of barrels used to empty the latrines.

Figure 3.17: Barrels used for pit emptying by legal pit emptiers'

Abandoned filled toilets and the activities of illegal pit latrine emptiers lead to frequent disease outbreaks, which was one of the dissatisfactions of the current sanitation situation by respondents. Figure 3.18 shows buried pit latrines (A and B) and abandoned filled pit latrines (C and D).

Figure 3.18: (A and B) Buried pit latrines (C and D) abandoned full pit latrine

The abandoned toilets are later re-dug after some years and re-used due to lack of space in the area. The emptied waste is then disposed of openly in the environment (Figure 3.19). It was observed that the majority of the respondents that were willing to contribute to projects that will improve their sanitation situation, for example clean and endearing facilities, were house owners. Tenants did not see the point in contributing for projects as they were of the view that they were only living in the area temporarily.

Figure 3.19: An old pit latrine that was once abandoned being emptied for re-use (notice the wall next to the pit latrine is a house)

3.2.3.3. Current sanitation situation in Chazanga

Like Kanyama, the most predominant type of sanitation facility in Chazanga was the traditional pit latrine with or without a slab. Eighty-four percent (84%) of the respondents used traditional pit latrines (Figure 3.20). Thirty-seven percent (37%) of the respondents had pit latrines without a slab. The cost of a pit latrine with a slab (Figure 3.21 A) is higher than that of a pit latrine without a slab. Eighty percent (80%) of the respondents reported that it is expensive to construct a pit latrine with a slab and strong superstructure. As a result, pit latrines constructed without a slab are prone to collapse in the area due to loose soils and high water table especially in rainy season. In addition, due to the high water table in the area, there are chances of contamination of ground water by excreta from the latrine, thereby threatening human health.

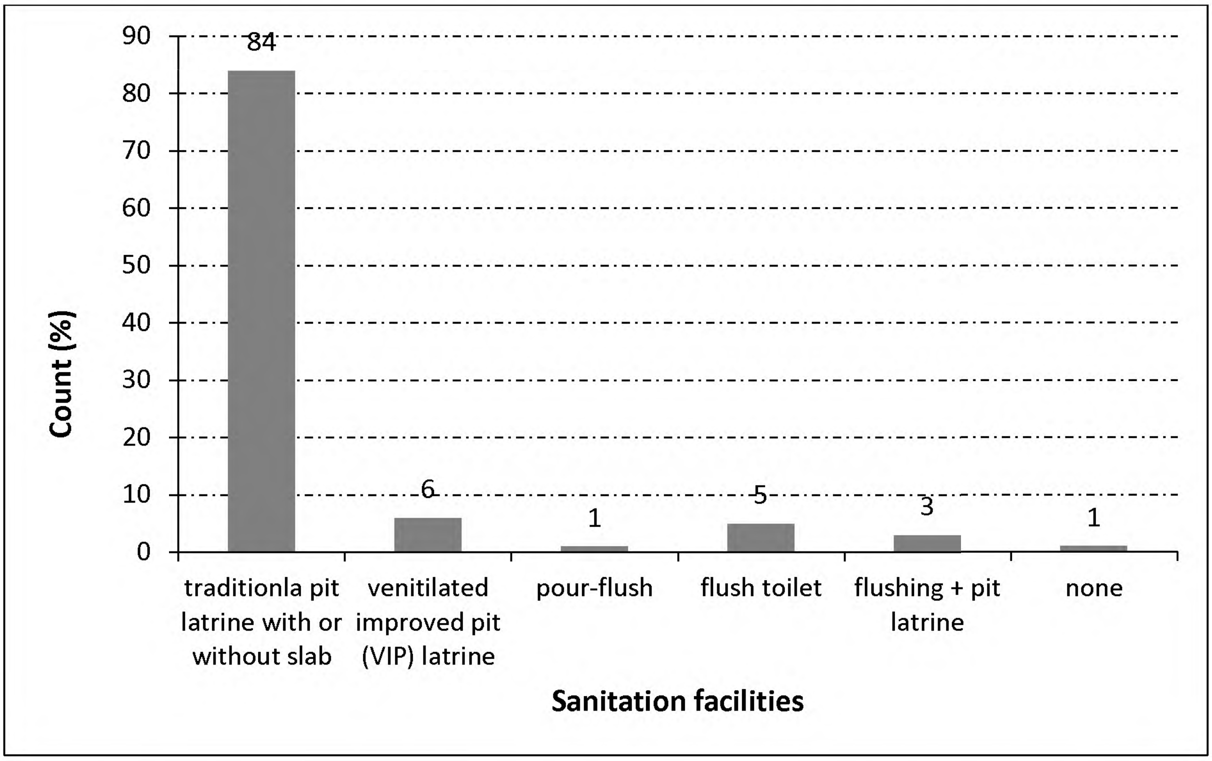

Figure 3.20: Sanitation facilities in Chazanga and percentage of users' of the technologies

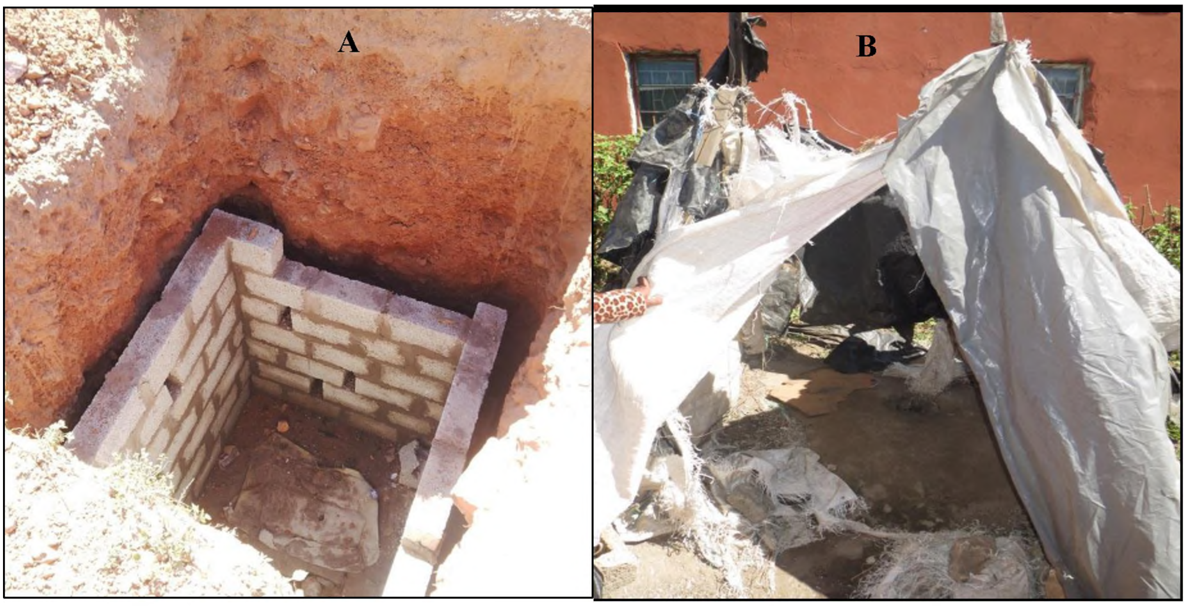

Figure 3.21: Construction of a pit latrine with a slab in Chazanga (A), and a traditional pit latrine in Kanyama (B)

Figure 3.22 shows the different types of latrines found in Chazanga. A few families that could afford used toilet pans that are then placed right above the pit for easy cleaning and use (C).

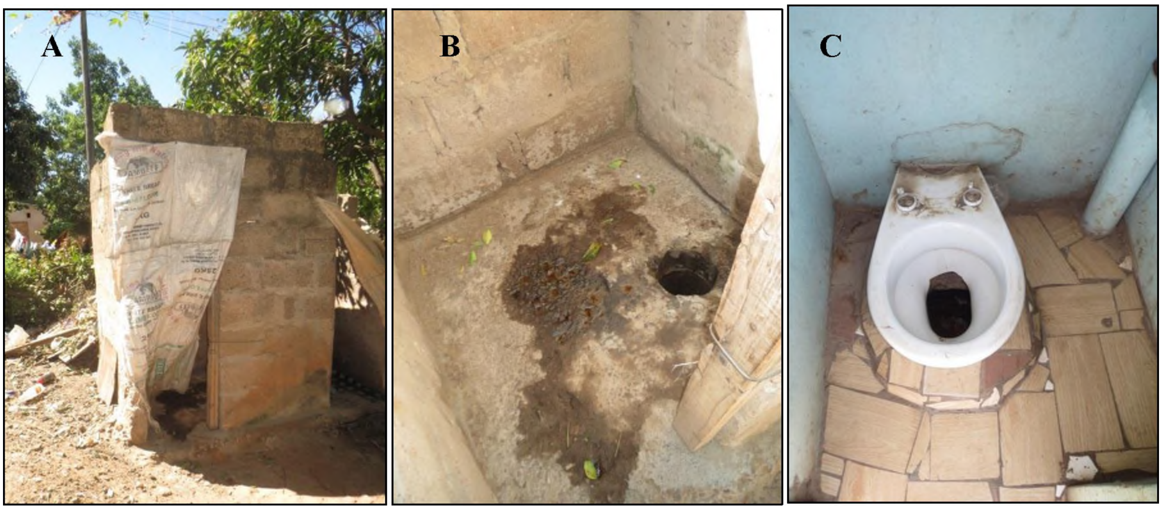

Figure 3.22: Different types of sanitation facilities found in Chazanga

Fifty-seven percent (57%), of the respondents' toilets take 2-5 years to fill up. This was attributed to the fact that the average number of households sharing a sanitation facility in Chazanga was four (4), with an average household size of six (6) persons. Figure 3.23 presents some of the sanitation challenges highlighted during the survey. Few challenges were highlighted in Chazanga compared to Kanyama.18% of the respondents complained of improper use of toilets, especially households that used shared sanitation facilities. This, according to 12% respondents, results in disease outbreak. Other challenges highlighted were intermittent water supply for households that used flush toilets and frequent collapse of pit latrines due to loose soils. 59% of the respondents in Chazanga did not empty their toilets; most toilets are abandoned and new ones constructed.

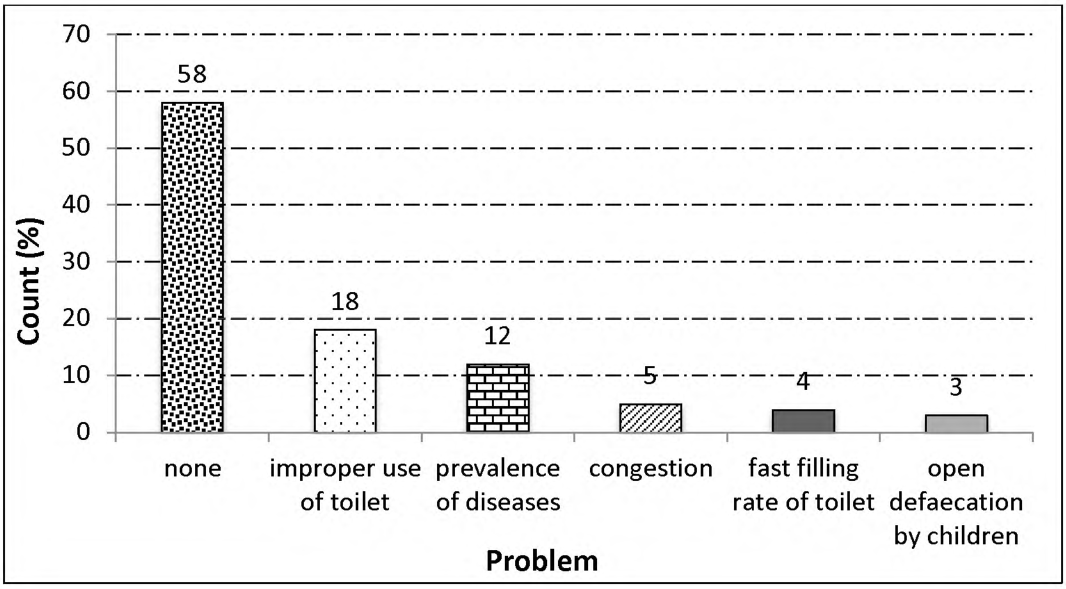

Figure 3.23: Problems faced with sharing a sanitation facility in Chazanga

3.3. Focus Group Discussions (FGD)

Two (2) Focus Group Discussions (FGDs) meetings were held during the survey; one from each study community. The aim of the FGDs was to gather information about people's preferences on the proposed sanitation technologies and incorporate views into the evaluation of appropriate technologies for the area. Table 3.4 provides an overview of the water supply and sanitation challenges highlighted during the FGDs conducted in Kanyama and Chazanga.

Table 3.4: Overview of water supply and sanitation challenges from the FGDs meetings in Kanyama and Chazanga

Chazanga		Kanyama	
Water challenges	**Sanitation challenges**	**Water challenges**	**Sanitation challenges**
• Drying of communal taps • Rationing of communal taps • Intermittent water supply for individual connections	• Collapsing of toilets in rainy season • Fast filling rate of toilets • Lack of money to construct proper toilets • Lack of proper understanding of the importance and benefits of pit emptying	• Low pressure • Distance to communal taps • Rationing of taps • Congestion	• Unregulated construction of , houses, pit latrines • Open defecation by children • Difficulties with cleaning of sanitation facilities • Lack of money to empty full latrines • Lack of sensitization on the new projects

In Chazanga, most of the participants complained of drying up of communal taps especially in dry season as well as water shortages with taps on premises. Participants that accessed water from communal taps complained of rationing of the taps. As a result of rationing, water is only available for 3-8 hours daily. However, congestion at the water sources is experienced, and consequently residents fail to fetch water within the allocated times. Participants further complained that some of the communal taps are far. As a result, residents are forced to wake up as early as 04:00am to queue for water to avoid congestion. Participants also complained of low water pressure at communal taps, which results in congestion at the taps. Furthermore, some of the taps are located far from some households, making some of the residents cover a distance of more than 500metres to fetch water. This is challenging especially that the taps are rationed. Water points installed are not adequate due to high demand and population growth, which also adds to congestion. The initial design of one communal tap is to serve about 100 households, but this is usually not the case as the tap can even serve more households than it was designed to do.

In terms of sanitation, both communities had similar challenges. In Chazanga, participants highlighted that majority of the toilets in the area are not in good condition. Due to lack of resources to construct proper toilets, toilets are dug very shallow and get full very quickly as a result. In cases where the toilet is full, people resort to defecating in polyethylene bags which are then disposed of openly into the environment. Participants also highlighted that they face difficulties with cleaning shared sanitation facilities. As a result, the sanitation facilities are left unclean and it is up to the users to clean it. Additionally, toilets in Chazanga collapse during rainy season since they are not constructed using proper material. In some instance, incidences occur whereby the pit latrines collapse when someone is using them.

In Kanyama, participants highlighted that the area experiences unregulated construction of houses due to lack of policy to regulate people with constructing houses as well as sanitation facilities. The local authorities do not regulate the construction of pit latrines. In some instances, pit latrines are dug next to shallow well and on drainage lines. This situation is even made worse during rainy season when the area is flooded due to lack of drainages. Further, it was highlighted that landlords are not mindful of the health of the tenants due to different expectation between them and tenants. Landlords should not just be interested in collecting money for rent, but also use part of the money for proper construction and maintenance of the toilets. Children in the area defecate in the open due to the type of sanitation facilities available. Parents allow the children to defecate in the open in fear that they might fall into the pits.

The participants further highlighted that majority of the resident in Kanyama and Chazanga are not adequately sensitised on the use of sanitation facilities implemented. Community members in both areas lack understanding on the importance and benefits of emptying the toilets. Sanitation is still not considered a priority. As a result, residents prefer to spend money for pit emptying or constructing a proper toilet on buying necessities for the households such as food. Thus, this drives people to empty the toilets indiscriminately into the environment. This practice is mostly carried out during the rainy season.

3.4. Selection of the proposed technologies in the two study areas

During the survey, four sanitation technologies namely Fossa Alterna, Pour-flush latrine, Ventilated Improved Pit (VIP) latrine and the Urine Diversion Dry Toilet (UDDT) were presented to the respondents to get their preferences and perceptions about the technologies. The technologies were presented to the respondents through information and illustrations. The advantages and disadvantages as well as uses of the technologies were then explained to the participants (see appendix A-C). This was to ensure that respondents make informed choices. Figure 3.24 shows the comparison in preference of sanitation facilities in Kanyama and Chazanga.

The most preferred sanitation technology in both study communities was the Pour-flush latrine (39.5%), closely followed by the VIP latrine (32.5%). Comparison of the study areas in terms of preference of sanitation facilities showed that in Kanyama, majority of the respondents preferred a VIP latrine, whereas in Chazanga, the majority preferred the Pour-flush latrine. This can be attributed to the fact that according to the findings on water supply, more people in Chazanga have access to water within their premises than Kanyama. This also justifies why 21% of the respondents in Chazanga preferred flushing toilets. The Pour-flush latrine was highly preferred based on the following reasons: clean sanitation option, easy to maintain, and conducive for use by children. The VIP latrine was chosen as a second option based on the reasons that it requires no water for use and does not require demolition when full, which makes it economically practicable. In addition, the VIP can be used as a bathroom. Most of the households in peri-urban areas have bathrooms outside their houses. Twelve and half percent (12.5 %) of the respondents chose the compost toilets. The compost latrines were chosen based on the re-use of manure for agricultural purposes. The choice of preference of sanitation was influenced by the fact that majority of respondents were residents that migrated from urban areas rather than rural areas.

However, despite the proposed low-cost technologies, 15.5% of the respondents did not prefer any of the sanitation facilities presented to them. They considered the options presented to them as “second class”. These respondents considered only a flushing toilet as an improved and clean sanitation option.

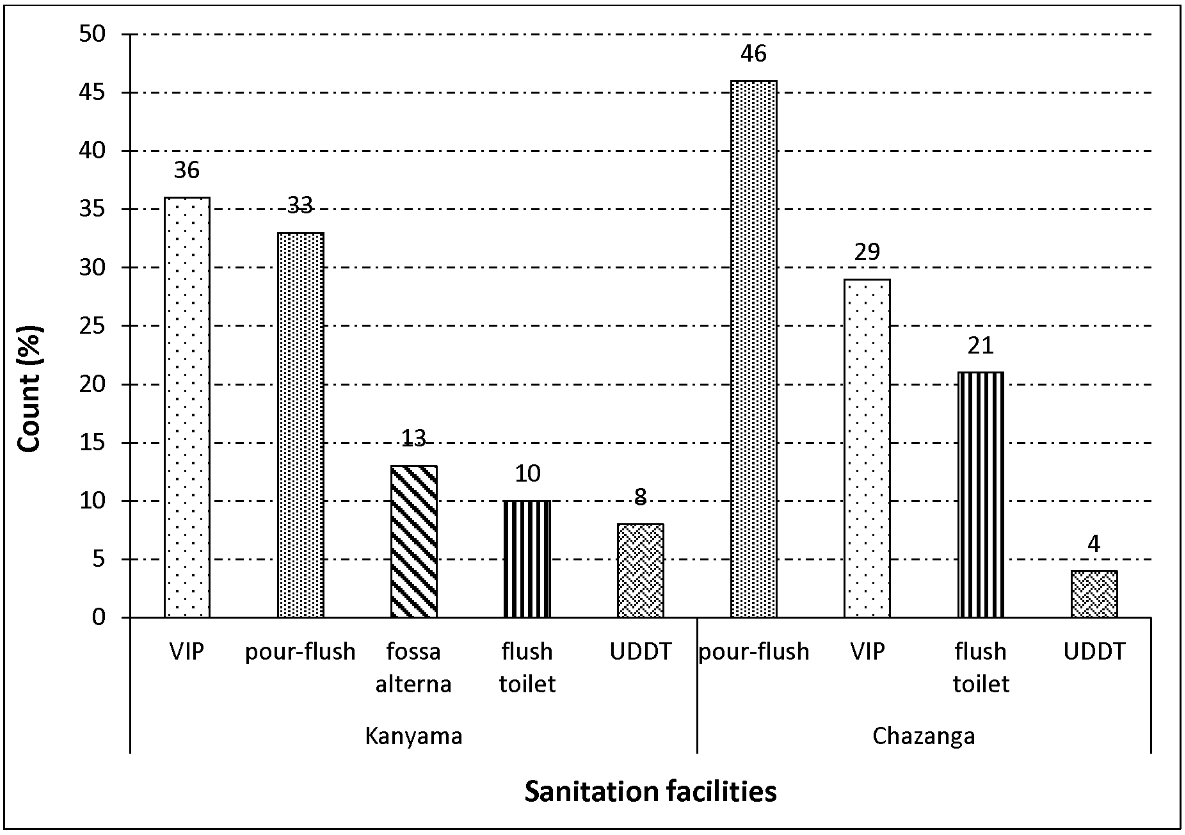

Figure 3.24: People’s preference on the presented sanitation facilities in the surveyed communities

Likewise, during the Focus Group Discussion (FGD), participants were provided with information and illustrations on the proposed sanitation options. Figure 3.25 presents the results from the two FGDs held in Chazanga and Kanyama. It is evident from the findings that Pour-flush toilets were the most preferred. The rest of the presented sanitation facilities were scored closely to each other. These included the Ventilated Improved Pit (VIP) (15%) and the Fossa Alterna. Reasons given by the participants for the preferences of Pour-flush latrine were similar to those presented in the household survey. These included reduction of disease spread, safe for use by children, uses less water, does not smell if kept clean, and easy to maintain even when used by many households. In Kanyama, one FGD participant was against all the technologies presented to them.

According to the participant, the only sanitation facility considered to them as improved was a flushing toilet. Further, the FGDs also sought the views and perceptions of participants about what they see as the most important characteristics in terms of a good sanitation facility. The most important characteristics listed included a sanitation facility that had water for hand washing (80%), a toilet that was easy to clean (76%), private sanitation facility (72%), a sanitation facility that was cheap to empty (63%), and toilet built with strong superstructure and can be used as a bathroom too (61%).

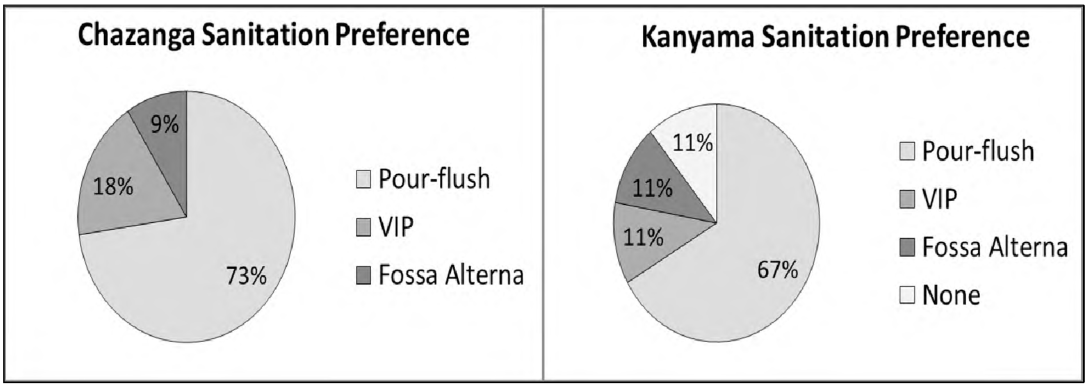

Figure 3.25: Sanitation preferences of participants of the FGDs in Chazanga and Kanyama

3.5. Discussion

3.5.1. Socio-economic aspects

The study found that in both Kanyama and Chazanga, households lived below the monthly household expenditure for urban areas. Average income in both areas from most sources was low and uneven, which explain why many households rely on more than one source. Majority of the interviewed households in the study areas were male headed and most of the women did not work. The majority of the respondents in both study areas have achieved some form of education. The study further found that age and gender had no effect on the household access to service provision. However, education levels had a significant impact of the type of sanitation preferred. Respondents with a higher educational attainment preferred better facilities that are not shared. This study agrees with findings by Kennedy-Walker *et al.* (2011) that found that no significant relationship between household income and the type of access to service facilities exists.

However, families with higher income had better access to service provision. The study found that there is no significant relationship between the numbers of years lived in an area to the type of sanitation facilities, especially in Kanyama. Most of the people in Kanyama come from outside Lusaka. It was observed that people chose to settle in Kanyama due to the low-cost of living which helps them save money and build houses in better peri-urban areas such as Chazanga. Kanyama has various housing structures mostly poorly and closely constructed houses without proper layout, which are relatively affordable for rent to low-income families. In addition, the area is very near the Central Business District (CBD), which makes it easily accessible as opposed to Chazanga. This also contributes to intra-migration of people within the area. In Chazanga, the fact that most of the people are owners of homes has a significant impact on the type of service facilities preferred. 21% of the respondents in Chazanga preferred flushing toilets. These results concur with other studies found by Kennedy-Walker *et al* (2011). It was observed that Chazanga has a high inter peri-urban migration. People migrate from other areas within Lusaka to settle in Chazanga because of the reasonably good housing structure, less crowding and sizeable household plots, which allows for household gardening of various crops. Most of the respondents grew crops within their compounds in the area as a source of income.

3.5.2. Water supply

Kanyama and Chazanga peri-urban areas are both on a water supply network through Lusaka Water and Sewerage Company (LWSC) or Water Trusts (WTs). The predominant type of water supply source is the communal taps. Other types of water supply facilities found in these two peri-urban areas included individual piped water connections, boreholes and shallow wells. Majority of the interviewed households accessed water from communal taps. The study found that Kanyama had a slightly high average monthly household expenditure on water than Chazanga. This could be attributed to the household size in Kanyama compared to Chazanga. Further, the study found that households with individual connections actually spend less money on water than households that accessed water from communal taps. Households in both study communities that had individual connections allowed other households within their premises to fetch water from the tap and share the monthly bill despite the act being illegal. Piped water is used for domestic consumption such as drinking and cooking, as it is considered to be cleaner water.

In both study communities, the average per capita consumption per day was found to be 27 litres for households that accessed water from communal taps. Due to high rate of demand, water pressure at communal taps is low. In both study areas, participants highlighted that due to congestion at communal taps, residents wake up very early to fetch water. In both study communities, residents were more willing to contribute to the improvement of water supply than sanitation. Reasons given for the preference of water supply than sanitation included to reduce congestion and time devoted to fetching water, reduce the rationing times which affects most of the activities of the households and to reduce the use of shallow wells which will contribute to the well-being of people.

3.5.3. Sanitation

The findings showed that almost all respondents claimed to have access to a sanitation facility irrespective of the type of system. Sanitation provision in the study areas is left to the initiative of the residents who mostly use unlined pit latrines that are dug within their plots (Von Münch and Mayumbelo, 2007). The most predominant type of sanitation facility used in the two study communities is the pit latrine. Both areas have no water-borne sewerage reticulation network (Yasini, 2007). Out of the 200 respondents interviewed, only 27% used flushing toilets due to lack of sewerage reticulation and the high costs of connecting to septic tanks. Majority of the respondents reported to use pit latrines due to their low cost of investment and availability of raw materials for construction (Kulabako *et al.*, 2010). The sanitation facilities were commonly shared by an average of 4-6 households. Children in both areas practiced open defecation, due to fear of falling into pit latrines.

Comparison of the satisfaction and dissatisfaction results of the current sanitation situation showed that satisfaction was greater among respondents that used private sanitation facilities. Majority of the respondents in Chazanga expressed satisfaction with the current sanitation situation. More than half of the respondents in the area were landlords who used private sanitation facilities only shared by members of the household. On the other hand, in Kanyama, this was a different case as majority of the respondents were tenants. Majority of the respondents were not satisfied with the current sanitation situation of the area.

Determinants of dissatisfaction listed by the respondents in Kanyama included lack of general cleanliness of the area, flooding, improper use of toilets, frequent outbreaks of disease and poor emptying of sanitation facilities. It was reported however that, since the inception of Faecal Sludge Management (FSM) by the Non-Governmental Organisations (NGOs), Water and Sanitation for Urban Poor (WSUP) and Water and Sanitation Association of Zambia (WASAZA), sanitation problems have reduced. The FSM aims at addressing problems associated with sanitation such as desludging, transportation, treatment and use of faecal sludge (Holm *et al.*, 2015).

Despite the introduction of FSM, majority of residents do not empty their full pits because they lack understanding of the importance and benefits of this practice. As a result, people have continued to empty toilets on their own during rainy season, while others defecate in plastic bags, which are disposed of in the open at night. Other dissatisfaction determinants listed included lack of waste management strategies, unregulated construction of households and poorly constructed pit latrines. For instance in Kanyama, it was observed that houses are not constructed in a proper layout and the area has no drainages. Therefore during rainy season, water becomes stagnant in peoples' compounds. Consequently, waste from the filled pits, coupled with stagnant water give rise to water-borne parasitic animals including worms, rodents and cockroaches. This has detrimental effects on people residing in affected communities as it has high propensity of transmitting diseases such as diarrhoea, cholera and dysentery.

In both study communities, it was found that majority of the tenants and a small number of landlords used shared sanitation facilities. Respondents who shared sanitation facilities complained about having to sometimes wait in order to use the toilet, high filling rate due to high user load. High filling rate of toilets make users to use other alternatives such as defecating in polythene bags which are disposed of in the environment at night (Mugo, 2006). The study found that most toilets when full were abandoned or informally emptied by informal pit emptiers. Informal pit emptying involves digging a hole beside the pit chamber and indiscriminately allowing the sludge flow out in the open environment. Other challenges of shared sanitation facilities included difficulties in sharing responsibilities of cleaning the sanitation facilities, as well as the misuse of toilets. Additionally, in Kanyama, the study found that tenants were not willing to contribute to the maintenance of sanitation facilities. Similar findings were found in a study by Katukiza *et al.*(2010) conducted in peri-urban settings where there was lack of willingness by tenants to contribute to the maintenance of a shared sanitation facility due to lack of ownership of facilities.

The study further found that sensitisation of new projects in both study communities is not well conducted. For example, some residents still are unaware of the services offered by WSUP and WASAZA and lack understanding on FSM and its benefits. Therefore, toilets are still abandoned or illegally emptied. An example of inadequate sensitisation was the introduction of Urine Diversion Dry Toilets (UDDTs) in 2010 in Kanyama. It was reported that users were not sensitised on the use of the toilets, and as a result, the toilets have not been viable for the area. 95% of the UDDTs users expressed dissatisfaction with the toilets. Reasons for dissatisfaction included improper use of toilets, fast filling rate of the latrines due to many users, and lack of emptying when toilets become full. These observations agree with studies conducted in Bwaise III, a per-urban in Kampala, Uganda, by Katukiza *et al.* (2010). They reported that for peri-urban residents to benefit from any sanitation project, it is important to design and implement sanitation systems suitable for local conditions. This means that users of such facilities must be consulted at all stages of the project. Additionally, the study found that communities are not made aware of the importance and benefits of having proper sanitation facilities. As a result, people do not see the need to have toilets and still prefer to spend money on other things like food and shelter instead of spending on constructing proper toilets.

Selection of sanitation technologies revealed that the most preferred sanitation technology in both study communities was the Pour-flush latrine. However, comparison of the two study areas in terms of preference of sanitation facilities showed that in Kanyama, majority of the respondents preferred a Ventilated Improved Pit (VIP) latrine, whereas, in Chazanga, the majority preferred the Pour-flush latrine. This can be attributed to the fact that according to the findings on water supply, more people in Chazanga have access to water within their premises than Kanyama. This also justifies why 21% of the respondents in Chazanga preferred flushing toilets. Socio-economic and technical determinants such as safety, cost as well as durability of a technology played an important role in the selection. Majority of the respondents chose the Pour-flush toilet due to it's safety use especially to the children. On the other hand, the VIP was selected due to it's longevity and no use of water especially in areas that have limited space.

3.6. Conclusion

It is clear from this study that majority of residents in Kanyama and Chazanga rely on communal taps for water supply. Residents in both study communities that access water from communal taps have low per capita consumption of water per day.

As a result, shallow wells are also a common source of water as they are used to supplement the amount of water obtained from communal taps. However, this according to the World Health Organisation (WHO) standards is considered unimproved. Congestion of communal taps as a result of low water pressure as well as rationing of taps, are some of the challenges experienced by residents in Kanyama and Chazanga. Other challenges include intermittent water supply for households with individual connections and drying of taps which are left unattended to by the local authorities. On the other hand, on-site sanitation with the use of pit latrines with or without a slab is predominant in Kanyama and Chazanga. Pit latrines are the most common type of facilities due to low-investment cost, operation and maintenance. However, they are not constructed well or according to the proper standards. Although some of the sanitation facilities can be termed "improved" since they have a slab, the material used for construction is not good enough and these toilets consequently flood or collapse in some cases, as they are also used as bathrooms for body hygiene.

Additionally, the use of shared sanitation facilities is a norm in peri-urban areas. However, this comes along with challenges such as difficulties in responsibilities of the cleaning and maintenance of sanitation facilities. As majority of residents in Kanyama and Chazanga are tenants, cleaning and maintenance of sanitation facilities is left to the user of the facility at that particular time (i.e. sharing tenants clean the sanitation facility whenever one wants to use the toilet). Consequently, the toilets are left uncleaned and misused. In terms of sanitation preferences, majority of the people in both study communities would prefer to have a Pour-flush toilet based on the reasons that the facility uses less water, does not smell as long as it is kept clean, is safer for use by children and that they are familiar with its use. The second preferred facility is the Ventilated Improved Pit (VIP) latrine. The VIP was chosen because it requires no water for use and when properly constructed, eliminates bad odours and can be used a bathroom.

CHAPTER FOUR: KEY EXPERT INTERVIEWS AND MULTI-CRITERION ANALYSIS (MCA)

4.1. Introduction

This chapter presents findings of the key expert interviews as well as a Multi-Criterion Analysis (MCA) ranking of the technologies. The interview was made up of two stages with separate questionnaires (Appendix B). The first stage involved an initial questionnaire interview with a total of seven experts (n=7). The questionnaire included issues on the present water supply and sanitation situation in peri-urban areas of Lusaka, involvement of the interviewed experts' organisations in the implementation of low-cost technologies, the type of technologies implemented, the challenges faced with regard to introduction of new technologies in peri-urban communities and the sustainability of low-cost technologies in Kanyama and Chazanga. The second stage of the key expert interview involved a follow-up questionnaire. This dealt with the ranking of sanitation options using an MCA (Table 4.1). Five sustainable aspects, namely technical, environmental, institutional, socio-cultural and economic aspects, were used for ranking the technologies.

Table 4.1: Sustainability aspects used in ranking of technology (after: Katukiza *et al*. 2010 and Mara *et al*. 2007)

Criteria	Indicator
Technical	• availability of construction material and labour • demand • compatibility with local conditions of the area
Environmental	• risk of emission of pollutants to the environment • risk of pollutants on the environment and human health • safe reuse of treated waste • protection of the source against contamination • accessibility, availability and reliability of technology
Institutional	• adoptability of the technology by users • involvement of users in planning, decision making, implementation and maintenance of technology • management of technology at lowest appropriate level
Socio-cultural	• acceptance of technology by the users • perception of the technology by the users • involvement of users in operation and maintenance • ease of use of facility by the users
Economic	• initial costs • flexibility of the technology to accommodate different household incomes and material availability • resources for operation and maintenance

4.2. Key expert interviews

The first stage of the interview was conducted with professionals from different government institutions and Non-Governmental Organisations (NGOs) working in the water and sanitation sector in Lusaka. Seven (7) experts interviewed included 3 engineers, 2 socio-development experts, 1 environmental health practitioner and 1 environmental scientist. Table 4.2 gives an overall representation of the results from the interviews.

Table 4.2: Overview of the expert interview results

Present water supply and sanitation challenges	• Big gaps exist in the provision of water and sanitation facilities to people in Peri-urban areas (PUAs) • Rapid rates of urbanisation is higher than the rate at which the strides to improve water and sanitation are being deployed
Types of technologies implemented in PUA's	• Decentralised wastewater treatment solutions such as biogas digesters, dry toilets with bio-digester, constructions of transfer stations to support latrine emptying, and construction of sludge drying beds substructure, Pour-flush toilets, and Ecosan toilets. • Water kiosks, communal taps, construction and design of water supply networks through laying of pipes, boreholes, and construction of water storage facilities (ground and elevated tanks) and individual yard connections.
Community involvement in planning, selection, implementation of technologies and willingness to pay for technologies	• Communities are involved in the planning, selection and implementation of technologies • A few residents from the communities are sensitised on the use and maintenance of technologies that then spread the word to others • Due to lack of sense of ownership, community members are reluctant to be involved in projects
Challenges faced with regard to introduction of new technologies	• Low priority on sanitation by both the local authorities and communities • Poor planning of PUAs which poses challenge in the construction and expansion of infrastructure • Lack of proper water and sanitation legal framework • Lack of willingness by households to pay for new technologies • Low acceptance of new some new technologies by the communities • Limited availability of finances by the Commercial Utilities

Sustainability of water supply and sanitation technologies for PUA's	• Ventilated Improved Pit (VIP) latrine is widely accepted in PUAs, however, if not properly constructed can lead to ground water contamination • Pour-flush has low operation and maintenance cost, does not need highly skilled labour for construction. However, they may be expensive to construct and requires water • Urine Diversion Dry Toilets (UDDTs) reduce odour, easy to manage solid material. However, it requires constant awareness of the community on its use; it is difficult to use especially by children due to separate urine and faecal chambers, may lead to spread of diseases if not properly handled. In addition, the toilets are not easily accepted by community members • Fossa Alterna can be used in areas prone to flooding since they can be elevated, and are economical; however, handling of waste is still a cultural challenge in Zambia • Traditional protected wells and rainwater harvesting were ranked low due to limited space in the peri-urban areas especially in Kanyama, where space is limited for installing water tanks • In Chazanga, houses have roof gutters that allow for collection of water; however, according to a study conducted in Chazanga, respondents in the area expressed concern about the taste and debris in the water collected

4.2.1. Present water supply and sanitation situation in peri-urban areas of Lusaka

Results from the experts showed that improvements in the provision of water supply and sanitation have been seen in peri-urban areas of Lusaka in recent years. There has been considerable progress made in various aspects of the water supply and sanitation sector as at 2015 even though that progress has fallen short of expectations. It was reported that in 2014, more than 50% of the proportion of the population in Lusaka was serviced by the communal taps and water kiosks in Lusaka (NWASCO, 2014). This development can be seen in the numerous water projects that have resulted in construction of water kiosks, which has consequently reduced walking distances and queueing times to fetch water, as well as congestions at water points. Water networks (pipes) have been extended to reach many people and more water storage facilities constructed so as to lessen shortages of water supply during times of power cuts/load shedding. Also, sanitation has improved because of the enormous support and commitment from Government, coupled with overwhelming response from donors towards investment in sanitation. The level of access is reported to have risen from 60.5% to 61.4% in urban areas (NWASCO, 2014). In addition, the National Water Supply and Sanitation Council (NWASCO), which regulates the provision of water supply and sanitation services for efficiency and sustainability, has set up a basket fund called the Devolution Trust Fund (DTF) that receives financing from donors and the government to finance projects in peri-urban areas in order to increase access to water. DTF has been constructing water kiosks which are an improved version of the open communal taps.

Different types of water supply and sanitation facilities re-implemented for peri-urban areas included piped water and boreholes. Piped water is managed by Commercial Water Utilities through communal taps, water kiosks and individual yard connections. Additionally, the formation of Water Trusts (WTs) in some peri-urban areas has greatly improved provision of water in peri-urban areas. The Water Trusts (WTs) deal with consumers' complaints, so as to reduce any inefficiency. For sanitation, options range from decentralised systems such as bio-digesters to Ecosan toilets such as Urine Diversion Dry Toilet (UDDT). The introduction of pit latrine emptying services in peri-urban areas, like Kanyama and Chazanga, has helped improve the sanitation situation, from living with full latrines that overflow in rainy seasons, to having the option to empty latrines in a safe and hygienic way and have the faecal matter taken away from their premises.

4.2.2. Implementation/introduction of low-cost technologies for water supply and sanitation

Low-cost technologies are implemented in peri-urban areas of Lusaka mainly because of affordability. Some of the types of low-cost technologies implemented include pour flush toilets connected to biogas digesters as intermediate settlers, Ecosan sanitation options such as Urine Diversion Dry Toilets (UDDTs), faecal sludge management and water supply sources such as kiosks and communal taps. For instance, one of the interviewed experts' organisation is currently in the process of implementing low-cost pour flush latrines in Chazanga, while another is involved in the implementation of pipe water schemes for small towns using solar power borehole pumps.

4.2.3. Community involvement in the selection, implementation, operation and maintenance of, and willingness to contribute to, projects

Communities' involvement in water and sanitation projects is very vital in determining the sustainability of such projects after implementation. Findings from the experts' interview revealed that communities are made aware of any project that the local authorities or private implementers intend on introducing in order to get their views/perceptions about the projects. This is achieved through inviting a selected number of residents from the communities (community and opinion leaders) to meetings to discuss the type of technologies that the local authorities are planning on implementing, as well as explaining to them about the use and maintenance of such technologies. In terms of willingness to pay for new projects, experts reported that there is lack of willingness by households to pay. This is a challenge especially in peri-urban areas that have majority of households as tenants.

4.2.4. Challenges of service provision to peri-urban areas of Lusaka

Despite the improvements in water supply and sanitation provision in peri-urban areas of Lusaka, the following challenges were established as key issues hindering water supply and sanitation in Chazanga and Kanyama included:

- ***Poor planning of peri-urban areas:*** Lack of regular layout planning in peri-urban areas makes it difficult to provide services. This is a challenge especially in the laying of networks for both water and sewerage. This is especially true for areas such as Kanyama, which is very populated such that houses are closely built. Some of the houses in the area are built on the service lines due to the landlord's continuous construction of houses within their plots so as to make profit out of it. This is a result of weak law enforcement by the local authorities regarding construction of houses as well as sanitation facilities.

- ***Limited availability of finances by the Commercial Utility (CU):*** It was reported that there is a lack of payment discipline among the residents, especially households with individual piped connections, due to intermittent water supplies and socio-economic factors such as irregular income. Majority of the people that pay their bills at the month end are elderly people and educated heads of households. More educated consumers as well as the elderly in peri-urban areas attach a higher opportunity cost for time spent collecting water from other sources, and prefer engaging in other more productive tasks. Consequently, limited availability of funds hinders the Commercial Utility (CU) to maintain services in the areas.

- ***Inadequate willingness by the communities to contribute to projects that improve water supply and sanitation:*** Majority of the residents in peri-urban areas are tenants who are renting the properties they are living in. Tenants do not see the need to pay and maintain facilities that they do not own. When local authorities plan on implementing a new technology, lack of willingness hinders their plans as only few people in the communities, particularly landlords, feel commitment towards paying for the service delivery. In the same way, due to lack of ownership, there is misuse of utility facilities by the communities. If people do not own something, they feel no commitment towards it, and will feel no guilt about destroying it if they can. These reported challenges were similar to the results from a study by Kayaga *et al.* (2003) conducted in 11 major towns of Uganda, that found willingness to pay to be even lower if several families share one property, because of low agreement on shared responsibilities.

In Kanyama, households that share sanitation facilities face difficulties in cleaning of the facilities. As a result, the facilities in most cases do not serve their designed life time.

- ***Lack of prioritisation for sanitation by both the donors/local authorities and communities:*** It was reported that water supply is highly prioritised than the provision of sanitation in peri-urban areas. For example, in Zambia, there is an overwhelming bias towards water supply in urban water and sanitation programme budget compared to sanitation. The Devolution Trust Fund (DTF) investment for water supply in 2014 (ZMW 4,399,644) was three times more than that for sanitation (ZMW 1,053,000) (DTF, 2015). The major reason for less investment in sanitation is the high cost associated with implementing sanitation projects. Key experts highlighted that, for instance, the same amount of resources spent on sanitation can be used to reach a higher number of beneficiaries per capita with a water supply project. Additionally, local community members do not prioritise sanitation due to lack of understanding of the importance and benefits of having good sanitation facilities. Households in peri-urban areas prefer to spend money on other items like food, and non-food items than on service delivery such as toilets.

- ***Lack of proper water supply and sanitation framework:*** The lack of having separate strategies for water and sanitation has been an inhibiting factor in the provision of water and sanitation to peri-urban areas. For instance, it is not until recently that Zambia developed separate water and sanitation strategies. Combining water with sanitation in one policy/strategy proved to be a challenge as most money budgeted for water and sanitation was going to mostly water projects compared to sanitation, but reported as water and sanitation projects.

- ***Low acceptance of some technologies by the communities:*** Due to lack of knowledge and proper understanding of the benefits of some technologies by the users, there is low acceptance of technologies, especially new technologies. Some technologies are seen as second-class solutions by many users.

Residents feel demeaned by providing them with especially low-cost technologies and tend to question why they are being offered such sanitation options instead of the conventional flush toilet. As a result, this creates a challenge for the local authorities to introduce new technologies.

4.3. Ranking of technologies and opportunities and constraints of the selected technologies

Seven key experts working in the water supply and sanitation sector were consulted to perform ranking of the technologies. Each expert performed the ranking process independently. Ranking was based on the aspects considered to be of utmost importance when evaluating the feasibility and sustainability of a technology for implementation in peri-urban areas such as Chazanga and Kanyama. Regular ranking with a scale of 1-5 (1 being the least important and 5 the most important) was used. The average values from the seven expert ranking were used to compute the final weight on the five aspects of sustainability. Table 4.3 present the total ranking values for each technology under each criterion. The seven experts interviewed stated that all five aspects are important in the implementation of any technology. However, these indicators are selected based on priority. On average, the experts ranked technical criterion very important with a value of 4.0, followed by environmental criterion of 3.5, institutional criterion of 3.4, and socio-cultural criterion of 3.3 and, economic criterion of 3.2.

Table 4.3: Ranking of sanitation technology options

Sanitation	**Ranking**						
Criterion and indicator	**VIP**		**Pour-flush**		**Fossa Alterna**		**TAS**
	TC ranking for each technology	AWS	TC ranking for each technology	AWS	TC ranking for each technology	AWS	
Technical	27.75	3.9	28.25	4.0	26.75	3.8	4.0
Environmental	25.25	3.6	25.75	3.6	23.75	3.3	3.5
Institutional	20.75	2.9	25.5	3.6	27.5	3.9	3.4
Socio-cultural	17.5	2.5	25.97	3.7	27.9	3.9	3.3
Economic	23.4	3.3	27.07	3.8	19.4	2.7	3.2

Note: *Total Criteria (TC) ranking for each technology = (sum of total criterion ranking/total number of criterion); Average Weighted Score (AWS) = (sum of total criteria ranking for each technology/total number of experts); Total Average Score (TAS) = (sum of average score/total number of criteria per technology.*

4.3.1. Technical

The Pour-flush had the highest average weighted score of 4.0, closely followed by the Ventilated Improved Pit (VIP) latrine with a score of 3.9, and Fossa Alterna had a score of 3.8. Despite the Pour-flush toilet having a low maintenance and operation cost, and a long life span, it can be expensive to construct. Space availability for the construction of the toilets needs to be considered during planning. Space availability is an issue especially for an area like Kanyama were houses are closely built. In Chazanga, the toilet can be easy to construct as most of the residents have sizeable plots that allow for digging of septic tanks. The toilets require a small amount of water for the conveyance of waste, which can be difficult especially in Kanyama were the majority of residents depend on water from communal taps. Likewise, a VIP does not need highly skilled labour to construct. Furthermore, the latrine can be used in areas that have no sewerage reticulation and easily emptied. Majority of local masons in both Chazanga and Kanyama are familiar with its construction. The disadvantage however with the toilet is that if not properly constructed, especially in areas that have high water tables such as Kanyama, it can lead to contamination of ground water and, can collapse in areas that have loose soils such as Chazanga. This means that local conditions of the areas like the level of the ground water table, types of soils, space and number of users need to be considered most in the selection of technologies. Technical aspects on the Fossa Alterna were ranked low as the toilet is feasible in both areas that have high water table and loose soils. The technology is adaptable to different environments and can be elevated in order to reduce risks of environmental as well as human contamination.

4.3.2. Environment

All the three sanitation options were ranked highly important under environmental aspect. It is important for a technology to improve the well-being of humans at the same time cause less harm to the environment. The VIP and Pour-flush had scores of 3.6. The Fossa Alterna was ranked a score of 3.3. It is important that the latrines are properly constructed to avoid contamination of ground water, especially that Lusaka has a high water table. Therefore, different geological conditions of the areas must be evaluated. Kanyama area experiences flooding in the rainy season and due to the rocky conditions of the area, it is difficult for flooded water to infiltrate. Accessibility of the toilets is important, as toilets in peri-urban areas are used by different households.

Therefore, it is important that the toilets have a high volumetric pit capacity to accommodate the high user load. If the waste from the pits is not emptied for VIPs and Pour-flush latrine, and handled properly for the Fossa Alterna, it can lead to spread of diseases.

4.3.3. Institutional

Under institutional criterion, the Fossa Alterna had the highest score of 3.9. The Fossa Alterna is a new technology in Zambia and as a result, majority of the people are not familiar with it. It is important that communities be involved in the selection, planning and implementation of the technology. There is need for local authorities to engage residents in the projects from the start, which includes choice of the technologies. The users should be made aware of the uses and management of the toilet in order for it to be sustainable. The Pour-flush was scored 3.6 and the Ventilated Improved Pit (VIP) latrine 2.9. Pour-flush and VIP are widely known in peri-urban areas. However, these technologies need to be managed at the lowest appropriate level economically by the users. Majority of peri-urban residents are tenants; management of the intended technology at the lowest level is vital. Different perceptions and expectations of landlords and tenants should be taken into consideration as they have a major role to play in the implementation of any technology. For instance, the expectations of landlords and tenants are different. A poor tenant may prefer a facility that suits their income, whereas the landlord may aim to get the best rental income from their tenants (Isunju *et al.*, 2011). Those who own the latrines as well as those that use it jointly should share the responsible of emptying and unblocking of them (Paterson *et al.*, 2007).

4.3.4. Socio-cultural

The Fossa Alterna was ranked highest with a score of 3.9, followed by Pour-flush 3.7 and Ventilated Improved Pit (VIP) latrine 2.5. For the Fossa Alterna, acceptance of the technology is vital for the toilets sustainability. Practices, perceptions and preferences of the users have to be understood. People in per-urban areas and Zambia in general, still view the handling of human waste as dirty and unacceptable. Therefore, it is important to understand people attitudes, behaviours and perceptions in order to develop strategies for sensitising and motivating people on the acceptance of the technology (Nawab *et al.*, 2006; Paterson *et al.*, 2007).

One of the constraints of compost toilets in peri-urban areas is the lack of knowledge about the technologies (John *et al*., 1980). The changing of tenants in households also contributes to the lack of sustainability of the toilets. The Fossa Alterna requires constant awareness on how to use the toilet, which can be a little difficult in rented homes where tenants are constantly changing especially in Kanyama, which proved difficult for them to know how exactly the toilet should be used. The lack of addition of soil or ash to the toilet renders it useless. On the other hand, the VIP and Pour-flush latrines are widely accepted by people in both Kanyama and Chazanga. Residents are familiar with their use. However, the involvement of the households in operation and maintenance such as cleaning and emptying of latrines when full is important. People are reluctant to clean or empty the toilets especially if they are shared. This leads to the lack of sustainability of the facilities.

4.3.5. Economic

In terms of economic, the Pour-flush had a score of 3.8. The initial cost of the toilet can be high for some of the peri-urban residents in Kanyama and Chazanga despite the advantages it offers such as long life span, easy to clean and ease of accessibility to children. The VIP was scored 3.3. Like the Pour-flush latrine, the VIP has a long span and can be used as a bathroom as well. However, it needs to be emptied when full. It is important to consider the levels of incomes of the communities. Local authorities therefore need to encourage and sensitise people on the importance of pit emptying in order for these technologies to be feasible in the areas. If left unemptied, the latrines can be smelly and attract flies. Fossa Alterna was scored low with 2.7. The latrines have a low initial construction cost, which is flexible to accommodate different household incomes, and are suitable for areas that have no piped water.

4.4. Conclusion

Provision of water supply and sanitation in peri-urban areas of Lusaka has improved in recent years. Various projects have been introduced in peri urban areas such as Kanyama and Chazanga to reduce challenge faced in water supply and sanitation. For instance, the construction of water kiosks has helped reduce congestion at the water points.

Additionally, the introduction of pit latrine emptying services in some areas has created opportunities for residents in Kanyama and Chazanga to have an option of emptying the latrines in a safe and hygienic way. However, there is still a lot that remains to be done in the area of sanitation to encourage people to upgrade to improved toilets and to let them know of the importance of having proper sanitation facilities. Despite improvements in water supply and sanitation, the study found that water supply projects are more prioritised than sanitation by the local authorities and donors. The major reason for less investment in sanitation is the high cost associated with implementing sanitation projects. As opposed to sanitation, the same amount of resources spent on sanitation can be used to reach large number of beneficiaries with a water project. Donors and implementers want to report that they reached a higher number of beneficiaries with minimal resources and this is easy to do with water supply than with sanitation. Lack of willingness by households to pay for facilities, misuse by community members and low acceptance are some challenges faced in peri-urban areas in the implementation of technologies. Other challenges are the unavailability of funds and poor planning of peri-urban areas.

Based on the communities preference, the VIP, Pour-flush and flush toilets were the most preferred by the study communities. However, according to the experts, the flushing toilet is infeasible especially in Kanyama where there is lack of proper layout of housing. Additionally, the initial cost of construction associated with flush toilets is high, beyond what can be afforded by majority of the poor living in peri-urban areas. In terms of the sustainability aspects considered as priority before implementing new water supply and sanitation projects, majority of the experts stated that all five aspects, namely socio-cultural, environmental, institutional, economic and technical, are important in the implementation of any new technology. Technologies to be implemented must be constructed well to avoid ground water contamination, should be affordable to the majority of the community residents, easy to use and should be acceptable to the intended users. The method of evaluating appropriate technology options for peri-urban areas and thereafter letting the users from the communities choose from the proposed technologies ensures a participatory approach. If communities feel involved in a project, they tend to make contribution towards it. Results from Multi-Criterion Analysis (MCA) showed that stakeholders' influence is essential for the selection of sustainable technology options.

CHAPTER FIVE: GENERAL CONCLUSIONS

5.1. Introduction

This chapter presents limitations encountered during the study and, conclusions drawn from the results and discussion. The conclusions look at how the objectives of the research have been met while the recommendations arise from the gaps that were established in the process of conducting the research, which need further improvement. The research carried out in this thesis is significant and the findings from the study forms an important basis for proper planning of sustainable water supply and sanitation services in Kanyama and Chazanga, as well as other peri-urban areas in Zambia.

5.2. Opportunities and constraints of low-cost technologies in peri-urban areas

Various low-cost technologies for water supply and sanitation are available for use in different peri-urban areas. However, it is important to assess the feasibility of the technologies critically for proper planning of sustainable facilities. Similar to findings conducted by Seleman and Bhat (2016) in Tanzania, a Multi-Criterion Assessment provides useful platform for ranking alternative technologies. However, the implementation process needs to look into different aspects of each individual technology with the preferences of the local communities, local environmental, socio-cultural, economic, technical and institutional conditions. The following are some of the opportunities and constraints of implementing low-cost technologies in Chazanga and Kanyama areas.

5.2.1. Opportunities and constraints for low-cost technology options for sustainable water supply and sanitation in Kanyama

5.2.1.1. Opportunities for water supply

- The area has a growing population which offers many ooportinities for the implementation of different low-cost water technologies. Technologies such as communal taps and kiosks provide a good source of water as it is accessible to many household.

Therefore, local authorities and other servie providers can install many water points thereby reducing congestion while at the same time providing better services to the growing population.

5.2.1.2. *Constraints for water supply*

- Due to lack of proper layout of housing structures, its is difficult to implement certain low-cost technologies in Kanyama such as rain water harvesting. Additionally, continuous increase in the construction of unregulated households and sanitation facilities, renders technologies such as protected wells not feasible to implement in Kanyama due to gradually diminishing spaces. The distance between pit latrines and wells is very short and it is possible for cross contamination of excreta and water to take place. Furthermore, physical conditions such as rocky grounds found in Kanyama is a disadvantage to the laying of pipes as it makes the cost to go up. Therefore, it is important for water providers to evaluate the environmental conditions against of the area against the technologies when planning to implement water technologies.

5.2.1.3. *Opportunities for sanitation*

- Different dynamics in the Kanyama such as the population as well as tenancy satus provide an opportunity for local authorities to explore various affordable and sustainable technologies for the provision of sanitation.

5.2.1.4. *Constraints for sanitation*

- In Kanyama, the user load on sanitation facilities is high due to a high number of households sharing one facility. As a result, toilets fill up quickly in Kanyama is high. This creates challenge especially in households whose pits are not properly constructed to allow for pit emptying. Therefore, it is important that the technical condition of the technologies to be implemented in the area are considered.

- Another constraint in Kanyama is the continuous changing of tents in rented households. Majority of the proportion of households in Kanyama is made up of tenants. As a result, there is a tendancy for mis-use of facilities by tenants because of lack of sense of ownership. Therefore, to avoid this, it is important for local authorities to provide continuous awareness on the use of implemented technologies for them to be sustainable. For example dry sanitation facilities such as the Urine Diversion Dry Toilet (UDDT) for requires contionous awareness on users on the proper operation and maintenance of the toilet.

- Environmenetal conditions of Kanyama are a constraint in the provision of low-cost technologies. The area is rocky and flooded during the rainy season. As a result, on-site technologies that cannot be raised above the ground are prone to flooding.

- Further, there is lack of willingness among residents to accept new technologies especially low-cost technologies as people consider them second class.

- Furthermore, there is lack of understanding by the residents on the importance of having access to proper sanitation facilities.

5.2.2. Opportunities and constraints for low-cost technology options for sustainable water supply and sanitation in Chazanga

5.2.2.1. Opportunities for water supply

- Chazanga area has lose soils which allow for easy laying of water pipes.

- Additionaly, houses in the area are spacely populated which allow for construction of protected well in yards away from pit latrines.

- Further, the use of roofs that have gutters in the area allow for implementation of technologies such as rainwater harvesting. However, a study by Handia *et al.* (2003) in Chazanga revealed that the quality of the water from the tanks can be questionable.

5.2.2.2. Constraints for water supply

- As majority of the residents in the area depend on various informal employment for their household income, economic conditions of any low-cost technology should be taken into account when considering implementation of the technologies. For example, the cost of acquiring tanks for rain water harvesting can be expensive to some households.

5.2.2.3. Opportunities for sanitation

- Plot sizes in Chazanga are big enough to allow for construction of sanitation facilities hat require big volumetric capacity chambers such as septik tanks. Therefore, large plot sizes allow for local authorities to explore various low-cost technologies.

- People are more open to accepting implementation of new technologies as long as they are well infomed about the project.

- As majority of households in the area have taps, wet sanitation low-cost technologies such as the Pour-flush latrine can be implemented for households that can afford the construction cost of the sanitation facility.

5.2.2.4. Constraints for sanitation

- Daily intermittent water supplies faced with individual connections can be a hinderance to the proper maintenance of the wet sanitation technologies.

- Loose soils in the area cause pit latrines to collapse especially rainy season. Therefore, it is important that the sanitation facilities are constructed with proper material to avoid collapse of toilets.

5.3. General concluding remarks

The foregoing sections presented opportunities and constraints for water supply and sanitation in Kanyama and Chazanga. Based on the outcomes of this study, it is possible for local authorities to use findings from this study in other peri-urban areas of Lusaka and Zambia as a whole. His will help implementors plan for proper water supply and sanitation technologies in dynamic environments such as peri-urban areas.

5.4. Limitations to the study

The following limitations were ecounterd during the period of study:

(i) The sample size for the household survey was limited by constraints in time and resources.

(ii) Data collection was only possible with respondents who were found at their homes during the sampling times. It would have be interesting to interview more household heads in the study as this would have an impact on the social factors considered in the study. As the majority of the people interviewed were female, this favoured the research since majority of people who are involved in household water supply are women and children.

(iii) Setting up of focus group discussions at the community level was another limitation. In Kanyama, for example, the meeting had to be rescheduled due to low stakeholder turn up.

Stakeholders did not come for the meeting due to fear of religious indoctrinations such as 'satanism', despite explaining to them the purpose of the meeting. However, problems were still faced with getting people to come to the rescheduled meeting.

(iv) Lack of keenness by the experts to participate in the interview, as a result, the number of experts interviewed was limited.

(v) Lack of sufficient funds to perform bacteriological test for water. The testing of the quality of water from various water sources which are found in both Kanyama and Chazanga would have added value to the findings of the research.

5.5. Recommendations

The research has highlighted the challenges faced in the implementation of technologies for the provision of water and sanitation in Kanyama and Chazanga. The following are some other factors that may be considered in order to provide services that are feasible and sustainable:

- **Consideration of different aspects of an area:** Different attributes such as population, economic, environment, and social needs of the community must be understood in order for the implementation of sustainable service in Kanyama and Chazanga.

- **Importance of awareness and understanding of the need for access to infrastructure development:** Local authorities need to come up with policies that will encourage and motivate residents (both tenants and landlords) to contribute to the sustainability of their facilities. This can be achieved by incorporating the intended users in the planning, selection, implementation, operation and maintenance of technologies. Additionally, periodic awareness training programs with communities on issues such as the importance of infrastructure development and the benefits it offers will motivate tenants to contribute to the maintenance of the facilities. Involvement of both tenants and landlords will motivate tenants as most of them feel landlords are only interested in making profit out of them and not caring about their health. Well-informed tenants and landlords will greatly improve the current state of water and sanitation in both areas.

- **Formulation and enforcement of policies and regulations:** With the projected rate of urbanisation in the future, there is need to have enforceable policies and regulations to ensure that construction of infrastructure in peri-urban areas meet expected standards.

- **More research needs to be conducted with water and sanitation experts in Zambia on the exploring of various water and sanitation innovative technologies:** There is lack of knowledge not only with communities but with experts from various institutions dealing with water and sanitation. Some experts interviewed from different areas were not familiar with other available low cost technologies. Therefore, there is a need for more research to recommend suitable technologies for different areas, especially to the large proportions of the population in dynamic environments such as Kanyama and Chazanga.

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APPENDIX A

HOUSEHOLD SAMPLE QUESTIONNAIRE (A)

Household questionnaire

1. Identification data

Date:	
Sample number:	
Household #:	
Area:	
Sex of interviewee:	1=Girl (<16 years) 4= Boy (<16 years) 2=Woman (16≥35 years) 5= Man (16≥35 years) 3= Adult woman (>35 years) 6= Adult man (>35 years)

A. Demographic/income data

A.1 How many occupants does your household have?

(*Total)...

Codes:

Gender: 1=Male 2=Female

Marital Status: 1=Married 2=Divorced 3=Widow

4=Single 5=Separated 6=Cohabiting

Education: 1= Primary 2= junior sec 3= senior sec 4=College
5= Degree 6=None 7= other: (specify)……………

mark *****HH head** ****HH member**	**Gender M/F**	**Age (Specify age or date of birth)**	**Marital Status**	**Education/ training level**	**Occupation**	**Earning an income**
Total:						

A.2 What are the main sources of household income?

1= Government employment
2= Private employment
3= Self-employed (own business)
4= Gov. Assistance (pension/welfare)
5 = Occasional jobs
6 = Seasonal worker
7= none
8= other

A.3 What is the approx. monthly household income (all income earning persons in the household)? (ZMK/month)

1= 0 – 499
2= 500 – 999
3= 1000 – 1999
4= 2000 – 2999
5= 3000 – 3999
6= 4000 +

A.4 If your answer to the previous question is above 4000, state approximately how much?

…………………………………………………………………………………………...

A.5 How much does your household spend per month on the following items? (*Specify priority of bill, 1: high, 2: medium, 3: low)

	Expenditure	**Amount (ZMK)**	**Priority**
1.	Water		
2.	Sanitation		
3.	Electricity		
4.	Entertainment		
5.	Telecommunication		
7.	Food		
9.	Rent		

A.6a For how long has your family been staying in this area?

1 = Less than 2 years
2 = 2 - 5 years
3 = 5 to 10 years
4 = Over 10 years

A.6b Where did you live before you came here?

……………………………………………………………………………...............................

A.7 Who owns the plot/structures found on your plot?

1= Self 2= Landlord 3= Gov. 4=Other: ………………

A.8a Are you paying rent?

1= Yes 2= No

A.8b If yes, how much do you pay per month?

……………………………………………………………………… **(ZMK/month)**

A.9 What religions are being practiced by household members?

1= Christianity 3= Islam 5= several of the afore mentioned

2= Hinduism 4= African tradition 6= others (specify):………

B. Sanitation assessment

B.1a Is there a toilet in these premises, if so, how many?……………

1= Yes 2= No

B.1b If no, what do you use instead of a toilet?

……………………………………………………………………………………………

B.2 Where do most of the members of your household usually ease themselves (including yourself)?

1=Own toilet 3=private 5=Others(open/bucket/flying toilet)

2=shared 4= public toilet

B.3 What type / types of toilet arrangements does your household have?

- **Are they in use?**
- **Are they shared?**(*tick in the table where necessary)

Type of toilets/defecation		***In use**		***Accessibility**
		Yes	No	Shared
1.	Traditional pit latrine without slab			
2.	Traditional pit latrine with slab			
3.	Ventilated Improved Pit (VIP) latrine			
4.	Ecosan toilet (UDDT)			
5.	Pour flush			
6.	Flush toilet			
7.	Public toilet			
8.	Open defecation			
9.	Other			

B.4 Where is the main toilet located?

1 = inside the house 3 = outside the plot

2 = outside the house, on plot 4 =other: (specify)…………………

B.5 Are there separate toilets for men and women?

1= Yes 2= No

B.6 Do you usually have to wait before you can use the toilet?

1=Never 3=Often

2=Sometimes 4= Always

B.7 Please tell us the three main problems regarding the use of your <u>main</u> toilet?

1.	
2.	
3.	

B.8 Who sorts out these problems?

…………………………………………………………………………………………………

B.9 In the case that you use a latrine, Ecosan or pour-flush sanitation arrangement, did you construct it yourself?

1= Yes 2= No

B.10 If yes, where did you get the material to construct it and how available is it, is it affordable?

……………………………………………………………………………………………………….

B.11 How long does the pit latrine or septic tank take to get filled up?

…………………………………………………………………………………………

B.12 How often is it being emptied?

1= less than 6 months 4= after 2 years 7= other:………
2= every 6 months 5= after 5 years
3= after 1 years 6= not at all

B.13 How is it emptied?

1= Vacuum tanker 3= Manual labour 5= other:…………….
2= Manual pumps 4= Not at all

B.14 If not at all, what do you do when a pit is full?

…………………………………………………………………………………………

B.15 In the case that you share a toilet with people outside your household, what is your relationship to the majority of the other people you share a toilet with?

1= Close family 3= Next door neighbours
2= Extended family 4= Other:…………

B.15a Do you need to pay for using it?

1= Yes 2= No

B.15b If yes, how much per month do you pay per household?

………………………………………………………………… **(ZMK/month)**

B.15c Who cleans the toilet?

…………………………………………………………………………………

B.15d How often is the toilet cleaned?

1= every day   3= once a week   5= other:………

2= twice a week   4= three times a week

B.16 What are the three main disadvantages/ problems you experience of using a shared toilet?

1.	
2.	
3.	

B.17 In case you could chose a toilet, what type of toilet do you prefer? (*Show/explain the pictures of different low-cost sanitation options)

1= Fossa alterna   3= Dry toilets (Ecosan/pit latrine)   5=other
2= VIP   4= Pour-flush

B.18a Please explain why?

1.	
2.	
3.	

B.18b If other, kindly specify?

……………………………………………………………………………………………

B.19 Do you have any religious or cultural beliefs regarding the use of decomposed waste (human excreta)? [ ]

1= Yes   2= No

B.19a If yes, could you kindly explain further?

………

B.20 How satisfied are you with the current sanitation situation in your area? [ ]

1= Very Satisfied   3= Unsatisfied

2= Satisfied   4= Very unsatisfied

B.21a In the meantime, do you have plans (other than Gov.) to improve your current sanitation situation? [ ]

1= Yes   2= No

B.21b If yes, please indicate what you are planning to do?

1.	
2.	
3.	

B.22a Would you be willing to contribute to a project improving your sanitation situation? [ ]

1= Yes 2= No

B.22b If yes, how much money from your current household income would you be willing to contribute on a monthly basis?

…………………………………………………………………… **(ZMK/month)**

B.23 Please share with us the main reason, why you want to spend money to improve the sanitation situation?

……

B.24 What do you consider as the <u>five most important</u> characteristics for an improved toilet? (* tick in the box where necessary in order of priority)

	Characteristic	
1	Close to the house	
2	Separate toilets/rooms for males and females	
3	No smell	
4	Private toilet	
5	Easy to clean	
6	Cheap to empty	
7	Toilet superstructure built with cement	
8	Toilet has adequate space	
9	Water for hand washing	
10	Water-borne flush toilets	

C. Water assessment

C.1 Where do you obtain your water from and for what purpose do you use this water?

	Purpose				
Water source	**Drinking**	**Cooking**	**Body Hygiene**	**Laundry**	**Other use**
Household connection					
Public tap					
Water kiosks					
Shallow wells					
Public borehole					
Own borehole					
Tap on plot					
Stream					

Other					

C.2 **a) Why do you prefer the water from this source?** *tick in the table below where necessary

b) What do you dislike about the water from this source? *

	Why do you prefer the water from this source?							What don’t you like about this water source?					
	source	colour	taste	smell	close	inexpensive	Others reasons	colour	taste	smell	Too far	expensive	Other reasons
Drinking	**1**												
	2												
	3												
	4												
	5												
	6												
	7												
	8												
Cooking	**1**												
	2												
	3												
	4												
	5												
	6												
	7												
	8												
Body hygiene	**1**												
	2												
	3												
	4												
	5												
	6												
	7												
	8												
Laundry	**1**												
	2												
	3												
	4												
	5												
	6												
	7												
	8												
Other use	**1**												
	2												
	3												
	4												
	5												
	6												
	7												
	8												

C.3 Who fetches water? In what container? What is the cost? How many trips per day does this person make in order to obtain water? (*fill in the table)

Gender (M/F)	Container	Cost	No: of trips per day

C.4 What is the approximate distance from your house to the water source?

……………………………………………………………………………………

C.5 Do you have any problems obtaining water from these sources? If yes, from what source and what is the problem? * fill in the table below

1= Yes 2= No

	Source	Problem
1	Household connection	
2	Public tap	
3	Water kiosk	
4	Shallow wells	
5	Public borehole	
6	Own borehole	
7	Tap on plot	
8	Stream	

C.6 How do you see the relationship between closeness of a water well and a pit latrine?

……………………………………………………………………………………

C.7 Do you pay for your water supply?

1= Yes 2= No

C.8 If yes, how much do you pay on a monthly basis?

………………………………………………………………… **(ZMK/month)**

C.9 Do you think the cost of water is? [ ]

1= High 2= fair 3= Low

C.10 Do you have plans to improve your current water supply situation? [ ]

1= Yes 2= No

C.11 If yes, please indicate what you are planning to do?

1.	
2.	
3.	

C.12 Would you be willing to spend more money in order to improve your water supply situation? [ ]

1= Yes 2= No

C.13 If no, what is your reason?

……………………………………………………………………………………

C.14 Please share with us the main reason, why you would want to spend money to improve the water supply situation?

1.	
2.	
3.	

C.15 What impacts does lack of water have on your current water use patterns?

……………………………………………………………………………………

C.16a Would you be willing to work with other people to improve water supply or sanitation in your area?

1= Yes 2= Perhaps 3= No

C.16b If yes or perhaps, under what condition would you work on improving water and sanitation?

1= voluntary (individual) 2= voluntary (community) 3= paid

FOCUS GROUP DISCUSSION QUESTIONNAIRE (B)

No of men: ___ No of women: ___ Location: ___________________ Date: ____________

Questions

Sanitation

1. Could you please tell us your perception on the present sanitation situation in this area? What types of toilets are being used?
2. What are the main problems regarding the toilets you have?
3. What do you think of these technologies (show them the different pictures of the technologies and explain to them about each technology)?
4. If you were to choose a technology, which one would you choose and why?

	Technology	**Reason**
1	Fossa Alterna	
2	UDDT	
3	VIP	
4	Pour-flush	

5. What do you consider as the five most important things about a toilet?

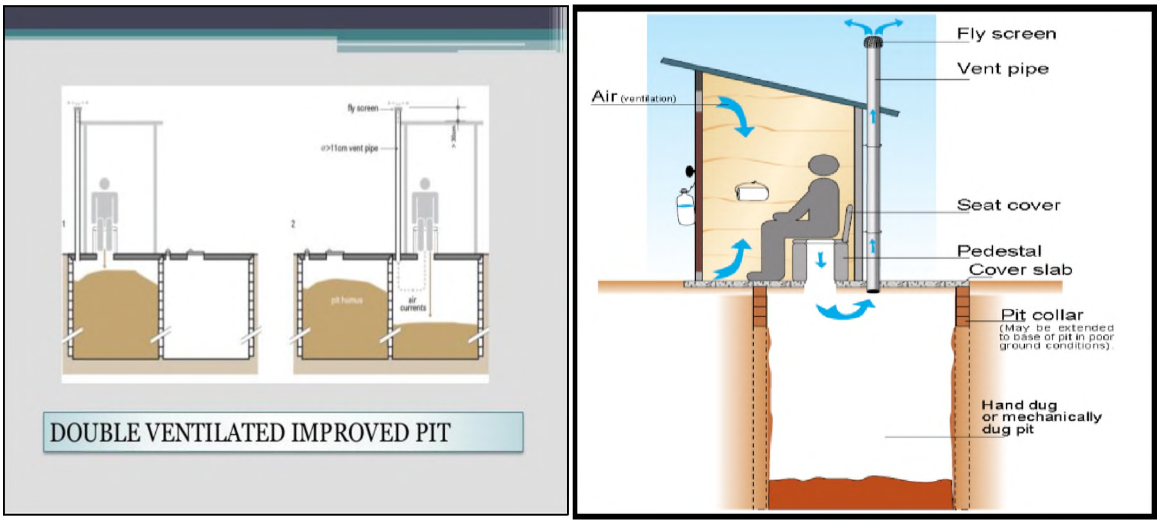
	Characteristic	**Reason**
1	Close to the house	
2	Separate toilets/rooms for males and females	
3	No smell	
4	Private toilet	
5	Easy to clean	
6	Cheap to empty	
7	Toilet superstructure built with cement	
8	Toilet has adequate space	
9	Water for hand washing	

Water supply

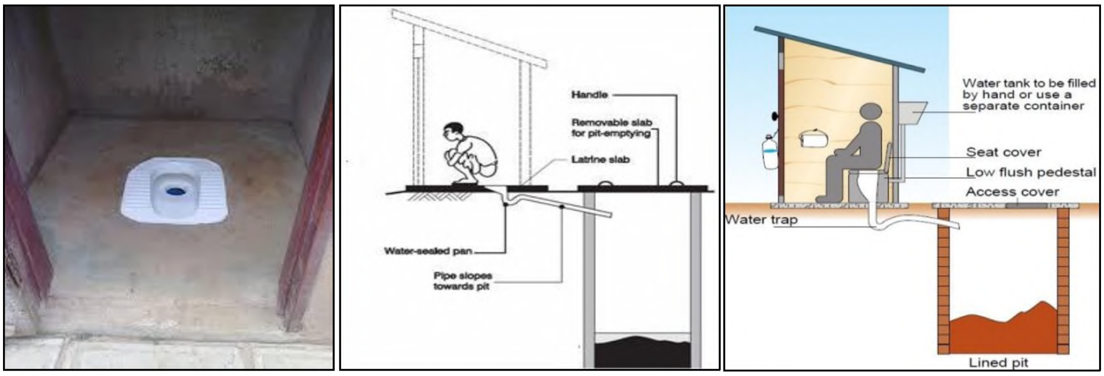
1. What is your perception on the present water supply services levels in this area?
2. What types of water supply facilities are being used? Are they efficient, reliable, accessible and affordable?
3. Do you get any help from the local or municipal council, in the provision of water and sanitation? Is the community involved in the implementation of projects in the local areas?

INFORMATION, COMMUNICATION AND EDUCATION MATERIAL (C)

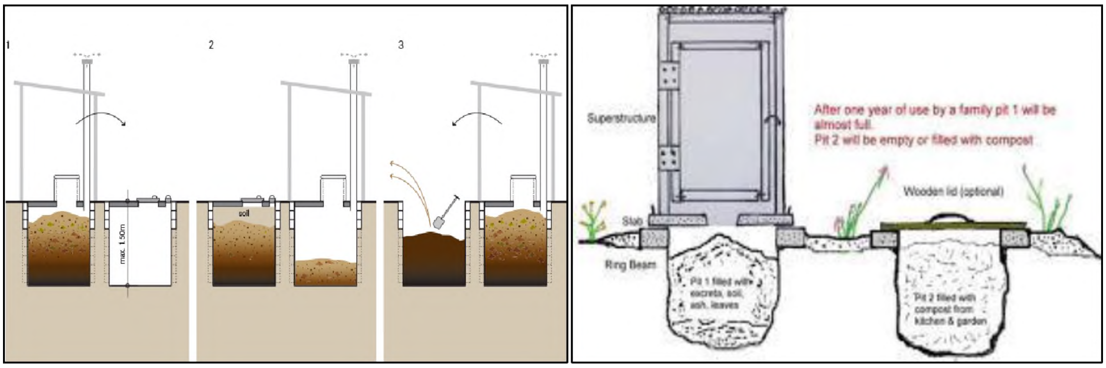
1. Ventilated Improved Pit latrine



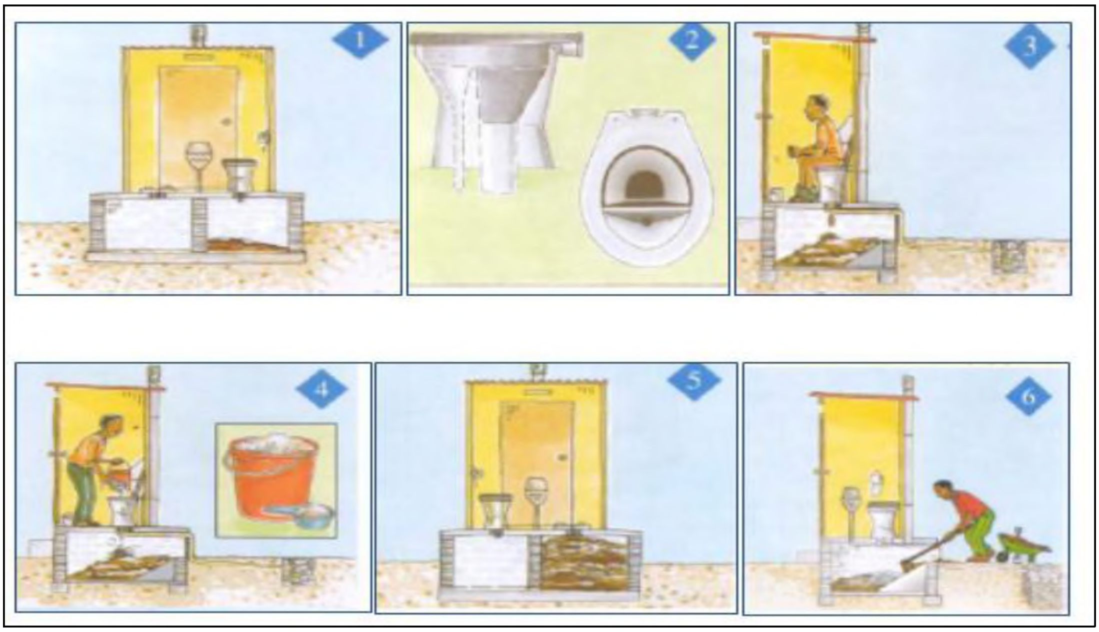
2. Pour-flush latrine



3. Fossa Alterna



4. Urine diverting toilet (UDDT)



APPENDIX B

KEY EXPERT QUESTIONNAIRE

Sex (F/M)	
Name of organisation	
Profession	
Years of experience	

2. **What is your role/mission of your organisation with respect to addressing issues of water supply and sanitation especially in peri-urban areas?**

………
…………………………………………………………………

3. **According to your previous experience in dealing with water supply and sanitation issues in peri-urban areas of Lusaka, how would you describe the present water supply and sanitation situation?** (kindly describe briefly whether there has been an improvement in the provision of water supply and sanitation in the past 5 years in peri-urban areas of Lusaka) ………
…………………………………………………………………

4. **What type(s) of water supply and sanitation arrangements/infrastructure does your organisation implement in peri-urban areas such as Chazanga and Kanyama?**

....
....

5. **Is your organisation involved in the implementation/introduction of low-cost technology infrastructure for water supply and sanitation?**

Yes/ No

If your answer is yes, what type of technologies do you implement?

………
…………………………………………………………………

6. **Is the community involved in the selection, implementation and if possible operation and maintenance of technologies?**

Yes/ No

If your answer is yes, are the communities trained or made aware of the use of the technologies (i.e. how to use the facilities, maintain them and sustain them?

………
…………………………………………………………………

7. **Are the community members willing to contribute or pay for technologies to improve their current water and sanitation situation?**

Yes/ No

8. **Kindly give your honest opinion of the feasibility of applying the following technologies in peri-urban areas?**

Technology	State major advantages	State major disadvantages	Can you recommend this technology in peri-urban areas of Lusaka?
Ventilated Improved pit (VIP) latrine			Yes / No
Pour-flush			Yes / No
Urine diverting toilet (UDDT)			Yes / No
Fossa alterna			Yes / No

9. What are some of the challenges faced by this organisation with regard to the introduction of new water supply and sanitation technologies in peri-urban areas?

………
…………………………………………………………………

KEY EXPERT MULTI-CRITERION ANALYSIS QUESTIONNAIRE

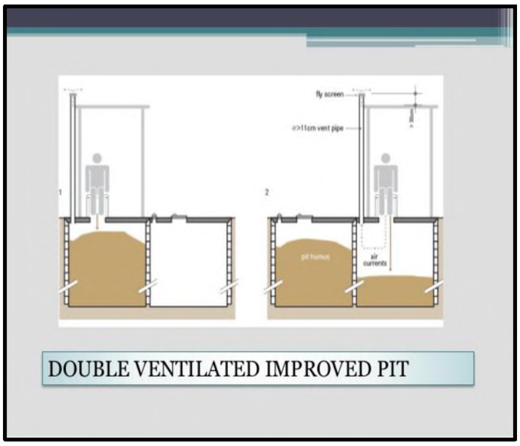
Sex (F/M)	
Name of organisation	
Profession (e.g. engineer, socio-scientist, economist)	
Years of experience	

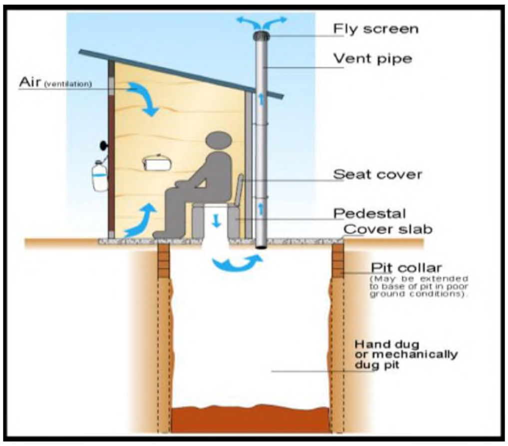
Sanitation

Kindly rank the following technologies based on the various indicators of sustainability for use in peri-urban areas. The following technologies are the most preferred sanitation facilities in both the sampled peri-urban areas i.e. Chazanga and Kanyama.

1. Ventilated Improved Pit (VIP) latrine

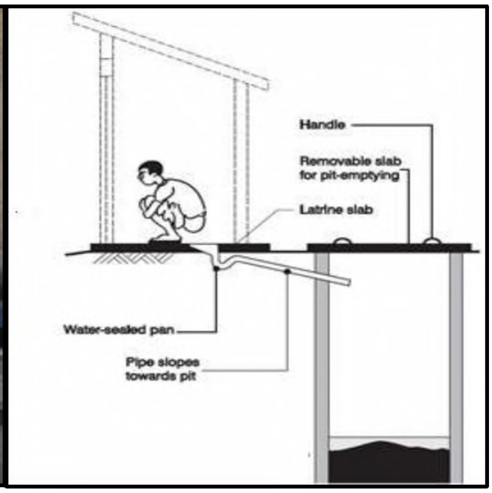
A pit latrine designed to reduce frequently encountered problems with traditional pit latrines, such as bad odours and insect increase. It has a screened ventilation pipe which extends from the pit to eliminate odour and flies.





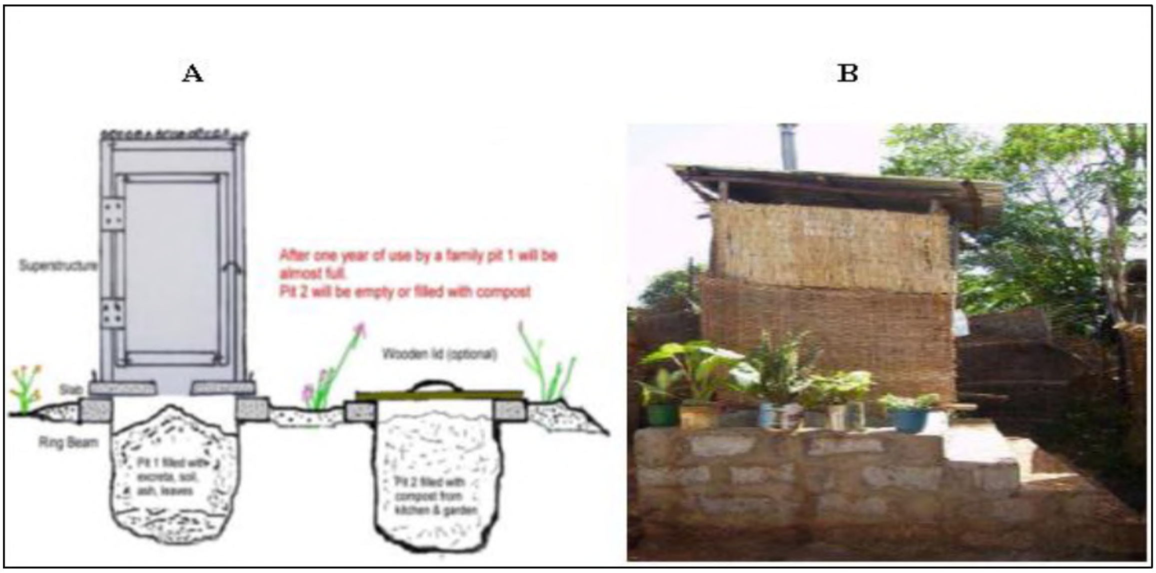
2. Pour-flush

A manually flushed toilet fitted with a shallow U-pipe. The U-pipe is designed to allow for low water volume (1.5 litres) flushing of excreta deposited on the pan. Water for flushing is poured by hand.



3. Fossa Alterna

A Fossa Alterna is a double pit compost toilet. The toilet is made up of two pits that are used interchangeably, when the first pit is full, it is filled with soil and leaves and covered while the second pit is used. In rocky condition, areas that have high water tables or prone to floods, the toilet can be constructed above the ground. The decomposed waste can be used for various agricultural purposes.



The ranking scale is as follows;

1= weakly important; 2= less important; 3= moderately important; 4= more important; 5= extremely important

Sustainability Criteria	Rank		
Indicator and criterion	**VIP Chazanga/ Kanyama**	**Pour-flush**	**Fossa Alterna**
1. Technical ▪ availability of construction material			
▪ adaptiveness of the technology to harsh environments			
▪ local labour for construction			
▪ meets the local conditions of the area			
2. Environmental ▪ risk of emission of pollutants to the environment			
▪ risk of pollutants on the environment and human health			
▪ improves human health			
▪ safe re-use of treated waste			
3. Institutional ▪ adoptability of the technology by the users			
▪ involvement of users in planning, decision making, implementation and maintenance of technology			
▪ management of the technology at lowest appropriate level			
▪ space for construction of the technology			
4. Socio-cultural ▪ acceptance of technology by users			
▪ user perception of the technology			

▪ attitude toward resource recovery	
▪ involvement of users in operation and maintenance	
▪ ease of use of facility by the users	
5. Economic ▪ initial cost	
▪ flexible to accommodate different household incomes and material availability	
▪ resources for operation and maintenance of the technology	

APPENDIX C

MAP OF WATER RETICULATION SYSTEM IN THE CITY OF LUSAKA

APPENDIX D

GLOSSARY

Adequate sanitation facility:	A sanitation facility that is convenient to all household members accessing it.
Communal tap:	An open centralised water source and distributes water from one or more taps to many users.
Flying toilet:	The practice of defecating in polyethene bags.
Formal employment:	A form of employment where the person has a monthly salary.
Household:	A house together with it's occupants.
Improved water supply facility:	A facility that is protected from outside contamination, especially feacl matter.
Improved sanitation facility:	A facility that hygienically seperates human excreta from human contact.
Individual connections:	Private water taps connected into ones' yard and the owner is accountable for the monthly bills.
Informal employment:	A form of employment or business that does not guarantee a monthly salary.
Kiosk:	A centralised water source and distributes water from one or more taps to many users, and has a shelter.
Local authorities:	Gorvenment service providers.
Low-cost technologies:	Technologies that offer a means of addressing water and sanitation needs in a more sustainable manner.
Ngwee:	Zambian currency.

Per capita water consumption: Water consumption per person.

Peri-urban areas: Areas characterised by overcrowding, high poverty levels, poor housing conditions and lack of adequate access to water supply and sanitation.

Plot: A small piece of land with a size of which can occupy a house and a small yard..

Respondent: Participant of the household survey.

Sustainable water supply and sanitation facilities: Facilities that meet the local requirements of areas they are implemented in such as demographic characteristics, economic, technical, socio-cultural and institutional conditions of the area.

Urban poor: Peri-urban residents.

Urbanisation: The increase in the proportion of pupualtion in urban areas.

Zambian Kwacha: Zambian currency