Development of an Inclusive City-Wide Faecal Sludge Management Business Model for Kabwe Town, Zambia

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ABSTRACT

Investments in sanitation solutions reduce disease burdens and is a huge market for public and private businesses since billons of people in the world do not have access to safely managed sanitation services. However, there remains much to be done to develop, pilot and scale up business models and technologies that work to fully understand the nature and quantities of faecal sludge needing collection and treatment. In Kabwe, the lack of a comprehensive business model informed by market research has contributed to faecal sludge not reaching designated treatment sites. Private operators charge unregulated fees for emptying and use unhealthy emptying methods that risk public health and groundwater resource. This research aimed at developing an inclusive city-wide FSM business model for Kabwe Town was conducted using mixed qualitative and quantitative approaches at 172 households and institutions spread across 20 wards. The results showed that 41 percent of the containments were unlined pits which could not be desludged easily. At least 84 percent of households could not afford to pay $42 for emptying services, but 96 percent were willing to contribute a monthly staggered tariff for emptying service which would make the service affordable regardless of socioeconomic status. It was estimated that at least 8,882m^3/year of sludge would be available for emptying. With minimal overhead costs, utilising existing infrastructure and charging an emptying fee of $1 – $3 or $3 – $9/m^3, the business would make a positive net profit in the first year of operations and offset a loan amount of up to $28,400. The model demonstrated that in as much as financial resources are required, minimal start-up capital coupled with prudent planning, utilisation of readily available resources are key success factors. The study brought out key areas of attention which includes the need for awareness creation, pro-poor diverse payment schemes to increase demand and concerted stakeholders efforts on issues of policy, enforcement and capacity strengthening.

Keywords-- Sanitation, Emptying Service, FSM Business Model, Faecal Sludge

I. INTRODUCTION

Management of wastewater and Faecal Sludge (FS) in developing countries has continued to be of growing concern due to the negative health implications it has on the biological and physical environment. Inadequate sanitation is linked to transmission of diseases such as cholera, diarrhoea, dysentery, hepatitis A, typhoid and polio and exacerbates stunting. Poor sanitation reduces human well-being, social and economic development due to impacts such as anxiety, risk of sexual assault, and lost educational opportunities (WHO, 2017). The United Nations (UN) estimates that achieving universal access to safely managed sanitation by 2030 will require a four-fold increase in current rates of progress (UN-Water, 2021). Almost half of the 2021 global population, 3.6 billion people lacked safe sanitation (WHO/UNICEF, 2021). Every day, over 700 children under the age of five die from diarrhoea linked to unsafe water, sanitation, and poor hygiene (UNICEF, 2021).

Zambia's situation regarding access to sanitation facilities has become a source of ill health and deaths as evidenced from the 2017/18 cholera epidemic that resulted in 5,900 cases and 114 deaths (Sinyange N, Brunkard JM, Kapata N, et.al, 2018). Diarrhoea is the third largest killer of children aged less than five in Zambia and it is estimated that every year 15 000 die because of the disease (Hamooya, BM. et al., 2020). Nearly 90 percent of these incidences are directly attributed to poor water, sanitation, and hygiene (WASH) conditions which results in an estimated US$167 million lost each year due to premature death (WSP, 2012). The lack of safely managed sanitation is also a major risk factor in Kabwe town, Central Province of Zambia. Developers and individual households have responded to this situation by providing their own sanitation facilities. These typically consist of a dry pit latrine toilet or in few instances a water-based toilet, from which excreta is flushed to a closed pit, septic tank, or soak-away pit. Facilities with on-site storage remove excreta from living spaces, reducing people's exposure to pathogens, and improving the local environment. However, overtime, sludge accumulates in pits or septic tanks, eventually exposing people to insanitary conditions unless the pits and septic tanks are either replaced or emptied. Replacement of pits is possible in low-density rural and peri-urban areas, but lack of space often precludes this option in higher-density urban areas. The only option for households living in these areas is to arrange to have pits and septic tanks emptied when they are full.

According to Hutton et. al (2007), in developing regions, the return on US$1 investment in sanitation was in the range of US$5 – 45, depending on the intervention. The World Bank estimated that poor sanitation costs Zambia approximately US$194 million every year, equivalent of US$16.4 per person or one point three percent of the national Gross Domestic Product (GDP) (WSP, 2012). According to the baseline survey conducted by Stichting Nederlandse Vrijwilligers (SNV) Netherlands Development Organisation at the beginning of 2018, 51 percent of the households in Kabwe used drop through toilets. With no safe collection, transportation, and treatment, it was certain that removed FS ends up in the environment where it poses a significant threat for disease transmission. The SNV survey estimated that there were about 6,425 wet pits which posed the greatest threat to groundwater pollution if not lined. This interface between humans and faecal matter is the one that provides the first source of danger in the sanitation value chain. Pit emptying has for a long time been done illegally especially in peri – urban areas by unregulated pit emptiers and vacuum tank operators (SNV, 2018). Public health standards demand that such activities are done in such a way that it protects public health and the physical environment during the process of emptying, storage, transportation, or disposal/reuse. Failure to arrange for safe FS removal, transportation, and treatment results in sanitation conditions that fail to meet the Sustainable Development Goals (SDGs) requirement for safely managed sanitation services.

Experiences worldwide have shown that sanitation can be a viable business opportunity and has the potential to provide multiple benefits to the poor. Market-based approaches seek to address the challenges of financial sustainability and to strengthen the role of the private business sector while empowering local communities and individuals to make their own informed decisions about obtaining sanitation products and services (Gröber, K. et al.,2012). The challenge is to identify efficient, scalable and sustainable sanitation solutions that have economic potential and to allocate investment capital and funds to implement these solutions at scale. The process of identifying these solutions needs to be a collaborative effort between experts in marketing, finance, and engineering. These efforts can effectively be supported by national and local governmental agencies as well as Non-Governmental Organisations (NGOs) with in-depth local knowledge (Gröber, K. et al., 2012).

With the rapid and uncoordinated urbanization, onsite sanitation services are a vital form of service delivery to ensure increased coverage and accessibility to safely managed sanitation, in the quest to meet the SDG target 6.2. The lack of adequate business models based on comprehensive market research has contributed to most FS not reaching the designated treatment plants. Water and Sanitation utilities have found it easier and convenient to provide water services as revenue is assured from water supply as opposed to onsite sanitation NWASCO, 2020). This ack of business models has also contributed to unhealthy emptying methods that risk public health, pollution of groundwater resources due to poorly constructed sanitation facilities and private operators charging unregulated amounts for emptying and disposal. Achieving increased coverage and access to safely managed sanitation services in Kabwe requires effective business models of the entire sanitation service chain.

Research on FSM business modelling will provide part of the solutions to the identified gaps. This research was aimed at developing an inclusive city-wide FSM business model for Kabwe Town by assessing the sanitation conditions necessary for FSM business modelling and then determination of market potential through pit latrine and septic tank sludge quantification.

II. LITERATURE REVIEW

2.1 Sanitation Challenge in Zambia

In 2019, at least three percent of urban and 32 percent of rural population had no access to sanitation. Unimproved sanitation accounted for 28 percent of the urban and 43 percent of the rural population. About 33 percent of the urban and 6 percent of the rural population had limited sanitation which is also below the acceptable standard of basic sanitation which stood at 19 percent in the rural and 36 percent in the urban (WHO/UNICEF, 2019). The most prominent issues that resurfaced every year in National Water Sector (WSS) reports and in NWASCO's 2016 – 2020 strategic plan are: dilapidated and inadequate infrastructure, inadequate commercial orientation, poor project management, poor asset management and low focus on sanitation service delivery. The decision to commercialise the sector was premised on the need to have financially viable water and sanitation service (WSS) institutions managed by business-oriented professionals, but the CUs still do not adequately treat the provision of the service as a business (NWASCO, 2016). The Urban OSS and FSM framework for provision and regulation of water and sanitation in Zambia identified the gaps that NWASCO was regulating sanitation service provision only through sewerage systems and not onsite sanitation, while Zambia Environmental Management Agency (ZEMA) licensed the exhauster truck and the construction and operation of wastewater treatment plants. Onsite sanitation facilities such as pit latrines and septic tanks were not constructed to enable safe emptying and protection of the environment as there were no national standards for this purpose. ZEMA had developed effluent standards, but FS standards were not in place.

There was also a lack of community emptying regulation leading to uncontrolled pricing and unaffordable onsite sanitation services (NWASCO, 2018).

2.2 Sanitation Services in Kabwe Town

Lukanga Water Supply and Sanitation Company (LgWSSC) is the main licensed provider of water and sanitation services in Kabwe Town. Initially these services were provided by Kabwe Municipal Council (KMC) but were later transferred to utility company which was formed through an act of parliament. The municipality of Kabwe is served by a combination of localized reticulated sewerage systems and onsite sanitation. The town has about 20% of households connected to sewerage system whereas 80% of settlements are not connected to the sewerage network system (LgWSSC, 2020). SNV baseline which was conducted in 2018 estimated that 6 percent of the population in Kabwe practiced open defecation, 27 percent had unimproved toilets, 16 percent with basic sanitation while 10 percent had improved toilets where flies could not easily access. The report goes further to state that 41 percent of the population had presumably environmentally safe sanitation (SNV, 2018).

2.3 Sanitation Service Chain

The functioning and process flow of an OSS is characterized by access to toilets, emptying, transport, treatment and disposal or reuse as highlighted in figure 1 - 1 below, and this is referred to as the sanitation service (delivery) chain (Trémolet, 2011).

Figure 1: Sanitation service delivery chain

The chain has been used by sanitation practitioners as a framework for analysing the physical flow of FS through the system (Blackett et al. 2014). This research uses the chain to present the stakeholders and business models in FSM. The different parts of the chain are briefly described below:

a) *Containment/ Access to toilet:* Practices of open defecation or lack of adequate sanitation facilities are dealt with through the provision of an improved sanitation system, such as pit latrines and septic tanks, which safely contain and store human excreta.
b) *Emptying and transport:* Septic tanks and pit latrines contain human excreta and gradually fill up over time. Once they are full, the sludge collected needs to be emptied and transported to a designated treatment site.
c) *Treatment:* FS collected from on- site sanitation systems is treated so that its solid and liquid fractions do not harm public health and the environment.
d) *Disposal:* Safe disposal of treated sludge, especially the part which does not provide value for resource recovery for reuse, is critical to ensure isolation of the waste from human and environmental contact.
e) *Reuse:* FS contains resources such as nutrients, energy and water, all of which have intrinsic value and can create financial benefits for wastewater treatment facilities. Depending on the process applied for treating FS, different types of products can be produced depending on the type of resource recovered. Reuse offers an additional value proposition to FS treatment with potential for revenues by valorization of intrinsic resources in FS. As highlighted in figure 1 above, resources in FS are primarily in the form of energy, nutrients and water (although other value propositions are possible, e.g., building material).

2.4 Safely Managed Sanitation along the Service Delivery Chain

FSM has often been considered an inferior, stop-gap solution compared to conventional sewerage options, by governments, utilities and urban planners alike (Blackett I., et al., 2016). However, service providers are increasingly recognizing that it will take many years, or may not be cost-effective, to achieve safely managed sanitation services via universal access to sewerage. Crucially, FSM services represent a feasible sanitation solution for many unplanned areas where it is hard to justify major public investments in underground infrastructure, for example due to the urban layout undergoing continual change, or to land tenure issues restricting opportunities for infrastructure development. Non-networked systems are therefore the norm in the majority of low- and middle-income countries, particularly amongst the poorest urban residents. These systems contain FS, which is raw or partially digested feces and urine, along with a variable amount of contaminated wastewater, often mixed with solid waste, menstrual hygiene materials and other waste dropped into toilets or directly into pits and tanks (Blackett I., et al., 2016).

2.5 Knowledge Gaps on City-Wide Urban Sanitation

Based on several studies conducted by the Word Bank (WSP, 2016) and the Bill and Melinda Gates Foundation (Schrecongost A., 2020), a few of key knowledge gaps and areas of weakness in city-wide sanitation were identified as: lack of inclusive and effective service and business delivery models, institutional, regulatory and technological issues. For

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institutional aspects of FSM, the development of viable business models which include considerations of scale, linkages with solid waste management services, on-demand vs. scheduled emptying, etc. where some of the major gaps.

2.6 Business Model Canvas for FSM

The business model canvas describes how a business creates, delivers and captures value, and hence it helps the business develop an operational process of delivering a product or service to a target customer segment. The business model canvas has nine building blocks (Osterwalder, A., et al., 2010). The nine elements of the business model are: Customer segment, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partners and cost structure. The positive and negative social and environmental costs or benefits are also considered for a generic FSM business.

The generic business model canvas for FSM can be interpreted by first linking the customer segment and the corresponding value proposition offered, followed by customer relationships and channels through which the value proposition is delivered to the customer segment. The next step is to analyse revenue streams from the value proposition offered and the relationship between remaining elements of the canvas to the corresponding value proposition. The canvas provides multiple value propositions, and its corresponding customer segments and other elements are categorised with specific colour codes.

The business model canvas in table 1 below presents generic key value propositions for providing FSM services (Rao, K. C. et al., 2016).

Table 1: Generic business model for FSM (adapted from Rao, K.C. et al., 2016)

Key Partners	**Key Activities**	**Value Proposition**	**Customer Relationships**	**Customer Segments**
*Municipal corporation and local authorities *Technology suppliers *Financial institutions *Community based Organisations *Research and Development Institutions (e.g., Universities)	*Toilet provision *Waste collection FS Collection FS treatment *Organic Waste & FS collection *Compost production *Compost sales & marketing Biogas production Biogas sales *Customer relationships management	*VP1: Access to toilet and increased revenue from reuse. *VP2: Timely emptying and transportation of FS *VP3: FS treatment for healthy and safe environment *VP4: High-quality compost (soil ameliorant) * VP5: Reliable and renewable energy service	*Direct sale of toilet *One-on-one service provision *Contract from municipality *Direct or through contracts *Direct compost sales *Distributors *Direct energy sale *Power purchase agreement	*Community *Businesses Households Businesses Municipality Farmers Municipal Park department Agriculture department Agroforestry Fertilizer industry Households Community Small businesses *Public sector (e.g., municipality, Ministry, etc.) Institutions
	Key Resources		**Channels**	
	*Appropriate technology and equipment *Labour *Finance *License and contracts for collecting waste		*Direct *Municipality *Word-of-mouth *Brochures and other media communications *Distributors and extension agents	

Cost Structure	**Revenue Streams**
*Fixed investment cost (construction, trucks, equipment, etc.) *Operation and maintenance cost (labour, raw material input, utilities, sales and marketing, license, etc.) *Interest payments	*Sale of toilet and reuse products *FS disposal fees, sanitation tax and *O&M budget support *Emptying fees and, in some instances, FS delivery fees *Sale of compost *Sale of energy
Social and environmental cost	**Social and environmental Benefits**
*Potential health risk for those in direct contact with FS (can be mitigated with the use of protective equipment) *Improper FS treatment and disposal causing environmental and health risks for citizens	*Reduced pollution of water bodies and soils *Improved soil and agricultural productivity *Reduced human exposure to untreated Faecal sludge *Improved energy security *Job creation

Broadly, the business models for FSM in table 1 can be classified under five value propositions (Rao, K. C. et al., 2016). The colour shades represent relevance of each value proposition (VP).

i. Value Proposition 1 (VP1) – Access to Toilet and Treatment for Reuse 3: Providing an improved sanitation service to communities through access to toilet, and recovery of nutrient or energy through treatment of FS.
ii. Value Proposition 2 (VP2) – Emptying and Transportation of FS: Providing a timely sanitation service for emptying pits and septic tanks when they are full.
iii. Value Proposition 3 (VP3) – Treatment of FS for Disposal: A healthier and safe environment through appropriate treatment of FS.
iv. Value Proposition 4 (VP4) – Reuse through Nutrient Recovery: Producing high-quality compost as a soil ameliorant.
v. Value Proposition 5 (VP5) – Reuse through Energy Recovery: Improving access to energy.

III. METHODOLOGY

3.1 Research Design and Data Collection Instruments

The research design for this study was both qualitative and quantitative. Qualitative data was collected through Self-Administered Interviews (SAI) and Key Informant Interviews (KII) with key stakeholders like LgWSSC, KMC, hardware shop suppliers and District Water and Sanitation Hygiene Committee (DWASHE). Quantitative data was obtained using a mobile based survey questionnaire on the status of sanitation in Kabwe.

3.2 Population and Quantitative Data Sample Size Calculation

The sample population included all households in the urban and peri-urban areas of Kabwe. As per Zambia Central Statistical Office (CSO), Kabwe was estimated to have a population of 225,631 people in 2020. With the help of LgWSSC officers, KMC officers and other stakeholders, the population was clustered and divided into urban or rural, planned or unplanned, formal or informal, sewered or non-sewered. The targeted wards were purposively identified. Respondent households in selected zones were chosen randomly using a skipping pattern.

Considering the 225,631 population, Cochran (1963) formula was used to calculate the sample size. The formula allowed the researcher to calculate an ideal sample size given a desired level of precision, desired confidence level, and the estimated proportion of the attribute present in the population. The Cochran formula used is:

$$No. = \frac{Z^2 pq}{e^2} \qquad [1]$$

Where:

$No.$ is the required sample size.
e is the desired level of precision (i.e., the margin of error of 0.05 or five percent),
p is the (estimated) proportion of the population which has the attribute in question, (estimated at 0.5 or at least 50 percent of population with a sanitation facility)
q is 1 – p (q = 1- p = 0.5)
Z is the value corresponding to level of confidence required (estimated at 1.96 as 95 percent confidence level gives us 1.96 from statistical z tables)

Therefore, the ideal sample size to get 95 percent confidence level was: $No.$ = ((1.96)2 (0.5) (0.5)) / (0.05)2 = 385 households/premises but due to time and resource limitations, an acceptable confidence level was adjusted from 95 percent to 90 percent and similarly, a margin of error was adjusted from 0.05 to 0.06. The resulting sample size was 170 premises. Two supplementary samples were added to make final sample size of 172.

Furthermore, a multistage sampling technique was employed to reduce marginal errors, potential biases and increase confidence levels. Below are the stages that were employed:

- All the four administrative blocks (Town, constituency, wards and zone) were picked. As per central statistics classification, the entire Kabwe district is considered urban. In the real sense, some wards are farming blocks and others are typically rural in nature. With the help of the local stakeholders (KMC and LgWSSC), 7 wards which were typically rural and not likely to be serviced by professional FSM services in the foreseeable future were set aside leaving 20 out of 27 wards.
- The second step was to look at the type of sanitation systems that were prominent in specific wards and zones. It was noted that some wards in low density areas were connected to conventional sewer system. However, they still had some isolated septic tank systems and pit latrines. This guided in selecting the number of samples to be taken in each ward as onsite sanitation services are likely to be used mostly in non-sewered settlements. Sewered settlements were already in the database of LgWSSC and were utilising wastewater conveyance and treatment services.
- The third stage was to look at the population weight of each ward, the average weighted population was factored into the distribution of 172 samples.

Overall, a total of 172 survey questionnaires were administered from 20 out of the 27 wards. Respondents were selected through a disproportionate random stratified sampling approach as more samples were picked from certain zones/wards depending on their population weight and other factors listed above. Respondent categories included, households, business premises (lodges and bars), public places and institutions like hospital and school premises from planned residential areas, the unplanned, informal settlements and a combination of both planned and unplanned settlements. Premise level data on sanitation practices,

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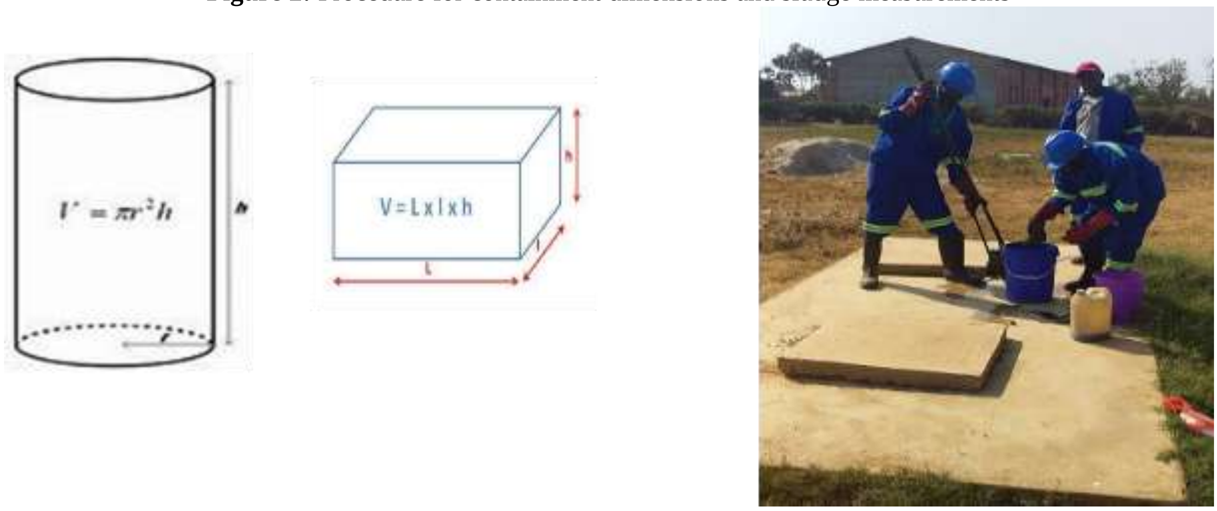
quality of containment facilities, ease with which containments could be emptied was collected to inform business modelling.

3.3 Sludge Quantification Data Collection Procedure

Estimation of sludge quantities in containments helped to determine market potential for business modelling. Some tools and equipment used for the collection of data include but not limited to mobile phones, 5m measuring tape, sludge measuring dipper of about 4.5 metres, personnel protective equipment (hardhats, gloves, gumboots, work suits) as the sludge is highly infectious, hand sanitiser and other disinfectants (chlorine, lime, germ guard). Figure 2 shows an overview of the process involved in measurement of dimensions and sludge in the containments.

Figure 2: Procedure for containment dimensions and sludge measurements



Below is a step-by-step process used in the collection of data to estimate sludge quantities.

i. Smart phone with Geographical Positioning System (GPS) and Akvoflow Applications installed were loaded with the questionnaire. Questionnaire on general sanitation conditions at a household/premise level included questions on containment dimensions like length, height/depth and width/diameter.
ii. A containment was first assessed if it could be opened or not. Containments which were sealed and could not open were not measured.
iii. For containments which opened, a dipping steel rod was inserted up to the bottom of the containment. The depth of the containment was recorded as "d" in meters.
iv. The height of sludge was also recorded as depth of containment minus distance from the top of the dipping rod to where the sludge marks began.
v. The length of the containment was recorded in meters. The width of the containment was also recorded in metres. For circular containments, the length and width dimension were replaced with radius or diameter.
vi. The premises were cleaned and disinfected by chlorine and germ guard antiseptic chemicals. The tools were also thoroughly cleaned with the disinfectants.
vii. The household was thanked for allowing the process to be taken at their house.
viii. As a quality control measure and to avoid mix up of numbers, all the figure of containment dimensions was recorded in metres and the mobile questionnaire was programmed to accept on that.
ix. Containment volume was calculated as:
$Volume\ (V) = Length(L)\ x\ Bredth\ (B) x\ Height\ (H)$ for rectangular containments
$Volume\ (V) = \pi r^2 h$ for circular containments was also estimated

3.4 Data Cleaning and Analysis

The survey tool was designed using AKVOFLOW software which was uploaded onto the mobile phones. Data was captured digitally. Prior to the survey, the questionnaire was pre-tested to check consistency with skipping pattern. Besides, two other officers from the municipality helped in data collection and as such they had to be trained. Assistants familiarised themselves with questionnaire contents, flow of questions, mobile data collection devices, and test run all the devices with the mounted questionnaire. The output of the Akvoflow application was an excel data sheet and some basic frequency charts. Data cleaning required a set of procedures aimed at assessing the sampling protocol adherence, completeness of collected data, accuracy, consistency and relevance of each of the data elements under consideration as well as actual correction of the data with errors for better data quality. The process of data cleaning ensured that the errors in data arising from missing data, outliers and

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other out of range issues were handled in time for better quality results.

Data analysis involved use of summary statistics such as frequency distribution, charts and means. In most cases, ward level analyses were also performed to look at trends and differences in the different wards. Though used, the Akvoflow system generated graphs were not very helpful in most cases as it lacked certain essential detail beyond basic frequency distribution table/graphs. Going by the nature of this study, excel pivot tables were mostly utilized to generate dynamic graphs that combined different parameters on the same page. The initially generated data on basic sanitation conditions and sludge quantification provided a springboard for further data analysis and finally the generation of the business model cash flow projections. Qualitative data was analysed using different approaches. Content analysis approach was used to categories verbal and behavioural data into summarised tabular formats for the business model calculations. Narrative analysis approach was used for reformulating/revising primary qualitative data presented by respondents considering context of each case and different experiences of each respondent. Discourse analysis was used on with naturally occurring talk and all types of written text (literature).

3.5 Limitations of the Research

Literature on the professional management of FSM and on-site sanitation in Southern Africa is less than 20 years old, so it is relatively new. Business modelling for FSM services in Zambia is particularly lacking and there is relatively small number of peer-reviewed journal articles pertaining to it. The surveys were undertaken on a sample basis as opposed to a complete census survey. Therefore, errors of estimation regardless of the thoroughness of the survey design. The confidence level of this research was reduced from 95% to 90% whereas the margin of error increased from 5% to 6%. The lack of data to account for seasonal sludge quantity fluctuations was limiting. To collect all the data sets required especially on sludge quantification in different seasons, a lot of time is required, and it is costly. This constraint also limits the number of surveys that one can carry out. Regardless of the above stated potential limitations, the results of this research can be relied on and be generalised.

3.6 Ethical Approval

The research was approved (REF NO. NASREC-2021-OCT-008) and followed all the ethical guidelines, as specified by the University of Zambia Natural and Applied Sciences Research Ethics Committee (NASREC).

IV. RESULTS AND ANALYSIS

4.1 Sample Characteristics

The urban part of Kabwe district has different types of settlements. These settlements were broadly categorised as planned, unplanned and informal/slum. Some areas have a combination of both the planned and unplanned settlements. Figure 3 gives a summary of how the sample was distributed across the different type of settlements.

Figure 3: Sample distribution per type of settlement

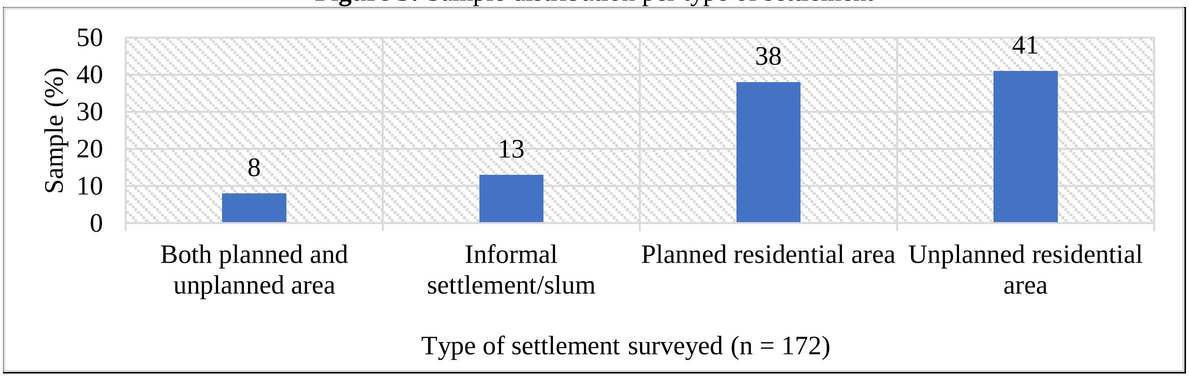

Figure 3 shows that 41 percent of the respondents were from unplanned residential areas, 38 percent were from planned residential areas whereas 13 percent and 8 percent were from informal/slum and a mix of planned and unplanned areas, respectively. Additionally, majority of the respondents were from residential facilities (132) with a few isolated public places such as bars and lodges (9), churches (4), markets (3) and shopping complexes (2). Institutions included health (5) and education facilities (17).

4.2 Sanitation Conditions Necessary for FSM Business Model Development in Kabwe

In assessing the necessary conditions relevant for FSM business model in Kabwe, data was collected on different nodes of the sanitation service chain. Data collected included but not limited to types of sanitation facilities, quality of sanitation facilities, social economic factors prevailing at premise or household level among other issues.

4.2.1 Sanitation Mix of Kabwe

Predominant sanitation type used in Kabwe are traditional unlined pit latrines. Figure 4 below

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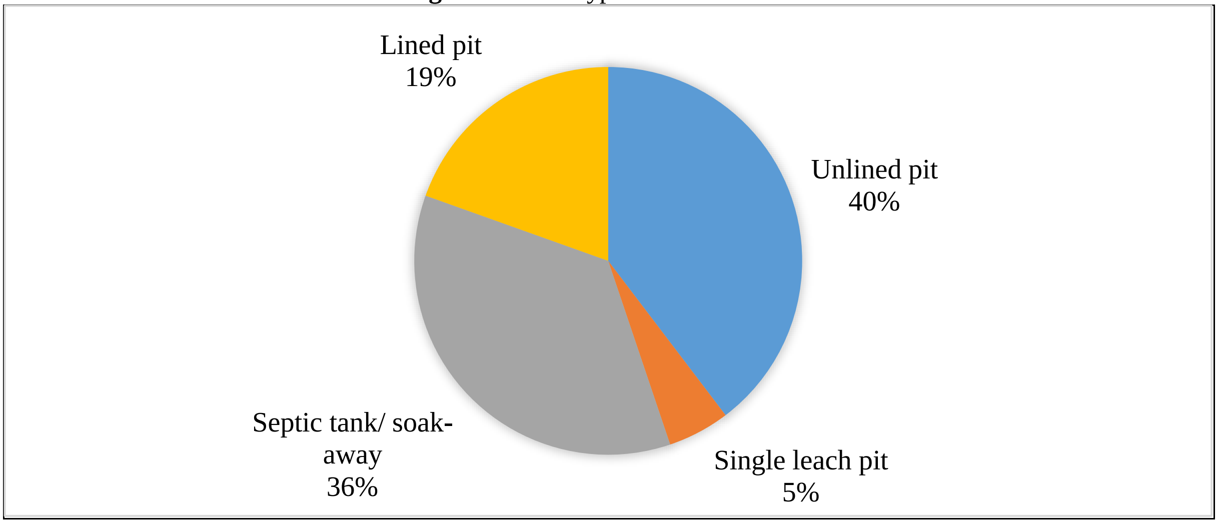
summarises the main types of toilet containment systems used. Four main categories were identified, and these are unlined pits at 40 percent, lined pits at 19 percent, leach pits at five percent and septic to soak away systems at 36 percent.

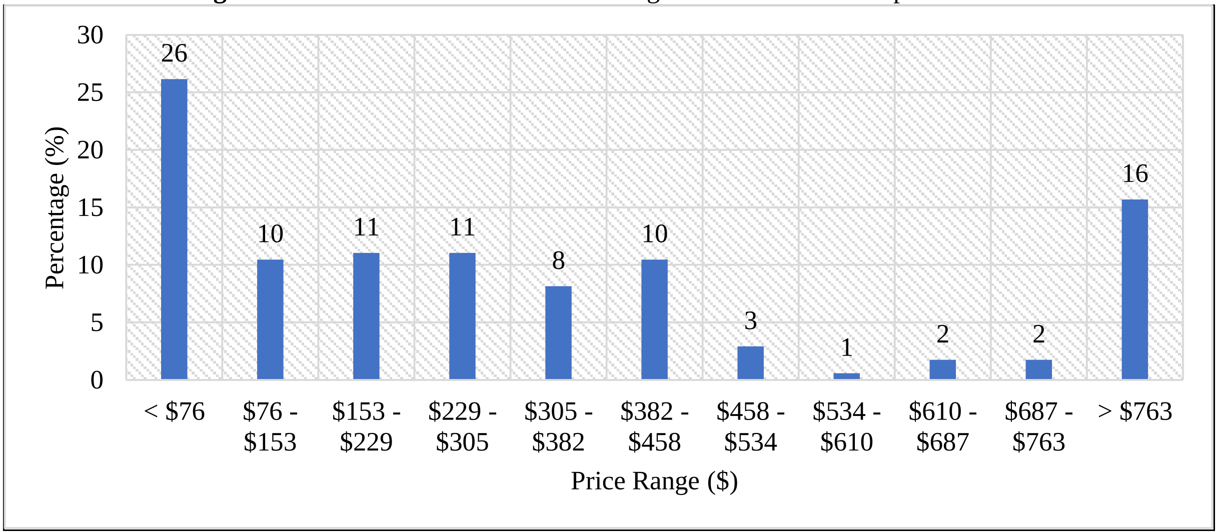
Figure 4: Main types of containments



4.2.2 Willingness to Invest in a New Emptiable Toilet

Considering the poor quality of most toilet structures, respondents were asked to indicate how much they were willing to invest in new emptiable toilet containments. Figure 5 shows that 26 percent of the respondents indicated willingness to invest less than $76 in a toilet. The willingness to invest in a toilet which costs more than $458 reduced drastically except for 16 percent respondents from low density areas who were willing to invest in a toilet which would cost up to and beyond $763.

Figure 5: How much a household is willing to invest in a new emptiable toilet



4.2.3 What Happened When Toilet Containments Were Full

The findings on the proportion of containments that were filled revealed that only 23 (13 percent) of the respondents indicated having had filled toilets before. The rest of the respondents 149 (87 percent) indicated not to have had been filled before. Respondents which indicated having had a filled toilet were probed further to explain how they dealt with filled up containments. Clearly from figure 6 below, most respondents, 67 percent called for an emptier to help them deal with a filled-up toilet containment. The second option for properties with filled up containments was to abandon the toilet and construct a new one as indicated by 21 percent of respondents. Some properties (eight percent) indicated having diverted the wastewater and continued using their containments. A small proportion (four percent) of respondents indicated having emptied toilet facilities on their own.

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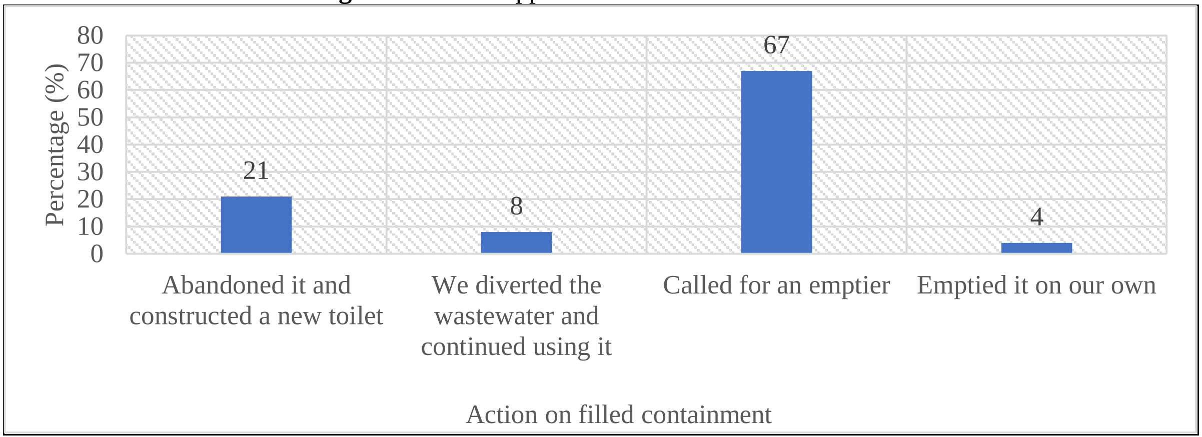
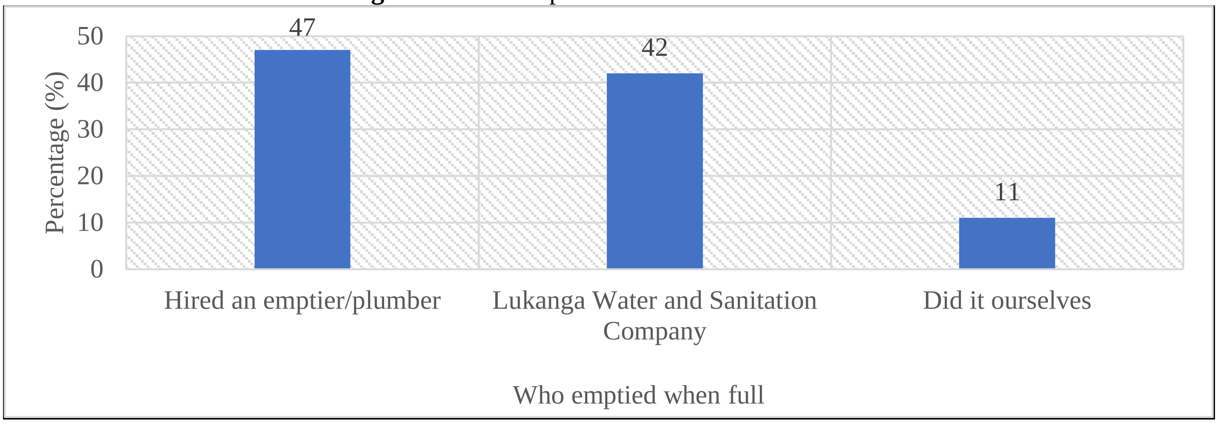
Figure 6: What happened when containment was full



4.2.4 Who Emptied When Containments Were Full

Figure 7 below shows the different categories of toilet emptiers. Local plumbers/emptiers were widely used by local people to empty toilets. At least 47 percent of the emptying jobs were done by local emptiers or plumbers who are primarily informal. A good number of emptying jobs 42 percent were executed by the mandated service provider, LgWSSC. A few cases were reported to have been done by property owners themselves.

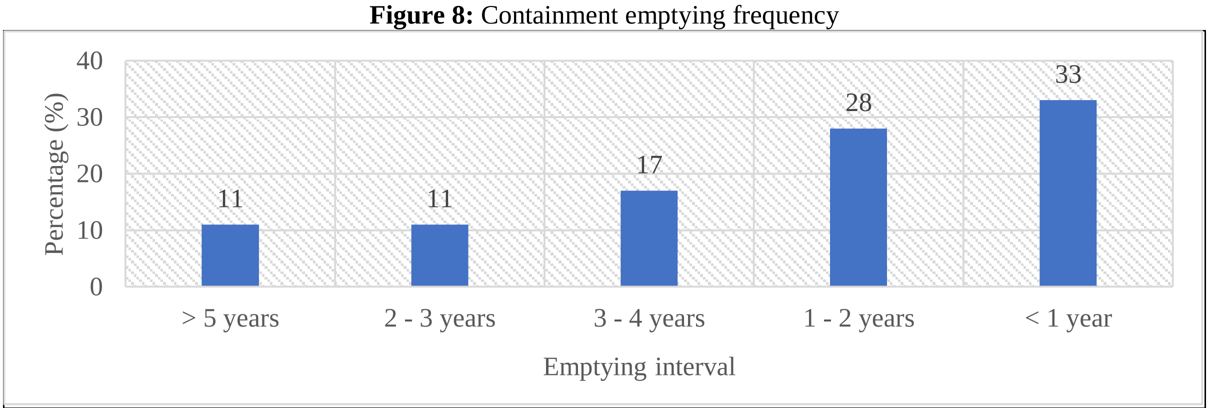
Figure 7: Who empties when containment is full



4.2.5 Containment Emptying Frequency

For properties that indicated having emptied before, figure 8 shows that 33 percent of the respondents have had their containments emptied once per year with 28 percent having emptied in a space of 1 – 2 years. Respondents having emptied in a space of between 2 – 3 year as well as more than 5 year were 11 percent and 17 percent of respondents had emptied between 3 – 4 years interval.

Figure 8: Containment emptying frequency



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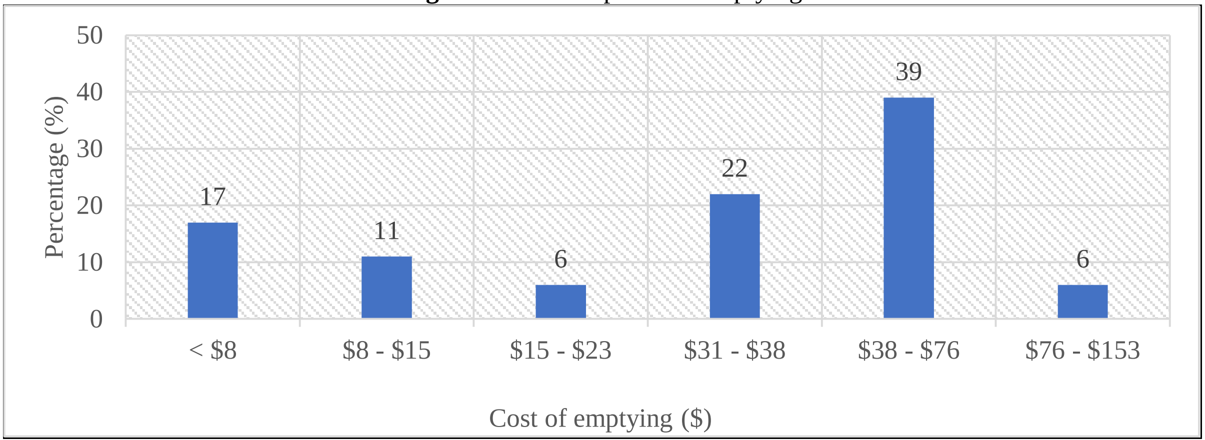
4.2.6 Price of Emptying

As shown by figure 9, the price for emptying varied from below $8 to $153. Majority of respondents, 39 percent indicated paying between $38 to $76. At least 22 percent of respondents paid between $31 to $38. Only 6 percent of respondents paid between $76 to $153, and the rest of the respondents paid amounts which were equal or less than $23.

Figure 9: Price of previous emptying



Results from KII indicated that informal emptiers did not have a fixed charge for emptying services. The price was dependent on the negotiation power of the premise owner and the flexibility of the emptiers. For LgWSSC, the price was determined by NWASCO and ranged from $42 to $58 depending on the customer category if commercial or domestic.

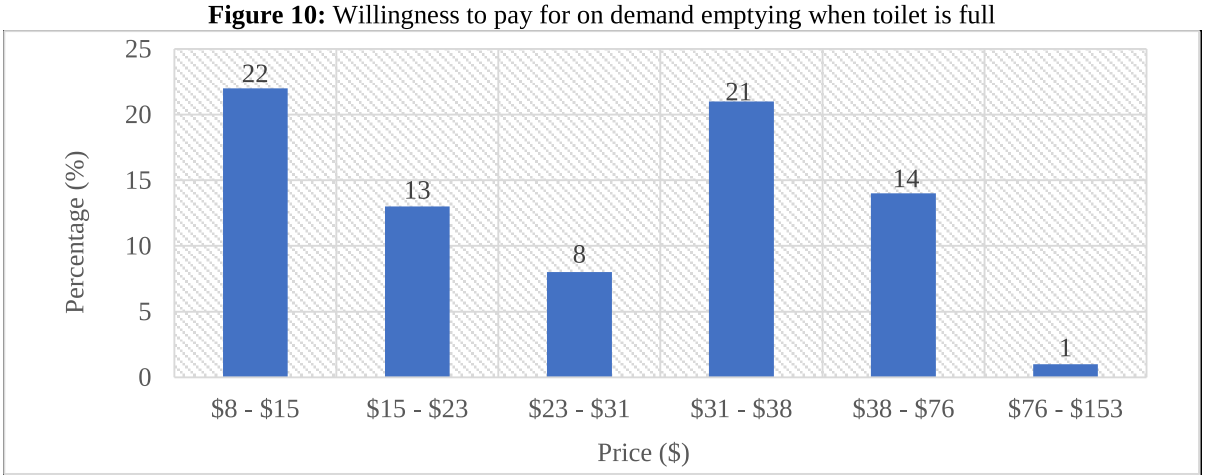
4.2.7 Willingness to empty containments when they get full

The findings show 96 percent of the premises were willing to empty their containments when they get full compared to four percent who were not willing to get their containments emptied. Willingness to emptying indicates how much of a nuisance a filled containment is to an average household regardless of social economic status. A few who were not willing to empty containments might have their reasons which could range from lack of desire to implement emptiable containments to culture myths associated with dealing with human waste.

4.2.8 Willingness to Pay for on Demand Emptying Services

The respondents who indicated that they were willing to get their containments emptied were further probed to state how much they would afford to put up for emptying services. Figure 10 shows that 22 percent of the respondents could pay between $8 - $15. There were 21 percent of the respondents who were willing to pay between $31 - $38. A total of 13 percent were able to afford between $15 - $23 and eight percent could only afford $23 - $31. Only one percent of the respondents indicated that they could afford any amount between $76 - $153.

Figure 10: Willingness to pay for on demand emptying when toilet is full



4.2.9 Preferred Emptying Service Provider

The results indicate in figure 11 that the majority, 92 percent (n =152) of the respondents would prefer that LgWSSC takes lead in the emptying services. There were four percent (n = 4) respondents that preferred a private emptying company, three percent (n =

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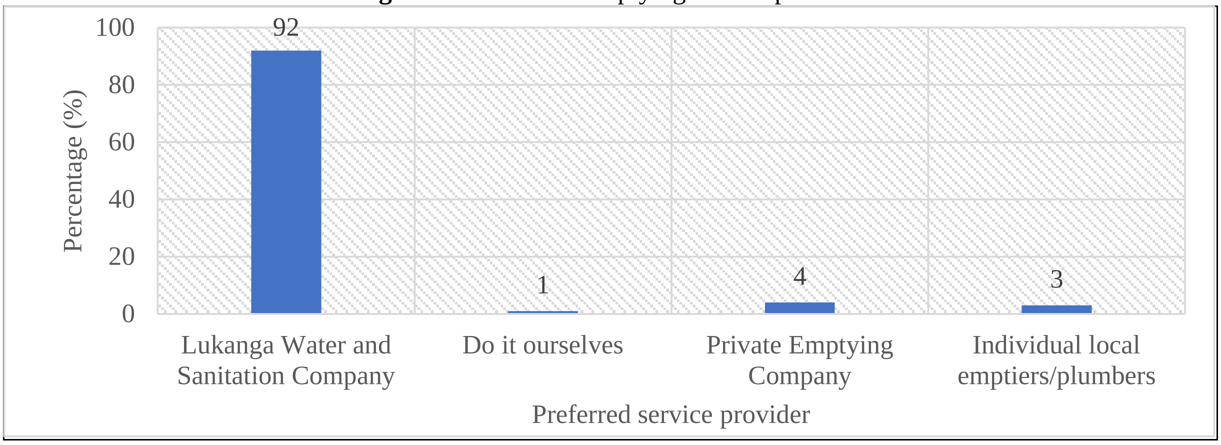
5) preferred individual local masons and one percent (n = 2) of the respondents preferred doing it on their own. Figure 11 below shows preferred emptying service provider

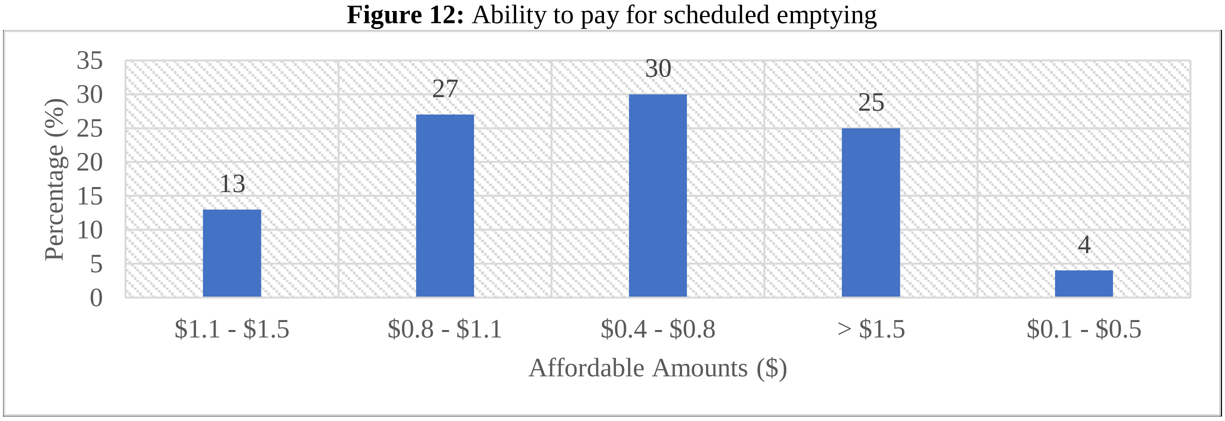
Figure 11: Preferred emptying service provider



4.2.10 Willingness and Ability to Pay for a Scheduled Emptying Programme

Like the on demand once off emptying service, respondents were asked to state if they would be willing to subscribe to a scheduled emptying service where their containments would be emptied once in every 3 -5 years. Similar results to the general on demand service were obtained, all the 165 respondents indicated that they were willing to subscribe to a scheduled emptying programme if introduced. Figure 12 shows that 30 percent of the respondents could afford $0.4 – $0.8 per month. This was followed by 27 percent of respondents who could pay $0.8 - $1.1. A total of 25 percent of respondents could pay any monthly amount above $1.5.

Figure 12: Ability to pay for scheduled emptying



4.2.11 Accessibility of Toilet Facilities Throughout the Season

The survey findings showed that 81 percent (n =141) of the roads were accessible throughout the year regardless of the season. However, 18 percent (n = 31) were not accessible during the rainy season as the roads become impassable. The results also show that there were isolated cases of about two percent of the facilities which were not easily accessible regardless of the season nor device being used. Figure 13 below shows condition of the access roads to the toilet in different seasons.

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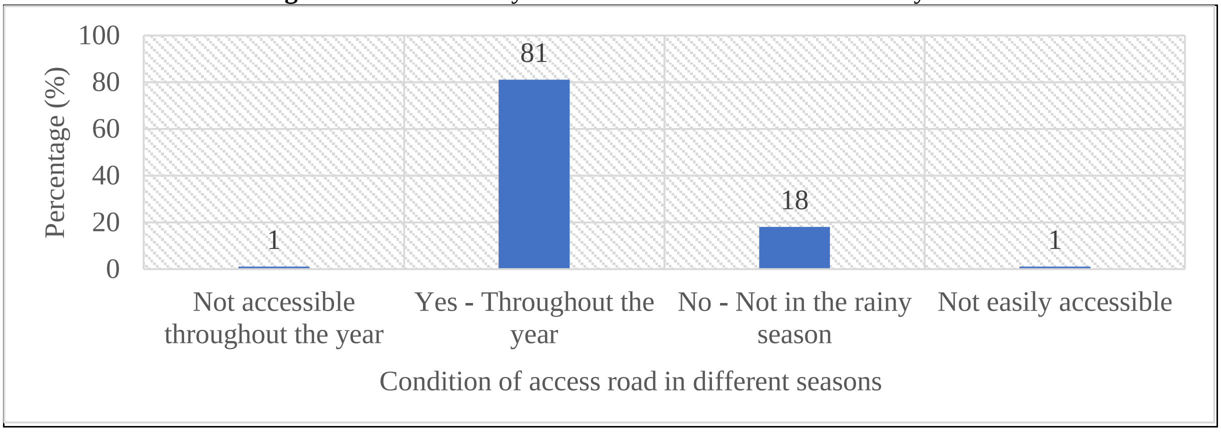
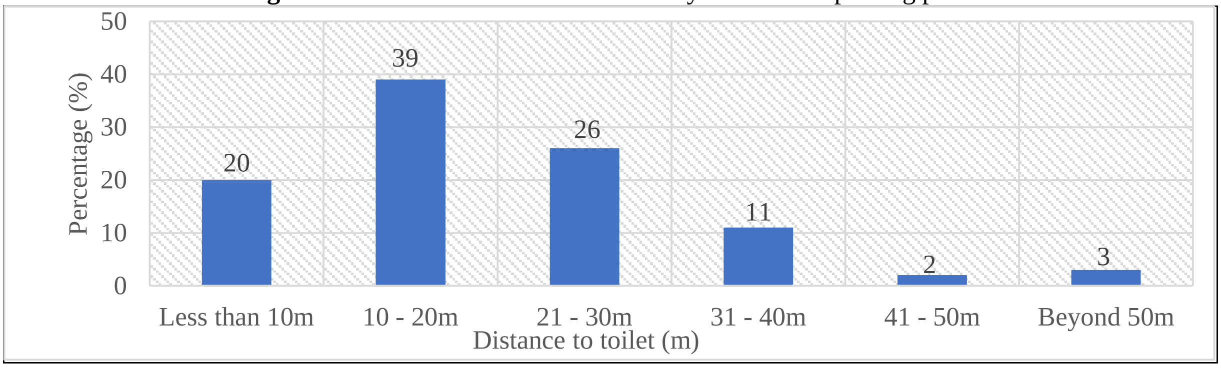
Figure 13: Accessibility of toilets in different seasons of the year



4.2.12 Distance between Toilet Facility and Nearest Parking Point

The last factor of assessment on transportation related issues was on the distance between the toilet facility and the nearest parking point for the sludge transportation vessel. Figure 14 below shows that 20 percent (n = 30) of the facilities were less than 10m from nearest parking point, 39 percent (n = 69) of the facilities were within 10 – 20m range. The findings reveal that 26 percent (n = 44) of the facilities were still within vacuum pumping range of 21 – 30m. The proportion of facilities that were in the range of 31 – 40m were 11 percent. Five percent of the facilities were found to be further than 40m from the nearest parking point.

Figure 14: Distance between toilet facility and nearest parking point



4.3 Market Potential through Quantification of Sludge in Pits and Septic Tanks

4.3.1 Future Hydraulic Loading Based on Mean Pit/Tank Sizes and Emptying Frequency

The hydraulic load was assessed using information on the number of tanks and pits to be emptied (Taylor, 2018) within Kabwe, an estimate of the average tank/pit size, and an assumed emptying interval. The equation for the hydraulic loading is:

$$V = \frac{N v_t c_r}{T} \quad \#\#[2]$$

Where:

V is the volume delivered to the treatment plant in m^3 per year, N is the number of pits and tanks in the service area, v_t is the average pit/tank capacity in m^3, cr is the proportion of on-site facilities that are regularly desludged; and T is the average interval between pit/tank desludging events in years.

The first step was to tease out corresponding dimension of each containment regardless of the circular or rectangular orientation. Table 2 below summarises results for containment dimensions and fill rates.

Table 2: Summary of containment dimensions and sludge fill rates by type of containment

Type of containment	No. of containments	Average Length (m)	Average Width (m)	Average Depth (m)	Current Sludge Depth (m)	Average Vol (m^3)	% Fill
Septic tank/ soak-away	61	2.54	1.78	2.18	1.06	10	49
Lined pit	33	2.15	1.58	1.94	0.71	7	37
Single leach pit	7	1.59	1.16	2.02	0.50	4	25
Lined pit|Single leach pit	1	2.70	1.47	2.80	1.50	11	54
Septic tank/ soak-away|Single leach pit	1	1.00	0.80	2.22	0.62	2	28
Unlined pit	69	1.82	1.34	2.05	0.50	5	25
Average						**6**	**42**

From containment measurements, it was estimated that 42 percent of containments were occupied with sludge. The average size of septic tanks was 10m^3 while the average size of pit latrines was 6m^3.

The final stage in the estimation of of sludge volume from both pits and septic tanks was done using equation 2. The equation was slightly modified by factoring in the willingness to pay and containment fill rates to give a true reflection of emptiable containments. Results obtained in figure 4, figure 8 and table 3 were used in the calculation. Table 3 below shows results of sludge volume using future loading method based on containment sizes and emptying frequency.

Table 3: Future hydraulic loading based on mean pit/septic sizes and emptying frequency

Key parameters for sludge volume calculation	Source of data	Pits	Septic
a) Population as per CSO 2010 projections, (No.)	(CSO, 2010)	225, 631	
b) Proportion of population on onsite sanitation (%)	(LgWSSC, 2020)	80	80
c) Proportion of different containment types (%)	(Figure 4)	64	36
d) Population based on containment type, (No)	(a x b x c)	111,912	68,592
e) Average Household size (No./HH)	(CSO, 2010)	5.8	5.8
f) Potential number of containments, N_t (No.)	(Item d/ Item e)	19,918	11,826
g) Number of containments in a service area, N	(Item d x Item b)	15,436	9,461
h) Average containment capacity, Vt	(Table 3)	6	10
i) Proportion of containments to be desludged, Cr (%)	(Figure 4)	25	35
j) Willingness to pay for emptying service, (%)	(Section 4.2.7)	96	96
k) Average containment fill rate, (%)	(Table 3)	33	49
l) Average time interval of desludge in years, (yrs.)	(Figure 8)	2	2
m) Volume of sludge, V (m^3/year) = (g x h x i x j x k) /l		**3,635**	**7,890**
Total sludge expected (m^3/year) = 3, 635 + 7, 890			**11,525**

4.3.2 Future Loading Based on Per-Capita Sludge Accumulation Rate

Another option for assessing future volumetric loading used was to base calculations on the per-capita sludge accumulation rate (Taylor, 2018). The equation for the volume (V, m^3) for this option is:

$$V = \frac{Pqc_o c_r}{1000} \quad \#[3]$$

Where: *'P' is the estimated population of the service area, including allowance for population growth and, where appropriate, any transient population, for instance tourists and migrant workers. 'q' is the average volume removed per person each year (litres per capita per year), comprising the faecal sludge accumulation rate and an allowance for any supernatant water removed with the sludge. 'c_o' is the proportion of the population served by on-site and decentralized sanitation facilities requiring septage removal, transport, and treatment services, expressed as a fraction; and 'c_r' is the proportion of on-site facilities that are regularly desludged.*

Using equation 3, we insert the key parameters in table 4, and we get the results as below.

Table 4: Sludge volume calculation based on per-capita sludge accumulation

Key Parameter for sludge volume estimations	**Source of data**	**Value**
a) Population as per CSO 2010 projections, (No.)	(CSO, 2010)	225,631
b) Average volume removed per person per year (lcp)	(Still & Foxon, 2012)	60
c) Population on onsite sanitation (%)	(LgWSSC, 2020), KII	80
d) Proportion of population served, requiring emptying, Co	(LgWSSC, 2020), KII	0.8
e) Willingness to pay for emptying service, (%)	(Section 4.2.7)	96
f) Proportion of facilities to be regularly desludged, d (%)	(Figure 4)	60
Volume (m^3/year) = (a x b x d x e x f)/ 1000		**6, 238**

4.3.3 Adopted Sludge Volume to Determine Market Potential and Business Modelling

Quantifying sludge based on existing emptying practices would give fair results if records were kept and other factors such as extent to which the tanker is filled are recorded regularly. This method though suppresses demand and/or not suitable for futuristic planning horizon. Average results of the first and second method are adopted for business modelling. Therefore, the potential market in terms of average sludge quantity in pits and septic tanks in Kabwe is estimated at: (6, 238 + 11,525)/2 = **8,882m^3/year.**

4.4 Development of Business Model for FSM Services in Kabwe

Following the adapted format presented in table 1, FSM business model canvas for Kabwe was developed. The financial, institutional, and service flows input information was aggregated from survey results, KII, SAI and stakeholder consultations. The model enables the utility to develop an operational process of delivering a professional, hygienic and safe emptying service to target customers (households, commercial, institutional and public places) of Kabwe who are on onsite sanitation. To deliver this value to the residents of Kabwe, key partners such as the Zambia Environmental Management Agency (ZEMA), NWASCO, Kabwe Municipal Council (KMC) were identified. The key partners would provide a conducive legal and regulatory environment and enable the FSM business processes. The day-to-day activities of emptying would be complimented by other intertwined business management processes and customer relation activities aimed at promoting, marketing and improving service delivery to meet customer needs and expectations. The identified partnerships, customer relations, emptying service delivery channels and key activities will cost the utility money and it's all summed up in the cost structure subcomponent. Emptying and all other service fees are highlighted as revenue streams of the model. Though emptying fees were identified as a main revenue stream, private emptiers disposal fees and sales of treated sludge products were additional sources of revenue.

Table 5 below gives proposed FSM business model canvas for Kabwe town anchored on LgWSSC operations. The model summarises how the utility will deliver professional pit and septic tanks emptying services, capture additional value such as groundwater protection, disease burden reduction and keep an aesthetic living environment at profit.

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Table 5: Business Model Canvas for Kabwe FSM services

Partnerships	Key Activities	Value Proposition	Customer Relations	Customer Segments
1. Local Authority: Land, Enforcement, Local ordinances formalization 2. ZEMA: Enforcement, Licensing. 3. NWASCO: Policy and Standards 4. MWDSEP: Policy guidance 5. Suppliers: Chemicals, Tools, PPE and Materials. 6. Civic Leaders: Policy influence and community engagement.	1. Pit Emptying – 5 trucks per day 2. Cleaning and Disinfection 3. Marketing and sensitization. 4. Customer management 5. Inspections and follow-ups 6. Administration issues: Record keeping, Accounting **Key Resources** 1. Sludge treatment plant 2. Professional emptying tools 3. Well trained personnel 4. Transportation equipment	1. Desludging of septic tank and latrines for households, commercial properties, institutions and public places. 2. An emptying service that will be cost effective for those that construct latrines very often. 3. Professional services that will be done hygienically and environmentally safely. 4. Reduction of odor. 5. Ground & surface water protection. 6. Disease prevention	1. One on one contacts 2. Personnel contacts 3. Social media 4. Virtual platforms 5. After sales services **Distribution Channels** 1. Radio, Public address 2. Social media 3. Flyers 4. Customer service	1. Domestic: Households 2. Commercial: shops, businesses & industries 3. Institutions: schools, hospitals 4. Public places: Markets, Churches, bus stations, etc.

Cost Structures	Revenue Streams
1. Labor costs: Wages and Salaries ($76 Supervisor + $92/Person for 5) 2. Transport costs: Fuels (30Ltr/day @ $1.5/L for 5 trips in a radius of 15km) 3. Disinfectants: Lime, Chlorine, Germ Guard ($76/month) 4. Personal Protective Equipment: ($76/person/year) 5. Service & Repairs: Vehicle service, emptying tools (scoping shovels, picks, barrels, wheelbarrows, buckets, barrier tapes) – $275/year ($38/month) 6. Marketing costs: Radio, PA Announcement, banners, flyers ($23/month)	I. Desludging fees: Low cost emptying band 1: $18 / 7m^3 load Medium cost emptying band 2: $37 / 7m^3 load High cost emptying band 3: 3 x 64 / 7m^3 load II. Other earnings: Licensing of private emptiers – $46/yr. = $3.8/month Disposal/Reuse fees – $0.4/m^3 x 34m^3/day x 30% private emptier disposal x 22days = $86/month

To further augment the FSM business model canvas, a process flow (figure 15) was developed to elaborate on the service, financial and institutional flows related to this business across the sanitation value chain. At the core of the business are the households/premises with about 24,900 onsite sanitation facilities receiving FS emptying service from LgWSSC or its delegated private agencies at $1 – $3/month or $3 – $9/m^3. The tariff considered different affordability levels. The collected revenue would offset capital expenditure, equipment, operations and maintenance costs for emptying, transportation and treatment nodes of service chain. The private service providers would pay annual license fees of about $46 and a daily disposal fee of 0.4/m^3 to LgWSSC. The total annual inflow including sales and loan is $74,522 and total outflows including loan repayment is $48,554. Deducting initial capital injection of $23, a net profit of $3,053 – $5,817 is released in the first year of operations. Though the research did not investigate further on modalities for treatment and reuse, this aspect was recognised as one that would complete the sanitation service chain. Figure 15 below shows the business process flows including financial and institutional flows.

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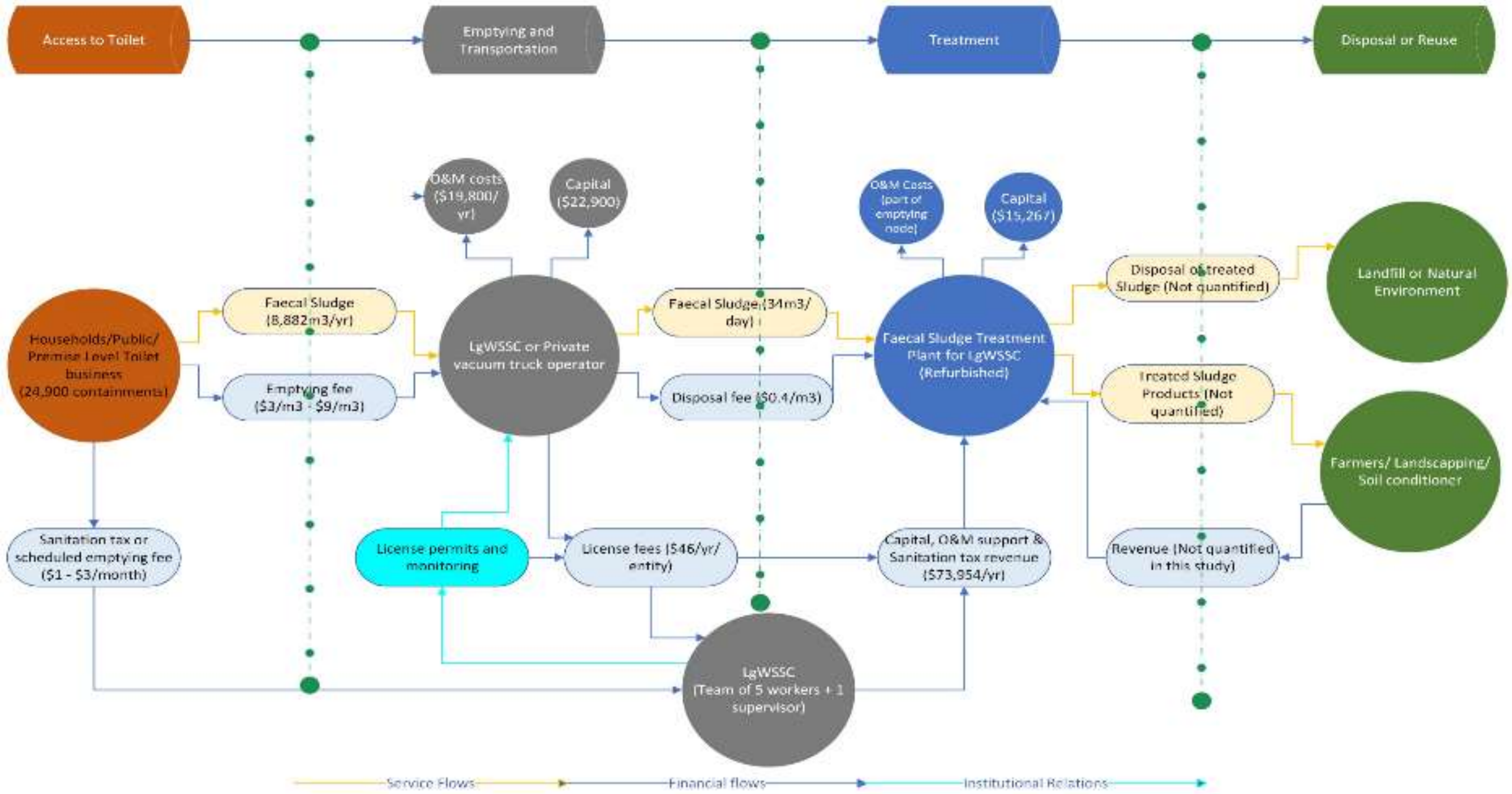
Figure 15: Costed FSM business model process flow for Kabwe Town



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4.5 Start-Up Capital Estimations, Profit and Loss and Liquidity Projections

Based on the results obtained from KII and SAI's, total startup capital required is estimated at $48,466. The business would still kick off with a minimal loan amount of $22,900 to $28,400 as other operational and maintenance costs are spread over a year. As estimated, at least 8,882m^3/yr. (equivalent to 34m^3/day or 106 of 7m^3 truck loads per year) of sludge would be available for emptying in Kabwe. Translating this finding into monetary market potential required triangulation with other key results such as willingness to pay, number of emptiable/lined containments, KII and SAI findings. Based on sanitation conditions and willingness to pay findings, three tariff structures were adopted using existing 7m^3 LgWSSC vacuum truck: low-cost tariff of $18/truck ($3/m^3), medium cost at $37/truck ($5/m^3) and $64/truck ($9/m^3). For scheduled emptying customers, the tariff band is $0.8/month, $1.5/month and $3/month. On the assumption that at least 30 percent of the emptying intervals would be done by private emptiers, the utility would earn an extra income for licensing and sludge disposal at treatment facility. The annual revenues for this business were projected $51,052. Deducting overhead costs, taxes and interest on loan would leave a positive annual profit of about $3,600 in the first year of operations.

V. DISCUSSION OF RESULTS

This research was aimed at developing an inclusive city-wide FSM business model for Kabwe Town that is practical and would be profitable. The research objectives and questions involved investigations of sanitation conditions necessary for FSM business modelling, market potential through pit and septic tank sludge quantification and finally the development of a business model. Following the detailed presentation and analysis of results, this chapter follows up and gives a description of the significance and implication of the research findings in relation to what is already known about the research problem.

Sanitation Conditions Necessary for FSM Business

This research showed that most (51 percent) people in Kabwe use traditional pit latrines which are usually unimproved. The findings are collaborated with the findings in the baseline report done by SNV in 2018 which established that 51 percent of toilet facilities in Kabwe may not be emptiable due to lack of lining. The sanitation mix of Kabwe gives a challenging outlook as business around sludge management may not fully thrive if the communities continue using unimproved sanitation facilities. As detailed by Jenkins et al. (2014) the lined pit has the potential of being desludged because of pit strength, in contrast to non-lined pits which may collapse during desludging. The 40 percent of the unlined containments are the ones which cannot be emptied easily by manual or mechanical methods. Technological upgrades to pit latrines may substantially reduce microbiological and chemical threats to groundwater quality. Latrine lining can minimize seepage of pit contents to groundwater and raised latrines may help minimize groundwater contamination by increasing vertical separation and promoting aerobic digestion of waste (Jay P., & Polizzotto M. L., 2013). Since most of the non-durable structures in Kabwe are also done by unstainable materials, collapsing of toilets in the rainy season is common and poses great danger to public health as water sources, especially open wells and boreholes get contaminated with faecal waste.

From the results, interest to construct a toilet which would cost a household more $76, decreased significantly with increase in costs. Tidwell et al., (2018) assessed on how sanitation investment was prioritised among other common plot improvements with landlords and masons in Lusaka. For a typical 2-room home costing about $1000 to build, a solid toilet structure with a simple lined pit costed about $200 to build and installing a flushing toilet in addition to the solid structure costed about $300 in total. As toilets are quicker and cheaper to construct than additional living spaces, households should invest in good quality, emptiable toilets. This increased the prevalence of solid superstructure, including walls, roofs, and doors, from 42 percent to 72 percent and flushing toilets from 15 percent to 58 percent (Tidwell et al., 2018). The world bank states that one of the essential ingredients to successful toilet construction programs is to trigger the people. An improved and emptiable toilet is generally more expensive than a self-constructed traditional unimproved toilet; thus, households on constrained budgets will not rush to get one (Muximpua O. et al., 2022). This research consolidates the important lesson from the world bank as the number of properties willing to invest more than $76 for an emptiable toilet in Kabwe drastically reduced. In comparing our results to those of older studies, it must be pointed out that the potential magnitude of the impact to invest more in an emptiable sanitation facility is clear. Duty bearers and mandated authorities like LgWSSC, KMC and other key stakeholders have a significant role of promoting toilets that can be emptied when full or connect to future sewerage improvements and in turn reduce disease burdens.

Even though the results showed that local plumbers and emptiers were market leaders when it came to emptying previously filled up containments, follow up results (92 percent) showed that LgWSSC was the preferred emptying entity. In line with the extended utility mandate (NWASCO, 2018) for utilities to provide onsite sanitation and FSM services, this result presents an opportunity for LgWSSC to step up and meet the demand. Clearly, there is also an opportunity for informal emptiers and mandated LgWSSC to co-exist and complement each other. The utility has the personnel, infrastructure, and expertise to handle such businesses in a hygienic manner. Private emptiers have a rapport with the community and can use their popularity to actualise a public private partnership. The results also showed that out of those who emptied, 61 percent of them had their containments emptied in less than two years, most of them being unlined pit latrines. A study on pit latrine emptying behaviour and demand for sanitation services in Dar Es Salaam, Tanzania established that average pit emptying frequency in the sub-Sahara region decreased with each additional time a facility had been emptied, from 14.4 years for latrines emptied once, to 4.8 years for latrines emptied four or more times (Jenkins MW et al., 2015). The difference in results of these studies and our research findings can be attributable to our undersized, poorly constructed containments and a lack of a city-wide, vibrant, and professional emptying service in Kabwe. This difference also indicates a limitation with our study that it did not investigate further on why the majority of those who emptied did it frequently. In contrast, the findings on pit/septic tank emptying frequency provide a good emptying interval for FSM business though it creates an adverse economic effect on property owners.

For those that accessed the emptying services, the price for emptying varied from about $8 to a maximum of $153. The majority (39 percent) being in the bracket of $31 to $76. About 17 percent indicated paying less than $8. About 96 percent of the households indicated willingness to empty containments when they get full in the future. However, more than 42 percent of them were not willing to pay more than $15. Annual emptying costs per user household in Dar Es salaam amounted to less than zero-point five percentage points of annual household income. While costs per year represented a small and quite affordable portion of income, median cash expenditure to empty represented nearly 100 percent of the median monthly income of the poorest 20 percent of respondent households and a third of the median monthly income across all respondent households (Jenkins MW et al., 2015). This result ties well with previous studies that established that wealth quintile has a bearing on access to sanitation services. When responsibility falls on the household as indicated, having enough cash available to pay for emptying when the need arises may pose a serious constraint. Pro poor approaches to FSM services are needed to ensure sustainable sanitation for all as per SDGs aspirations.

One of the methods of making the service affordable for all is the introduction of scheduled emptying approach as opposed to an on-demand payment approach. The findings revealed that all the respondents were willing to subscribe to a scheduled emptying service without being forced. On the emptying frequency the evidence from this research indicates that those who emptied before, majority (61 percent) did it between zero to two years. Studies have suggested that a desludging frequency of less than one year disrupts the biological process and results in lower digestion rates. Anything from two to five years is required for the biological processes to develop fully within a septic tank and allow the system to operate properly (Gill et al., 2016). A higher desludging frequency which is more than designed period, results in substantial portion of solids escaping with effluent. Demand-based desludging practices are often hard to regulate and result in high prices for desludging, especially for the poor and in small towns (CPHEEO, 2013). Households generally pay these high charges as a “distress price” as they have no other recourse. These high charges also indirectly affect the sustainability of an open defecation free city situation, as some household members may choose to defecate in the open so that the tank does not become full (Mehta et al.,2019). The willingness to subscribe to a scheduled emptying scheme portrayed by households in Kabwe is a good sign for the proposed business model as LgWSSC and KMC may not need to struggle in signing people up for the service. From the results, and experiences across the globe, an optimal scheduled desludging interval for Kabwe should be between two and 3 years. A suitable emptying interval helps to balance emptying and service costs, environmental and public health benefits hence providing part of an ideal solution to the identified challenges that this research is seeking to address.

The last node of the sanitation service that this research looked at in assessing sanitation conditions necessary for FSM business model was the transport or conveyance component. An access road of 4m width and above is regarded as accessible while a road width of less than that is regarded as inaccessible (Mchome, 2017). Difficulties in accessing sanitation facilities hinders effective service provision in informal settlements. For Kampala, this was mainly attributed to the high density of housing units, which limited access, especially by large cesspool trucks. The problem was further compounded by poor siting and design of latrines and septic tanks (Singh et al., 2022). Though results show that poor siting and design of containments is also common in Kabwe, the town has not reached a critical phase where emptying vehicles fail to access the facilities. The results also show that most containments are near vehicle access roads regardless of the season.

5.1 Market Potential through Quantification of Faecal Sludge in Kabwe

The future hydraulic loading method used to quantify sludge based on mean pit/septic sizes and emptying frequency required the assessment of containment sizes, frequency of emptying, population on onsite sanitation, willingness to pay and other conditions. The annual sludge quantity was estimated at over 11, 525m^3. The other method of sludge quantification based on per capita sludge accumulation rates estimated 6,238m^3 /year. Taylor (2018) and other renowned practitioners in FS and sanitation business advise that methods of quantifying amount of FS contained in pits/septic tanks are varied and still being developed. Principles from earlier studies advise that accuracy of any method to estimate the volume of FS generated depends on the quality of the available data, and the reasonableness of assumptions that are made (Niwagaba C et al, 2009). The assumptions for estimating sludge quantity as estimated by this study were reasonable and consistent with industry practices. To cure the optimistic and pessimistic challenge, an average of the two methods gave a realistic sludge quantity of 8,882m^3/year. This sludge quantity also dealt with the futuristic business aspects.

5.2 FSM Business Model Canvas and Service Flows

Life without a toilet is undignified (UN, 2022). For a city-wide sanitation business, every owner and user of an onsite sanitation facility in Kabwe is a customer. One of the factors for a successful sanitation business model is good customer relation. The customers need to understand the implication, trust, and believe in the service that they are receiving. The pit emptying services need to be reliable and ready to respond to customers neededs. The customer segments (households, institutions, public places, etc.) help to understand the unique needs, buying power, motivations, and aspirations of each customer grouping. Viable business models could emerge from designing faecal sludge management systems around resource recovery, which would in turn help ensure sustainable provision of adequate sanitation (Murray and Ray, 2010). This study is limited on resource recovery aspects in that it did not investigate on resource recovery of FSM business in Kabwe. However, this feature would bring more dimensions to the FSM service flows in Kabwe. To resolve the identified sanitation challenges and issues, a professional emptying service that is cost effective, hygienic and environmentally safe for all was identified as a unique value proposition. The features and attributes of the proposed value proposition sets the mandated service provider – LgWSSC apart from other competitors (informal emptiers) in many respects. Jenkins et al. (2015), in a study on unhygienic desludging in urban settlements in Dar es Salaam, found that reliance on the unhygienic practice is, in part, because of lack of access to hygienic desludging services; this concurs with the results from this study but that is not the sole reason as technological, social and economic factors also play a role in Kabwe and hence the need for professional emptying business.

The developed business model for FSM in Kabwe proposes to implement an emptying tariff of $1 – $3/month or $3 – $9/m^3. A study conducted by Economic Consulting Associates (ECA) and Water and Sanitation for Urban Poor (WSUP) on pit emptying practices in Lusaka noted that, health and environmental hazards had been worsened by the unsafe disposal of pit latrine sludge by informal emptiers. Charges of formal emptying ranged from US$25 for 12 barrels (0.6m^3) to US$45 for 32 barrels (1.6m^3), with an average charge of US$38/m^3. Conversely, charges of informal emptiers ranged from $75 to $120 (K750 to K1200) per job (ECA and WSUP., 2018). A variance in emptying fees between the findings of ECA and WSUP and this research can be attributable to the high buying power of Lusaka residents compared to Kabwe. Nonetheless, the results of this finding are well justified, the business model stands a greater chance to succeed as low emptying fees will enable most vulnerable people afford the services in Kabwe.

The annual sales and loan were estimated at $73,954 and total outflows including loan repayment was $48,183. Deducting initial capital injection of $22,901, a net profit of $3,053 – $3,817would be realised in the first year of operations. More profit would be achieved in subsequent years as loan repayments would be completed. Further, the results showed that fuel ($962/month) was 58 percent of monthly operating expenses ($1,649) without income tax and loan repayment expenses. With the inclusion of income tax and loan repayments, the expenditure on fuel was 24 percent and 14 percent on wages. A study in more than 30 cities in Africa and Asia established vast differences in operating expenses. Of the average $31,000 a year in expenses to operate a truck in Africa, 40 percent of the expenses were for fuel and 16 percent used for maintenance of trucks. In Asia, operating a truck costed only about $11,000 a year, of which fuel made up 24 percent and maintenance only seven percent of the total expenses. Very high initial capital costs and the subsequent high operating costs per truck made it a very difficult market to enter in Africa (Chowdhry, S and Kone, D., 2012). Similar fuel expenditure was seen in a study by the World Bank (Advani R., 2008) for private operators in Uganda, where the costs for fuel were seen to be 46 percent of the total expenses. Correlation to profitability was seen across the regions to the size of the business, that is the number of trucks operated, rather than trucks capacity or size of the city served (Chowdhry, S. and Kone, D., 2012). The results of this study tie well with previous studies in that it has been shown that operating costs on fuel are very high in Africa. Once the loan is fully repaid, the net profit would increase significantly and match up with the findings in literature. There are also some important differences between our study and previous studies on FSM business models in Africa and Asia. The fuel rate used in our study was futuristic (higher than the rate at the time of data collection) in anticipation that the business would not take off immediately. Unlike previous studies which assessed existing businesses, our study is based on a business model that has not taken off yet. The model is not fixed, certain parameters will change or be updated as business takes off.

For the successful implementation of FSM systems, an institutional framework needs to be developed based on the specifics of the local situation (Ingallina et al., 2002). Adequate attention to organisational aspects is rare and unfortunately many projects only consider one aspect of the service chain (e.g., subsidising septic tanks or only building a treatment plant). There are several examples where governments have focused only on the physical infrastructure and not the organisational or financial

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aspects, and as a result experienced failures of their FSM systems (Koné, 2010). Based on the FSM business cases analysed, corresponding business models developed, the key stakeholders engaged in FSM can be categorised across the components of the sanitation service chain (Rao, K. C. et al., 2016). To deliver sanitation value to the residents of Kabwe, national and local key partners such as ZEMA, NWASCO, LA were identified. The key partners would provide a conducive legal and regulatory environment and enable the FSM business processes. The day-to-day activities of emptying would be complimented by other intertwined business management processes and customer relation activities aimed at promoting, marketing and improving service delivery to meet customer needs and expectations. Private emptiers can also empty and dispose at the designed LgWSSC treatment plant at a fee. The licensing and supervision seats with LgWSSC.

FSM systems require many interactions among stakeholders (e.g., household, collection and transport company, treatment plant, end use or disposal), in comparison to one utility managing a sewer-based system (Murray and Ray, 2010). The financial burden of sanitation on Kabwe residents and LgWSSC can be shifted by creating new value propositions as showed by the results of this study. The additional financial flow is at the back end of the service chain, by tapping into a customer segment interested in resource recovery from waste derived products. This new value proposition of selling end products following treatment would complement the existing value proposition, which is typically only an emptying service to the household customer group. With a multi-stakeholder approach to sanitation, it is important to develop commercially viable business models that depart from subsidy-driven approaches, with self-sustaining or even profit-oriented business approaches, in which costs are recovered fully. An additional revenue stream by sale of products generated from treated waste could alter the financial flow of the service chain, and result in an offset of disposal costs. This could potentially reduce the amount paid at the household level, thereby increasing a household's ability to pay for service, which in turn improves the overall access to sanitation and impacts on hygiene, health and wellbeing in Kabwe.

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The sanitation mix of Kabwe gives a challenging outlook as business around FSM may not fully thrive if the communities continue using unimproved sanitation facilities. In line with other studies, this research has pointed out the urgent need to invest in emptiable sanitation facilities as it brings social economic and environmental benefits to an investor and the community at large. Duty bearers and mandated authorities like LgWSSC, KMC and other key stakeholders have a significant role of promoting emptiable toilets. A research question on how the community was managing full toilets in Kabwe was also answered. The study established that private informal emptiers have an established relationship with the community and have done more emptying jobs than the licensed LgWSSC. In line with NWASCO's mandate for utilities to provide onsite sanitation, it has been shown that there is an opportunity for LgWSSC to work in partnership with private informal emptiers. In contrast with other studies, the findings on the on-demand emptying frequency of one to two years in Kabwe provide a good emptying interval for FSM business but for high household costs. There is an opportunity for further research on this short on-demand emptying frequency in Kabwe. Innovative and pro-poor approaches to FSM services such as scheduled emptying as opposed to on-demand approach are essential to ensure sustainable sanitation for all as per SDGs aspirations. The extent of willingness to subscribe to a scheduled emptying scheme portrayed by households in Kabwe is a good sign for the proposed business model. Coupled with willingness to empty, an optimal scheduled desludging interval of not less than two years would help balance service and emptying costs, environmental and public health benefits hence providing part of an ideal solution to the identified challenges that this research is seeking to address. It can also be concluded that access to toilet facilities by common sludge emptying vehicles in Kabwe is not a challenge regardless of the emptying approach or season. The second objective of this research was to determine market potential for FSM through pit and septic tank sludge quantification. To avoid being optimistic or pessimistic and considering that this business would face other earlier highlighted hurdles such as low ability to pay, poor quality containments, it is concluded that an average sludge quantity of 8,882m^3/year is realistic for Kabwe FSM business model.

The final objective of this study was to develop FSM business model for Kabwe which covers the sanitation service chain from containment, emptying and transportation. To achieve this objective, the research responded to questions on customer segmentation, value propositioning, revenue streams and cost structures. To resolve some of the identified sanitation challenges and issues in Kabwe, a professional emptying service that is cost effective, hygienic and environmentally safe for all was identified as a unique value proposition. The model with its value proposition sets the mandated service provider – LgWSSC apart from other competitors (informal emptiers) in many respects. The developed business model for FSM in Kabwe has demonstrated that with minimal capital injection, the business is able to make a positive net profit in its first year of operations. More profit would be realised in subsequent years after loan repayments. To fully implement this model, multiple stakeholders for regulation, enforcement, marketing and households need to be engaged.

Overall, this study has demonstrated that it is possible to generate revenue out of human excreta. The developed business model for Kabwe has shown that with minimal startup capital, the service provider can recoup their investments in less than two years of operation. If the assumptions prove true, the research establishes that cost recovery on O&M and capital investment are a possibility. The model has demonstrated that in as much as financial resources are required, minimal start-up capital coupled with prudent planning, utilisation of readily available resources such as treatment plant, emptying trucks, etc. are key success factors.

6.2 Recommendations

With the knowledge gap that exists with inadequacy of business models in the sanitation sector, this research has contributed by narrowing the gap through the development of a business model for Kabwe Town. The business model has highlighted the common barriers to be overcome by FSM stakeholders, and potential opportunities and scope for increased private sector participation in sanitation service delivery. It is therefore recommended as follows:

1) Discourage construction of unimproved sanitation facilities that cannot be emptied as it is too expensive for households to afford in the long run. Households need sensitisation and empowerment for them to realise the long-term costs related to apparently cheap materials that end up being expensive, compromising their privacy and public health.
2) To reduce environmental and public health hazards, formalise informal emptiers who are emptying pits/septic tanks unhygienically. The formalisation process would include.
    a. Recognition by mandate agencies like KMC and LgWSSC
    b. Skills development and training in occupational health and safety,
    c. Development of standard operating procedures for safe emptying and disposal
3) Implement a scheduled emptying approach that encompasses all customer segments. This would make the service affordable for all as the households would pay small incremental fees over a long period of time as compared to paying the once of emptying fees when need arises.
4) The business model for FSM services in Kabwe should be anchored on the mandated but also preferred service provider - LgWSSC. As concluded, the utility can partner with informal emptiers and maximise on each partners strength.
5) The developed business model has demonstrated that sustainable and profitable onsite sanitation service provision is possible. The model is a living document and needs to adjust as situations evolve. Incremental stepwise approach to service is recommended.
6) Since this is a model, cost factors can be assessed further, and strategic decisions made to realign with prevailing conditions. A decision on one parameter affects the rest of the model. E.g., an increase in fuel market prices increases operating costs and reduces profit. Similarly, an investment in marketing increases customer base and more profits.
7) More research is required on sludge characterisation (both quality and quantity), social economic factors leading to high emptying frequency, ideal optimal emptying frequency, treatment, business opportunities for reuse and disposal of treated sludge.

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