SFD Report

Lilongwe
Malawi

Final Report

This SFD Report - Initial level - was prepared by Department of Civil and Environmental Engineering, University of Zambia.

Date of production: 13/06/2023

Last update: 09/02/2024

SFD Report Lilongwe, Malawi, 2024

Produced by:

Phyllis George Mkwezalamba, University of Zambia

Joel Kabika PhD, University of Zambia

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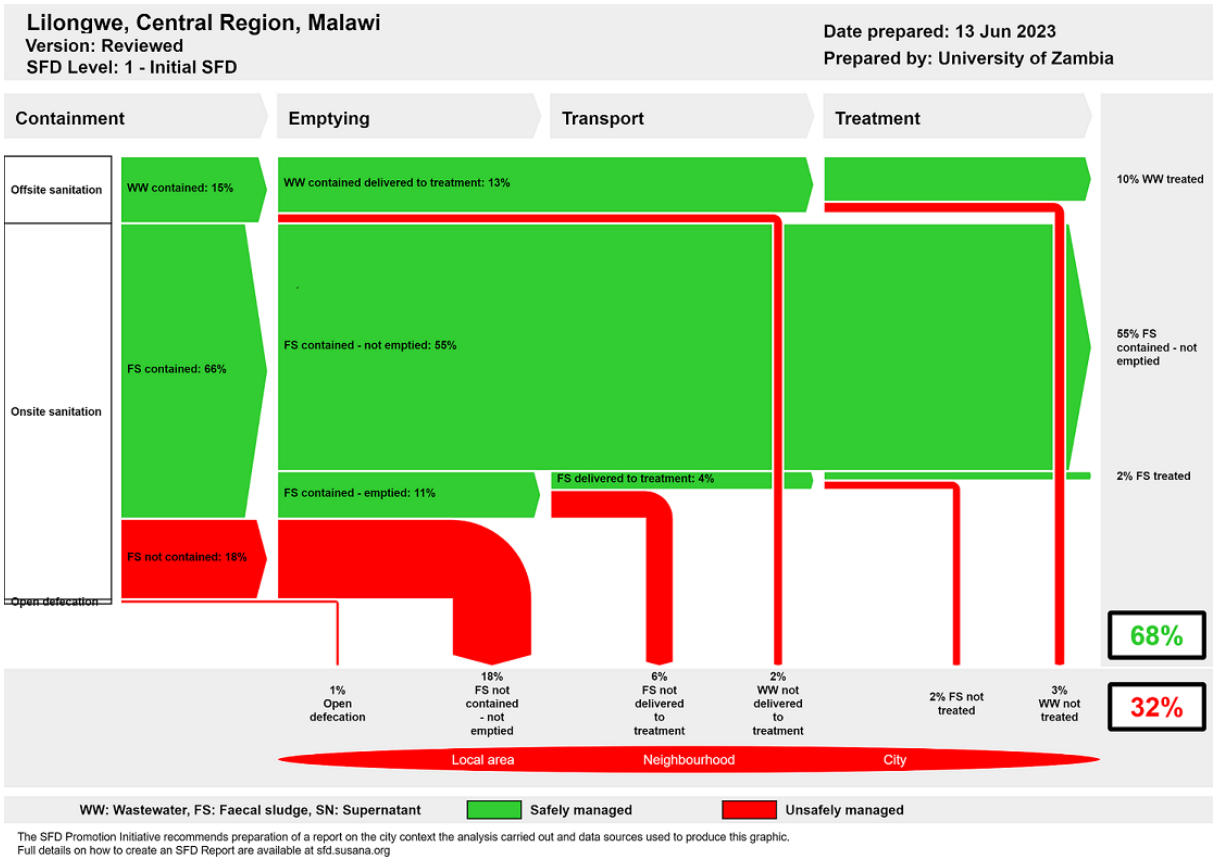
1. The SFD Graphic



The SFD Promotion Initiative recommends preparation of a report on the city context the analysis carried out and data sources used to produce this graphic.
Full details on how to create an SFD Report are available at sfd.susana.org

2. Diagram information

SFD Level:

This SFD is a level 1 - Initial report.

Produced by:

The Shit Flow Diagram (SFD) was developed by Phyllis George Mkwezalamba and Joel Kabika of the University of Zambia, in the School of Engineering, Department of Civil and Environmental Engineering.

Collaborating partners:

Lilongwe Water Board (LWB), Lilongwe City Council (LCC).

Status:

Final SFD report.

Date of production: 13/06/2023

3. General city information

Lilongwe City, Malawi's capital, is located in the Lilongwe river inland plains at the junction of Namanthanga and Lilongwe rivers. With a population of 989,318 in 2018, it is situated in the Central Region of the Republic of Malawi. The city's population has grown from 1,660 people per km^2 in 2008 to 1,225,395 in 2023, at a 4.42% growth rate.

The city has a moderate tropical climate with mean annual temperatures ranging from 20°C to 22.5°C. Its cool season is from May to July, dry season from August to October, and rainy season from October to mid-April. With a total area of 456 km^2, the city has diverse land uses and sanitation services, complementing containment, collection, and treatment methods.

4. Service outcomes

The overview of different sanitation technologies across the sanitation value chain in the Lilongwe City is briefly explained in this section. All data in this section are from the household and institutional surveys conducted for this study (Mkwezalamba and Kabika, 2023).

Lilongwe City, a growing city in sub Saharan Africa, has a diverse population with varying income levels, leading to various sanitation service options. 84% of the population uses onsite sanitation, 15% use offsite sanitation, and 1% practice open defecation. Pit latrines are the most common method, followed by septic tanks and open defecators. Low-income areas primarily rely on pit latrines (45%), while middle- to high-income communities use flush toilets connected to septic tanks (39%).

5. Service delivery context

Because of its diverse population and range of income levels, Lilongwe City, a developing city in sub-Saharan Africa, offers a wide range of sanitation service options.

Sewerage coverage in Lilongwe is about 15%. The Lilongwe Wastewater Treatment Plant (WWTP) network accounts for over 76% of the approximately 200 km of the city's sewer network. Lilongwe WWTP has a treatment capacity of Treatment Capacity 6,800 m^3/day. Additionally, two more WWTP operate in the city: Kanengo WWTP and Lumbadzi WWTP with treatment capacities of 635 and 1,200 m^3/day, respectively.

Private operators in the city handle a significant portion of Faecal Sludge (FS), categorized into formal and informal operators, who use mechanical equipment and manual techniques, but are organized as associations.

The SFD graphic shows that 32% of the excreta generated are unsafely managed while 68% are safely managed. A majority of this FS (26%) comes from pit latrines, that are never emptied and are abandoned when full which are located in areas of low risk of groundwater contamination. The remaining percentage comes from FS contained in septic tanks which are not emptied. However, these containments will require emptying services in the short and medium term as they fill up.

6. Overview of stakeholders

At national level the Ministry of Water and Sanitation, comprising three technical departments and a corporate office, provides policy direction, coordination, and management in water, sanitation, and hygiene. matters. It also collaborates with other ministries at national level such as Ministry of Health, Ministry of Local Government, Youth and Culture. While at regional level it collaborates with the Lilongwe Water Board (LWB), as well as Lilongwe City Council (LCC), who at local level interact with other different stakeholders and partners as shown in table 1 below. Wastewater management services have since October 1, 2023 been transferred to LWB from LCC, who operates 3 WWTPs with one of them combining wastewater and faecal sludge treatment. Faecal Sludge Management (FSM) is supported by private operators or emptiers who are also organised through an association.

Table 1: Key stakeholders.

Key Stakeholders	Institutions / Organizations /
Public Institutions	Ministry of Water & Sanitation Ministry of Health Ministry of Local Government, Youth and Culture Lilongwe Water Board Lilongwe City Council Ministry of Justice National Water Resources Authority
Non-governmental Organizations	WaterAid CICOD Waste Advisers Water for People WESNET
Private Sector	Lilongwe Pit Emptiers Association
Development Partners, Donors	World Bank UNICEF
Others	University of Zambia

7. Process of SFD development

This study developed data collection tools through literature review, consultations, and case studies. Key informant interviews, Focus Group Discussions (FGDs), secondary literature, and field observations were used to develop a comprehensive understanding of sanitation scenarios in Lilongwe city. Stakeholder identification was done using Onsite Sanitation (OSS) systems, and questionnaires were developed for engagement with government officials, emptiers, field observations, feedback, and efficiency of treatments systems.

10. Credibility of data

To ensure data quality (validity and reliability) was maintained throughout the process of the study and report preparation, Quantitative data was gathered using a digital questionnaire with various sections administered in person using a tablet or smart phone, a total of 216 were administered. Other data was gathered using data sheets, particularly those that focused on the volumes of FS disposed of at the WWTP by FSM operators and other stakeholders at the WWTP. This was done for over a period of 9 months.

KIIs, FGDs, and checklists created specifically for that purpose were used to gather qualitative data, a total of 13 KIIs, 6 FGDs were conducted. Every day after data collection was finished, this data was examined for validity and completeness. Data was generally made available and options shared, however in some cases the informants were non responsive, while others representatives were sent for the FDGs, while for the household survey mostly questionnaires were administered to other household members other than the household head as they were reported to be away (to work or business).

11. List of data sources

The list of data sources to produce this executive summary is as follows:

- Detailed Diagnostic Studies Report: Diagnostic and Pre-Feasibility Studies for Resilient Urban Development and Service Delivery in Lilongwe City, HS International and ALMA Consult, 2020.
- Sanitation and Drainage Master Plan: Sanitation and Drainage Improvement Strategy and Master Plan for The City of Lilongwe, Existing Situation Report, Engidro Engineering Solutions, 2020.
- Mkwezalamba, P.G. and Kabika J. (2023). Assessment of Sanitation Status of Lilongwe city. Questionnaire results. University of Zambia.
- National Statistical Office (2019), Malawi Population and Housing Census 2018 Final Report. Government Print, Zomba.
- National Statistical Office, Fifth Integrated Household Survey 2019-2020 Report. Government Print, Zomba.
- World Bank (2017a). Lilongwe Citywide Sanitation Survey. Interim Report.
- World Bank (2017b) Project Appraisal Document Report No: PAD2548.

SFD Lilongwe, Malawi, 2024

Produced by:

University of Zambia, Phyllis George Mkwezalamba

Editing:

University of Zambia, Joel Kabika PhD.

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Abbreviations

ADL	Airport Development Limited
CICOD	Circle for Integrated Community Development
DN	Nominal Diameter
EIA	Environmental Impact Assessment
FGD	Focus Group Discussion
FS	Faecal Sludge
FSM	Faecal Sludge Management
JICA	Japanese International Cooperation Agency
KIA	Kamuzu International Airport
KII	Key Informant Interview
LCC	Lilongwe City Council
LIA	Low Income Areas
LWB	Lilongwe Water Board
LWSP	Lilongwe Water and Sanitation Project
LWWTP	Lilongwe Wastewater Treatment Plant
MEPA	Malawi Environmental Protection Agency
MGDS	Malawi Growth Development Strategy
NRC	Natural Resources College
NSO	National Statistical Office
NWRA	National Water Resources Authority
OSS	Onsite Sanitation
PHA	Public Health Act
SFD	Shit Flow Diagram
SSC	Sanitation Service Chain
STP	Sewerage Treatment Plant
UNICEF	United Nations Children's Fund
WESNET	Water and Environmental Sanitation Network
WSP	Waste Stabilization Pond
WWTP	Wastewater Treatment Plant

1 City Context

The capital city of Malawi, Lilongwe City, is situated in the Lilongwe river inland plains at the junction of the Namanthanga and Lilongwe rivers. The city is located in Lilongwe District which is found in the Central Region of the Republic of Malawi. With isolated inselbergs rising above this level, the city is situated at an altitude of between 1,000 and 1,400 metres above sea level.

Lilongwe city had a population of 989,318 people as per the most recent census in 2018, which was 5.6% of Malawi's total population. As of 2018, there were 230,266 households in Lilongwe city, with 4.3 people on average per home (National Statistical Office, 2019).

According to NSO, the city's population has grown from 1,660 people per km^2 in 2008 to 2,453 people per km^2 in 2018. For purposes of this report, the city's population in 2023, was estimated at 1,225,395 based on a growth rate of 4.42%. Figure 1 shows the population density of Lilongwe city.

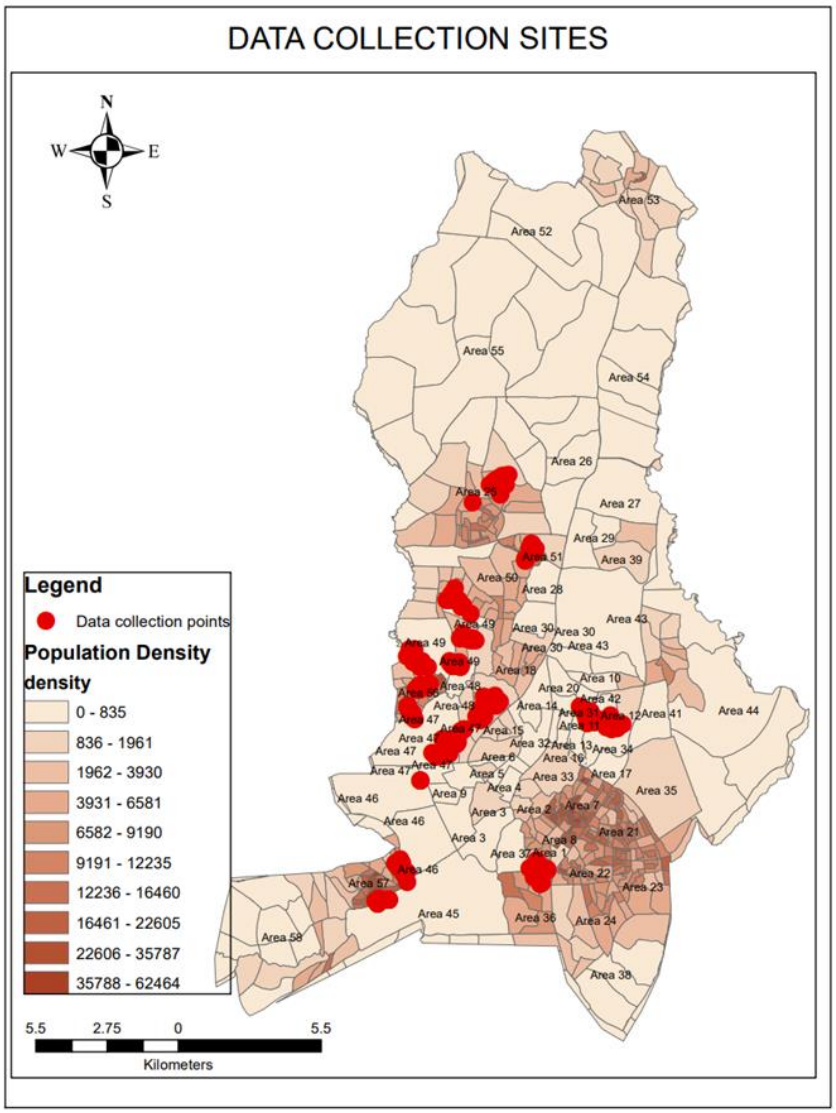

Figure 1: Population Density of Lilongwe City and data collection points.

With mean annual temperatures ranging from 20 °C to 22.5 °C, the city enjoys a moderate tropical climate. May to July is considered the cool season, August to October is considered the dry season, and October to mid-April is typically considered the rainy season. The average annual precipitation fluctuates greatly between seasons and on an annual basis (880 mm from 1970 to 2009; 841 mm from 1988 to 2018) (JICA, 2014) (Warnatzsch & Reay, 2018)

The city has a total area of 456 km^2, of which 30% is private land and 60% is public land, 10% of the land is on customary land (UN-HABITAT, 2011). The city therefore comprises of different land uses such as residential, commercial, industrial, agricultural as well as settlements covering informal, peri-urban, urban, and different income levels.

In many poor nations, like Malawi, access to toilets in rural and urban regions is mostly dependent on on-site sanitation systems like septic tanks and pit latrines. More than 2.7 billion individuals are already served by these systems worldwide, and by 2030, that number may reach 4.9 billion (Cairns Smith, et al., 2014).

The future of Onsite Sanitation (OSS) depends on how well these systems are maintained and what steps are taken to fill in any gaps and overcome any obstacles in the sanitation service chain. This clearly illustrates the importance OSS will play even for the next generation.

2 Service Outcomes

2.1 Overview

Current data on sanitation situation were collected through household and institutional surveys (Mkwezalamba and Kabika, 2023). A total of 216 households were sampled from 1,225,395 households (further details are presented in section 4). The results obtained after the triangulation and validation of the data with all the data sources including literature reviews, Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) are presented in this section.

The city of Lilongwe has a diverse population with different levels of income, leading to a myriad of sanitation service options and technologies as shown by the SFD selection grid (Figure 2).

List A: Where does the toilet discharge to? (i.e. what type of containment technology, if any?)	List B: What is the containment technology connected to? (i.e. where does the outlet or overflow discharge to, if anything?)									
	to centralised combined sewer	to centralised foul/separate sewer	to decentralised combined sewer	to decentralised foul/separate sewer	to soakpit	to open drain or storm sewer	to water body	to open ground	to 'don't know where'	no outlet or overflow
No onsite container. Toilet discharges directly to destination given in List B		T1A1C2			Significant risk of GW pollution Low risk of GW pollution					Not Applicable
Septic tank					Significant risk of GW pollution T1A2C5					
Fully lined tank (sealed)					Significant risk of GW pollution Low risk of GW pollution					T1A3C10
Lined tank with impermeable walls and open bottom	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution					Significant risk of GW pollution Low risk of GW pollution
Lined pit with semi-permeable walls and open bottom	Not Applicable									Significant risk of GW pollution Low risk of GW pollution
Unlined pit										Significant risk of GW pollution Low risk of GW pollution
Pit (all types), never emptied but abandoned when full and covered with soil										Significant risk of GW pollution T1B7C10
Pit (all types), never emptied, abandoned when full but NOT adequately covered with soil										T1B8C10
Toilet failed, damaged, collapsed or flooded										
Containment (septic tank or tank or pit latrine) failed, damaged, collapsed or flooded										
No toilet. Open defecation	Not Applicable							T1B11 C7 TO C9		Not Applicable

Figure 2: SFD Selection Grid.

2.1.1 Sanitation Situation

Previous studies established that the existing sewer network serves only 5% of Lilongwe city's present population, with the majority (around 95%) relying on local sanitation facilities to supply their demands. Pit latrines (69%) being the most common method of containing excreta, whereas 25% utilized septic tanks and about 1% estimated to be open defecators (World Bank, 2017).

Lilongwe City's situation is similar to many growing cities in the sub Saharan Africa, based on a research study conducted in the development of this SFD report, it was established that 84% of the city's population uses onsite sanitation options, 15% offsite sanitation and about 1% estimated to be practising open defecation (Mkwezalamba and Kabika, 2023).

Sanitation services and technologies are equally unique and diverse coupled by complementing containment, collection and treatment methods and options of faecal management in the varied development sectors of the city. Figure 3 shows different sanitation options in the city of Lilongwe.

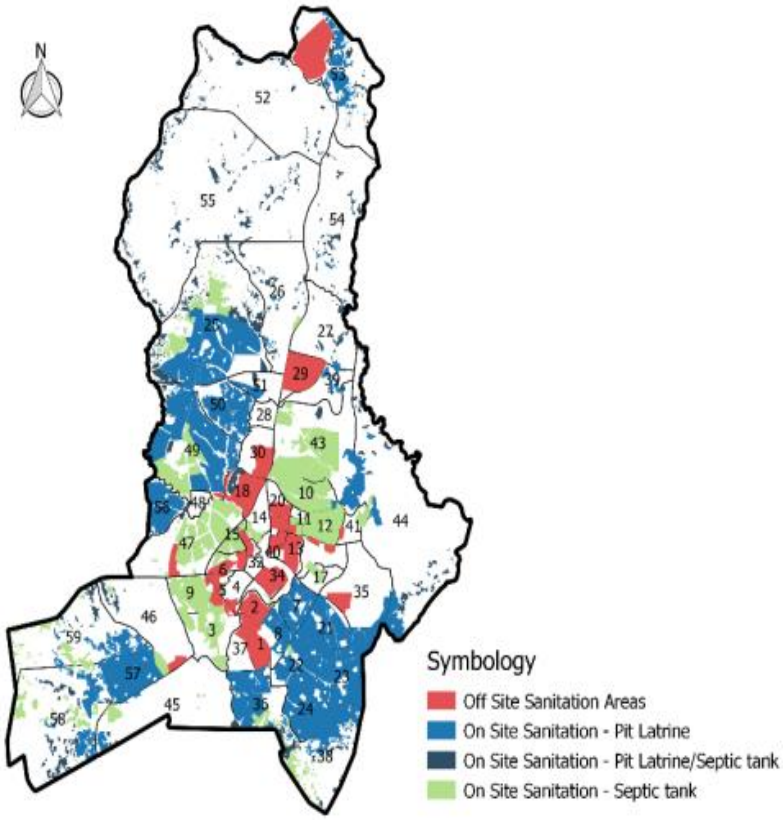

Figure 3: Sanitation Options in Lilongwe City (Engidro Engineering Solutions, 2021).

2.1.2 Sanitation Situation - Onsite Sanitation

The two primary types of on-site sanitation systems are pit latrines and water closets (flush toilets) connected to septic tanks, which make up to 84%.

Low-Income Areas (LIA) with high population densities primarily rely on pit latrines, ranging from unlined pits with a slab, unlined without a slab and lined VIP latrines, making about 45% while communities with middle- to high-income levels, flush toilets connected to septic tanks are common (39%) (Table 1).

Due to the inherent difficulties in maintaining non-impermeable toilet floors, inadequate hygiene is primarily a problem in low-income regions (Engidro Engineering Solutions, 2021), Figure 4 depicts a traditional pit latrine.

Figure 4: A Pit latrine without slab or lining (Mkwezalamba and Kabika, 2023).

Table 1 shows the percentage of households with different types of containment in Lilongwe according to the SFD-PI.

Table 1: Types of containment in households in Lilongwe (Mkwezalamba and Kabika, 2023).

Containment	Groundwater Risk	Connected to	%	Recategorized as SFD	System	%
Toilet	NA	Sewer network	15 %	Toilet discharges directly to a decentralised foul/separate sewer	T1A1C2	15%
Septic tank	Low	Soak pit	39 %	Septic tank connected to soak pit	T1A2C5	39%
Pit latrine	Low	No outlet/ abandoned when full	45 %	Fully lined tank (sealed), no outlet or overflow	T1A3C10	1%
				Pit (all types), never emptied but abandoned when full and covered with soil, no outlet or overflow	T1B7C10	26%
				Pit (all types), never emptied, abandoned when full but NOT adequately covered with soil, no outlet or overflow	T1B8C10	18%
Open defecation	NA	NA	1%	Open defecation	T1B11 C7 TO C9	1%
TOTAL						100%

2.1.3 Sanitation Situation - Faecal Sludge Management (FSM)

Private operators handle a large portion of Faecal Sludge Management (FSM) in the city, however private operators are categorized into two, namely; formal FSM operators (who employ mechanical equipment such as vacuum trucks or cesspool tankers), and informal FSM operators (who use crude manual techniques of emptying such as gulpers, barrels, drums and buckets, etc- (Association, 2023) (Figure 5).

However, the operators are formally organised as an association made of both formal and informal operators, and was registered as such in March 2022, (Longwe, 2023)

Figure 5: Faecal sludge operators emptying a public sanitation facility (School Toilet) (Mkwezalamba and Kabika, 2023).

<u>Transport and treatment of faecal sludge</u>

Lilongwe Wastewater Treatment Plant (WWTP) was designed to handle discharges of up to 72 m^3/day (Japanese International Cooperation Agency, 1994), translating to 26,280 m^3/yr. Based on a study conducted as part of the development of this report, 26% of the OSS units are reported to be emptied every 12 to 24 months, while 58% are reported not to have ever been emptied (Mkwezalamba and Kabika, 2023).

Of all the WWTPs in the city, only the Lilongwe WWTP has facilities and was designed to receive FS through two (2) septage lagoons with a detention time of two days at a depth of 3m and covering a surface area of 0.24ha and a BOD loading of 200g/l/d (LCC, 1997). Figure 6 shows a tanker emptying in a septage lagoon at the Lilongwe WWTP.

Figure 6: Vacuum truck emptying faecal sludge in a lagoon (Mkwezalamba and Kabika, 2023).

2.1.4 Sanitation Situation - Sewerage Network

Sewerage coverage in Lilongwe is about 15%. The Lilongwe WWTP network accounts for over 76% of the approximately 200 km of the city's sewer network. The sewers' diameters range from 110 to 825 mm, with 30% having Nominal Diameter (DN) 160 mm (Mweso, 2023). Some of Lilongwe's more localized regions, including Lumbadzi Airport Development Ltd Housing Estate, part of Kanengo industrial area (area 28), Cold Storage (area 46), Kamuzu Barracks, Kamuzu International Airport (KIA), and Lilongwe University of Agriculture and Natural Resources-NRC campus, are served by smaller localised sewerage systems. Table 2 shows the different existing treatment plants by location, service area and capacity.

Table 2: WWTPs by location, service area and capacity. Source: (Engidro Engineering Solutions, 2021).

WWTP	Location (Area)	Areas Served	Treatment Option	Discharge Point	Treatment Capacity (m^3/day)	Management	Year Commissioned	Pipe size & Length
Lilongwe	44	1, 2, 3,4,6,11, 12,13, 18,19,20, 32,34,37, 40, 47,48 and 49	WSP: 4-anearobic 4-Facultattive 6-Maturation 2-Septage lagoons 4-Drying beds	Lilongwe River	6,800	LWB/LCC	1997	110-825mm 153.3km
Kanengo	29	Area 29-Kanengo Industrial Area	WSP: 2-anearobic 2-Facultattive 2-Maturation	Nearby Stream	635	LWB/LCC	1994	110-315mm 4.5km
Lumbadzi	53	53-ADL Housing Estate	WSP: 1-Facultattive 2-Maturation	Lumbadzi River	1,200	LWB/LCC	1984	110-315mm 41.9km

The Lilongwe WWTPnetwork being the largest has over 7,567 sewer connected customers, followed by Lumbadzi (845) and Kanengo which are largely commercial and industrial premises (39).

The following maps (Figure 7, Figure 8 and Figure 9) characterises the existing sewerage network in the three treatment plant catchments as managed by the Lilongwe Water Board.

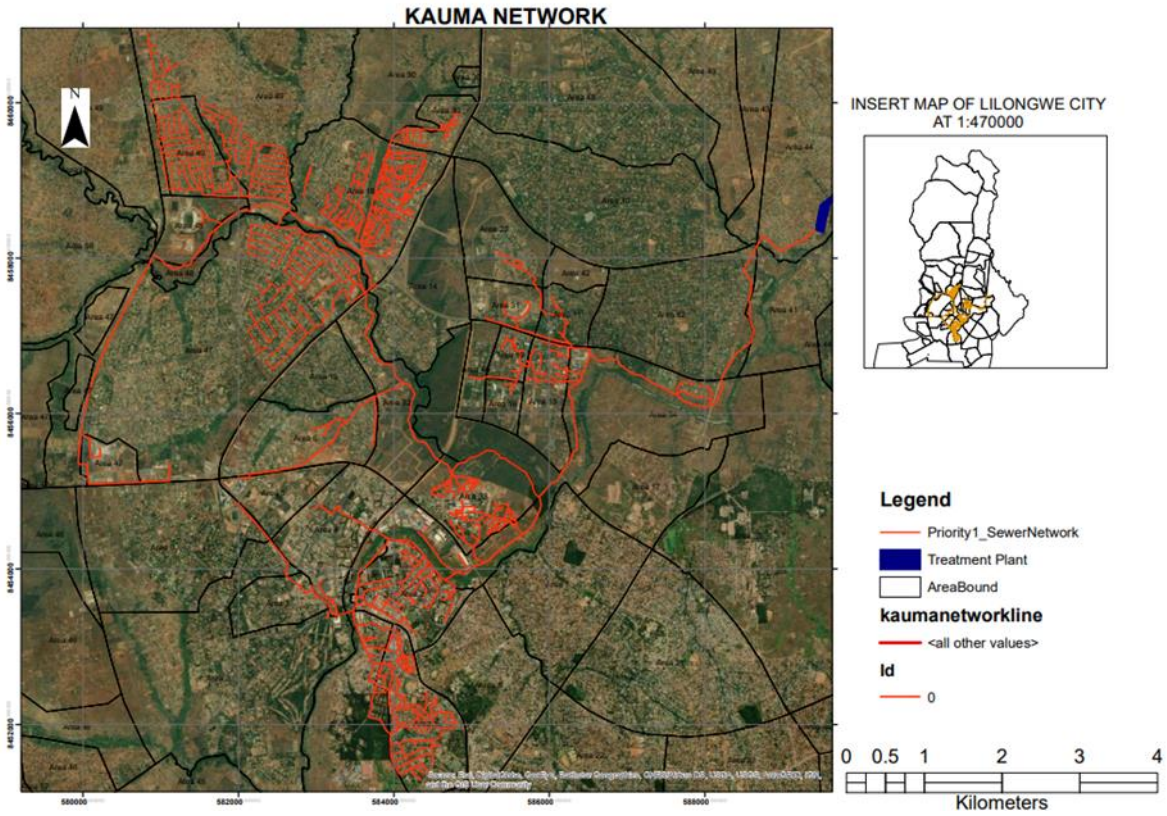

Figure 7: Map of Lilongwe Wastewater Treatment Plant Network (LWB, 2023).

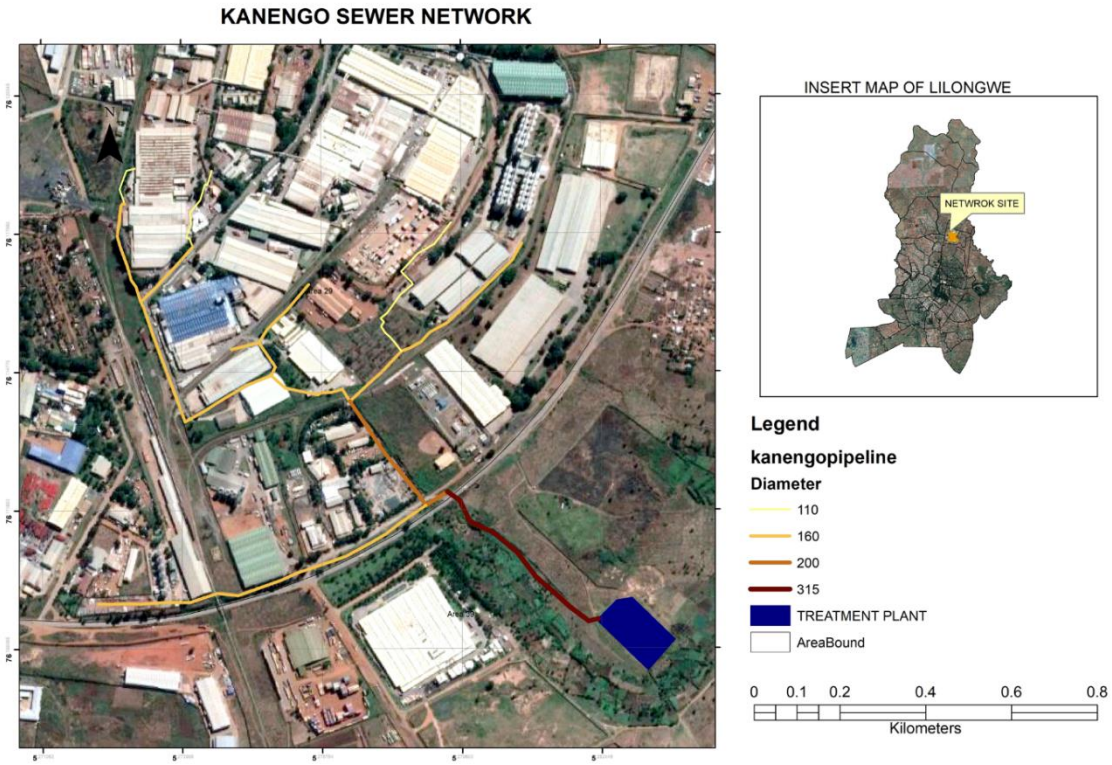

Figure 8: Map of Kanengo Sewerage Treatment Plant. Source: (LWB, 2023).

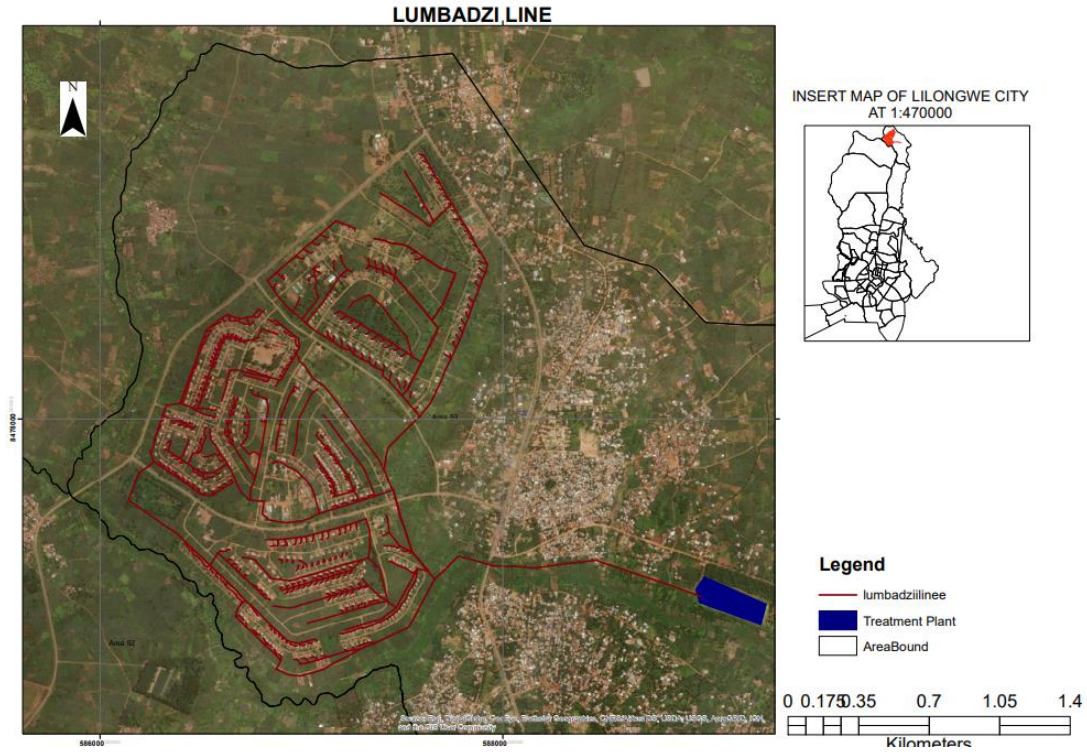

Figure 9: Map of Lumbadzi Sewerage Network. Source: (LWB, 2023).

2.1.5 Sanitation Situation - Wastewater Treatment Plants

(1) Lilongwe Wastewater Treatment Plant (LWWTP)

This WWTP was commissioned in 1997 and is located in Area 44, covering areas 1, 2, 3, 4, 6, 11, 12, 13, 18, 19, 20, 32, 34, 37, 40, 47, 48 and 49. The network serves about 15% of the population thus covering mostly Central and Southern parts of Lilongwe City. The initial design capacity of the existing installation is 6,100 m³/day but through the Lilongwe Water and Sanitation Project (LWSP), has been increased to 6,800 m³/day by adding (constructing) one anaerobic pond, and installation of baffle walls in three facultative ponds and five maturation ponds (Nyando, 2023) (Figure 10).

Figure 10: Lilongwe Wastewater Treatment Plant-Facultative & Maturation Ponds (Mkwezalamba and Kabika, 2023).

The treatment plant is made up of a series of waste stabilization ponds (WSP), four (4) anaerobic ponds, four (4) facultative ponds, and six (6) maturation ponds. There are also two septage lagoons that receive faecal sludge. The plant also has four drying beds and two rock filters (Figure 11 and Figure 12).

Figure 11: Lilongwe Wastewater Treatment Plant-FS Drying Beds (Mkwezalamba and Kabika, 2023).

Figure 12: Lilongwe Wastewater Treatment Plant (Google earth, 2023).

(2) Kanengo Wastewater Treatment Plant (WWTP)

Kanengo Wastewater Treatment Plant receives wastewater from area 29 industrial site and the treatment process is based on stabilization ponds, with a capacity of 635 m^3/day. It was constructed in 1996. The preliminary treatment consists of manual screening followed by a grit chamber, and a series of two anaerobic ponds, two facultative ponds and two maturation ponds, which all operate in parallel (Figure 13 and Figure 14).

Figure 13: Kanengo Wastewater Treatment Plant- Inlet structures, Anaerobic and facultative Ponds (Mkwezalamba and Kabika, 2023).

Figure 14: Kanengo Wastewater Treatment plant (Google earth, 2023).

(3) Lumbadzi Wastewater Treatment Plant (WWTP)

The treatment process of Lumbadzi WWTP is based on a modified stabilization pond, with a capacity of 1,200 m^3/day constructed in 1984. It serves Lumbadzi Airport Development Limited (ADL) Housing Estate. The preliminary treatment consists of a manual screening followed by a grit chamber, and a set of three modified stabilisation ponds (Figure 15 and Figure 16).

Figure 15: Lumbadzi Wastewater Treatment Plant (Mkwezalamba and Kabika, 2023).

Figure 16: Lumbadzi Wastewater Treatment Plant (Google earth, 2023).

2.2 SFD Matrix

Data and values used in the creation of this SFD were obtained through a study, while for other section assumptions were used and highlighted as such. This section through Figure 17 shows and highlights the narrative and data collected as well as assumptions done during the study (Mkwezalamba and Kabika, 2023).

Lilongwe, Central Region, Malawi, 13 Jun 2023. SFD Level: 1 - Initial SFD
Population: 1225395
Proportion of tanks: septic tanks: 100%, fully lined tanks: 100%, lined, open bottom tanks: 100%

Containment						
System type	Population	WW transport	WW treatment	FS emptying	FS transport	FS treatment
	Pop	W4a	W5a	F3	F4	F5
System label and description	Proportion of population using this type of system (p)	Proportion of wastewater in sewer system, which is delivered to centralised treatment plants	Proportion of wastewater delivered to centralised treatment plants, which is treated	Proportion of this type of system from which faecal sludge is emptied	Proportion of faecal sludge emptied, which is delivered to treatment plants	Proportion of faecal sludge delivered to treatment plants, which is treated
T1A1C2 Toilet discharges directly to a centralised foul/separate sewer	15.0	85.0	80.0			
T1A2C5 Septic tank connected to soak pit	39.0			26.0	39.0	50.0
T1A3C10 Fully lined tank (sealed), no outlet or overflow	1.0			50.0	50.0	50.0
T1B11 C7 TO C9 Open defecation	1.0					
T1B7C10 Pit (all types), never emptied but abandoned when full and covered with soil, no outlet or overflow	26.0					
T1B8C10 Pit (all types), never emptied, abandoned when full but NOT adequately covered with soil, no outlet or overflow	18.0					

Figure 17: SFD Matrix for Lilongwe.

2.2. Risk of Groundwater Contamination

An alarming difference between safely and unsafely managed excreta was noted based on the SFD graphic outcome, with particular difficulties stemming from unemptied and abandoned pit latrines. A restricted percentage of excreta has also been noted to reach treatment plants and receive the appropriate treatment, in addition to this discrepancy. The SFD graphic indicated the possibility of increased groundwater contamination in the city as a result of the observed challenges.

To further evaluate the groundwater pollution risk potential, a groundwater literature review study was conducted. Mainly the 2021 Groundwater Vulnerability Assessment Report for Lilongwe City by the Ministry of Forestry and Natural Resources was reviewed (Malawi Government, 2021). Lilongwe City is mainly comprised of three types of aquifers; weathered gneiss aquifer, fractured gneiss aquifer and outcropping fractured gneiss aquifer. However, the urban area where this study was conducted is comprised mainly of fractured gneiss and outcropping gneiss aquifers. The fractured gneiss aquifer present is formed under unsaturated

weathered regolith and superficial deposits, while the type of outcropping gneiss aquifers present have thin or no overburden, occurring in undulating terrain of the city with high runoff. The reviewed report found that all the aquifer types in the city have an 80% groundwater potential and a high transmissivity ranging from $1m^2$ per day to $58m^2$ per day. The groundwater chemistry however was found to be within the Malawi drinking water standards for boreholes and shallow wells as stipulated by MS 733, 2005. Thus, sanitation systems are assumed to be located in areas of low risk of groundwater contamination (T1A2C5) and (T1B7C10).

Nevertheless, groundwater quality analysis also showed that there is a relative prevalence of sodium (Na^+) and sulphates (SO_4^{2-}), as well as calcium (Ca^{2+}), magnesium (Mg^{2+}) and hydro-carbonates HCO_3^-) in weather and shallow aquifers. This therefore raises concerns regarding the potential impact of anthropogenic activities on the groundwater quality.

Therefore, while the groundwater vulnerability assessment showed that the groundwater quality in the city is within drinking standards, the SFD graphic highlights that around 32% of the households do not safely manage their excreta and that a majority of the excreta that is not safely managed comes from unlined and unemptied pit latrines, indicating the possibility of water pollution in the shallow aquifers. The relative prevalence of sodium, sulphates, and other ions associated with human waste in the groundwater suggests possible contamination from untreated or inadequately managed sanitation sources (Deshmukh, 2013).

Similarly, the geological features of fractured and outcropping gneiss aquifers in Lilongwe City increase the potential impact of groundwater pollution. The fractures, lack of overburden and high transmissivity in these aquifers create pathways for contaminants to enter and move within the groundwater system (Akanbi, 2018; Collins, et al., 2020; Lachassagne, et al., 2021).

In conclusion, while Lilongwe City's aquifers exhibit promising characteristics in terms of potential and transmissivity, the presence of specific ions associated with anthropogenic activities such as unemptied unlined pit latrines which are buried when full, raises concerns about the higher potential for groundwater pollution.

2.3. Summary of Assumptions

Offsite sanitation Systems:

- ✓ 15% of the households depends on offsite sanitation systems as they have connected toilets directly with sewer network. The proportion of wastewater in sewer system, which is delivered to centralised treatment plants has been assumed at 85% (loses are due to exfiltration and blockages). So, value for variable W4a has been set to 85%.
- ✓ The proportion of wastewater delivered to centralised treatment plants which is treated has been assumed at 85% based on treatment efficiency or BOD/COC organic load removals. So, value for variable W5a has been set to 85%.

Onsite Sanitation Systems:

- ✓ The proportion of FS in septic tanks was set to 100%, the proportion of FS in fully lined tanks was set to 100% and the proportion of FS in lined tanks with impermeable walls and open bottom and all types of pits was set to 100% according to the relative proportions of the systems in the SMC, as per the guidance provided by SuSanA.
- ✓ Variables F3, F4 and F5 for all onsite sanitation systems were derived from the household survey and cross-checked with KIIs conducted.
- ✓ For septic tanks, the proportion that is emptied was set to 26% (F3 = 26%) , the proportion of FS delivered to treatment was set to 39% (F4 = 39%) and the FS delivered to treatment which is treated was set to 50% (F5 = 50%) (Mkwezalamba and Kabika, 2023).
- ✓ For septic tanks (T1A2C5), the proportion that is emptied was set to 26% (F3 = 26%) , the proportion of FS delivered to treatment was set to 39% (F4 = 39%) and the FS delivered to treatment which is treated was set to 50% (F5 = 50%) (Mkwezalamba and Kabika, 2023).
- ✓ For fully lined tanks (sealed), no outlet or overflow (T1A3C10), the proportion that is emptied was set to 50% (F3 = 50%) , the proportion of FS delivered to treatment was set to 50% (F4 = 50%) and the FS delivered to treatment which is treated was set to 50% (F5 = 50%) (Mkwezalamba and Kabika, 2023).
- ✓ From the household survey and the questionnaire carried out, unlined pits with a top slabare assumed as pits (all types), never emptied but abandoned when full and covered with soil, no outlet or overflow (T1B7C10) and unlined without top slab are assumed as pits (all types), never emptied, abandoned when full but not adequately covered with soil, no outlet or overflow (T1B8C10).

2.3 SFD Graphic

Overall, the generated SFD graphic indicated 68% of excreta that is generated in the sampled wards as being safely managed, while 32% comprised the unsafely managed excreta.

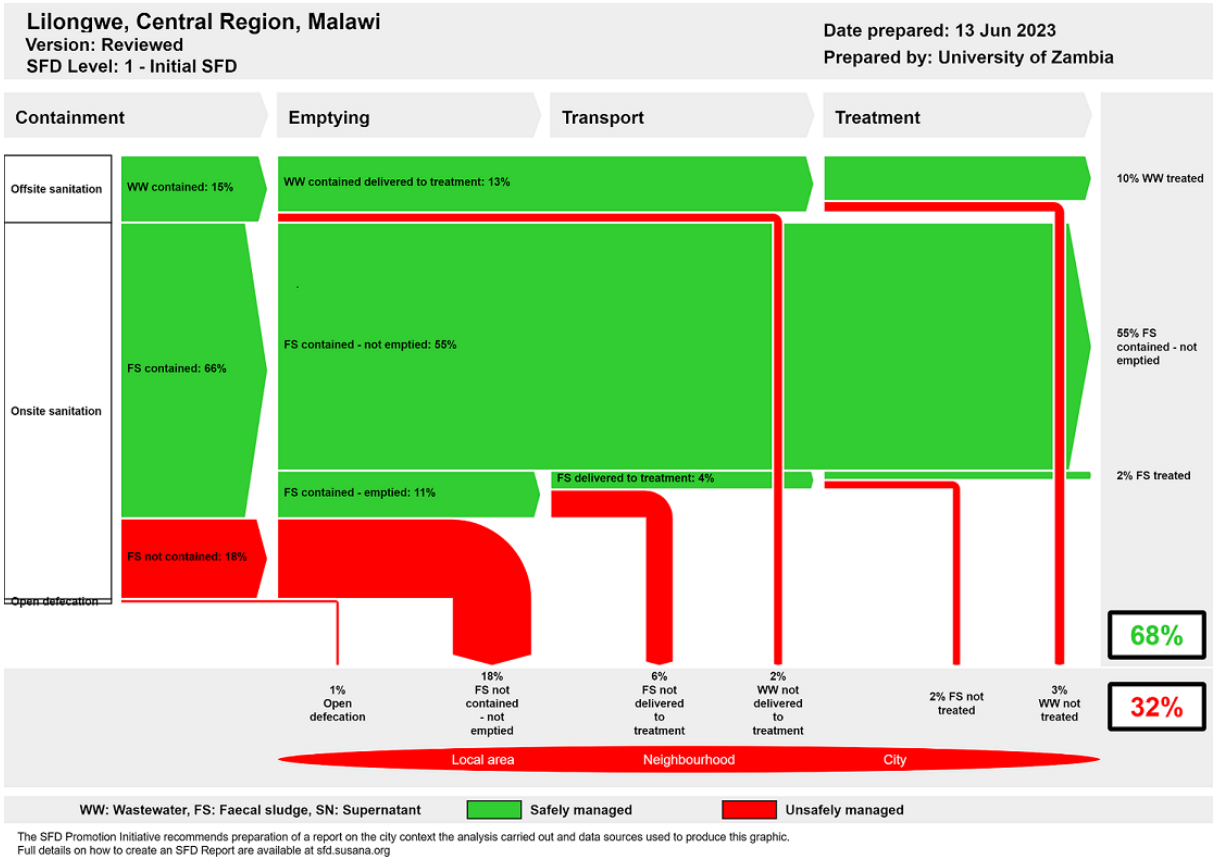

Figure 18: SFD Graphic for Lilongwe.

The SFD shows that the safely managed excreta originates from wastewater delivered to treatment and treated (10%); FS delivered to treatment and treated (2%) and 55% of FS contained - not emptied. A majority of this FS (26%) comes from pit latrines, that are never emptied and are abandoned when full which are located in areas of low risk of groundwater contamination. The remaining percentage comes from FS contained in septic tanks which are not emptied. However, these containments will require emptying services in the short and medium term as they fill up.

The unsafely managed excreta originates from wastewater delivered to treatment but not treated due to inefficiencies in the wastewater treatment (3%); wastewater not delivered to treatment due to losses and blockages in the sewer network (2%); FS delivered to treatment but not treated due to inefficiencies in the FS treatment (2%); FS not delivered to treatment (6%); FS not contained - not emptied from pits abandoned when full but not adequately covered with soil (18%) and people practising open defecation (1%).

In conclusion therefore, the SFD graphic and the associated research analyses have provided valuable insights into the state of excreta management in Lilongwe City. The results reveal a concerning disparity between safely and unsafely managed excreta, with specific challenges arising from abandoned and unemptied pit latrines. Additionally, the study highlights the limited proportion of excreta that reaches treatment plants and undergoes proper treatment. With 68% of excreta in the sampled wards considered safe, there remains a pressing need for strategic interventions and policy changes to address the 32% that still present challenges in containment and treatment. Hence, the importance of taking action to enhance public health and environmental sustainability in Lilongwe City's sanitation practices.

3 Service delivery context

There are various legislation, policies and strategies which govern the management and operation of water and sanitation in Lilongwe of which most of them apply at national level as follows;

3.1 Policy, legislation and regulation

3.1.1 Policy

Malawi Vision 2063

The newly launched Malawi Vision 2063 aims to achieve, an inclusively wealthy and self-reliant middle-income country. It is the successor to Vision 2020, and provides a comprehensive long-term plan to guide Malawi's development path. The Vision allows Malawi government to intervene systematically through multiple approaches to foster balanced growth. This will be done via 10-year accelerator plans as the implementation frameworks for Vision 2063. Whereas the water and sanitation sector is not one of the pillars of Vision 2063, the sector is recognized as an essential public service under the enabler 'human capital'. The 10-year accelerator plans present an opportunity to explicitly define and incorporate the necessary reforms to drive the water and sanitation sector forward. The Vision also highlights that provision of clean water, sanitation and hygienic services will be critical at the household and community level.

Therefore, government shall take the lead and rally partners and communities in promoting the adoption of safe water and sanitation practices at the individual and household level. This shall include the provision and promotion of the use of improved and accessible sanitation facilities in all public places as well as improving the management and disposal of liquid and solid waste. The Vision is thus encompassing on the need for sanitation minimum standards and the need to manage both the liquid and solid wastes.

Decentralization Policy

The Decentralization Policy (1998) provides for devolution of fiscal, political and administrative functions including urban planning, environmental protection and waste management, including sanitation. The policy transfers critical social service functions to the local authorities. The Policy's intentions are embodied in the law via the Local Government Act of 1998. Although after, over 20 years later, most of the decentralization policy's ambitions have not been realized. By and large, power is still centralized, and service delivery at the local level is fragmented.

National Environmental Policy

The National Environmental Policy was formulated in 1996 and revised in 2004. Among others, the revised National Environmental Policy meant to iron out the observed policy gaps, conflicts, and duplications which adversely affects effective implementation of the policies. In addition, the revised Policy was meant to take into account the importance of creating an enabling policy and legal framework for cross sector coordination, participation of non-state sectors, strengthening the enforcement machinery, and decentralizing environmental management and governance, among others. In that respect, the policy provides the overall goals, objectives and key principles for sound environment management. It provides the basis for the

formulation of a comprehensive environmental, legal, institutional and regulatory framework. Further, the Policy seeks to be in tandem with other policies; for instance, the policy provides that the “Polluter-Pays Principle” shall be incorporated in Water Policy and Legislation so as to ensure that costs of unsustainable water utilization and management are borne by the party responsible for such acts. Following the framework provided by the policy, Malawi’s commitment to environmentally sustainable social and economic development was showcased with the enactment of the Environment Management Act (2017), and the establishment of Malawi Environment Protection Authority (MEPA).

National Water Policy

The National Water Policy (2005) sets the framework for water resources management, development and service delivery. The intention of the policy is to enable Malawi government to meet its national and global commitments. The overall policy goal is to secure water and sanitation services that satisfy the basic requirements of every Malawian, while protecting the country’s natural ecosystems. The Policy defines the roles of the private sector, civil society and other non-state actors. It promotes integrated water resources management for sustainability. The Policy, among other things, provides for the creation of responsible institutions; devolution of integrated water resources management; promoting proper management and disposal of waste; developing coherent national sanitation policy; setting out water standards and regulations; and promoting coordination with other institutions.

The Policy employs the “Polluter-Pays Principle” at the full cost of treatment, monitoring and management of water resources to reduce pollution loads to acceptable standards that will not cause environmental damage or loss of beneficial use to others. The National Water Policy is housed by the Ministry of Water and Sanitation.

National Sanitation Policy

The National Sanitation Policy (2005) seeks to achieve universal access to improved sanitation and hygienic practices. The Policy promotes safe recycling of liquid, solid waste and safe disposal of human excreta to ensure environmental protection and management. The Sanitation Policy recommends targeted subsidies for the most vulnerable and disadvantaged groups. In addition to the roles of water utilities and other players, the policy sets out the roles of other institutions in the sanitation and hygiene sub-sector. It provides for the role of other institutions in sanitation planning, monitoring and provision in Cities, Municipalities, Peri-Urban Areas, Towns, Market Centres and Districts.

Malawi Growth and Development Strategy III (2017 – 2022)

This strategy was rolled out in 2017, and covers the period 2017-22. In the MGDS, the government committed to improving sustainable access to water supply and sanitation in urban, peri-urban and rural areas through demand-responsive and demand-driven approaches. The strategy promotes public-private partnerships and community participation in the delivery of water and sanitation services. MGDS III was formulated as the medium-term development framework for achieving the aspirations of National Vision 2020. The latter has since been replaced by Vision 2063.

National Sanitation and Hygiene Strategy

The National Sanitation and Hygiene Strategy 2018-24 seeks to re-align Malawi's efforts in attaining universal, sustainable, and equitable access to sanitation and hygiene, and the elimination of open defecation. It builds on the lessons learnt from previous strategies. The Strategy aligns with global frameworks and national-level policies. It sets national-level access targets for rural, urban and institutional (health care facilities, markets, schools, and so on) settings. The strategy promotes sustainable waste management, and proposes areas for reform and review of related policies, laws, by-laws and institutional arrangements for sanitation and hygiene. It further sets a framework for mobilization of resources for investment in the sanitation and hygiene sub-sector.

Conclusion

Malawi’s policy framework on water, and sanitation lays a good foundation to guide sector players working at various levels. It is important to note that the Policies recognize the existence of other policies held by other sector players and efforts are being made to update and align the policies in view of new developments. Quite notably, the National Sanitation Policy (2008) is wide ranging in calling and accommodating other cross-sectoral players for coordination and service delivery, recognizing their policy mandates.

3.1.2 Institutional roles

The legal framework for water supply, sanitation and drainage in Malawi consists of Acts, Regulation, Ordinances and other legal instruments specifying the functions and responsibilities of the relevant organizations. The major legal instruments are as follows:

The Constitution

The Constitution of 1995 as amended is the supreme law of the Republic of Malawi. The Constitution instructs the State to promote the welfare and development of the people of Malawi. The Constitution provides for equity, sustainable environmental management and promotion of a good quality of life for the people of Malawi. Human rights, of which the right to clean and safe water is part, are entrenched in Chapter 4 of the Constitution. The Constitution implores the Malawian State to take all practical measures to promote a good water management system at all levels. The Constitution provides the foundation on which other laws are built. Consequently, a number of Acts have been passed and form part and parcel of the legal framework, which steers development efforts towards reaching the national objectives set out in the Constitution. The following legislation has an influence on sanitation:

Public Health Act

The Public Health Act (1948) (PHA), which predates the Constitution, provides for local authorities to take necessary measures to protect and promote public health. The PHA regulates the provision of safe water supply, and the control and amelioration of water pollution in general. The Act specifies remedial measures for pollution including legal proceedings against offenders. Section 62 of the Act stipulates actions that may damage public health. The actions relate to standing water, wastewater, protection of water sources and supply, solid waste, latrines, watercourses, streams, and drains.

Part X of the Act allocates responsibility for sewerage to local authorities, the PHA plays an important role in ensuring safe water and prevention of pollution. The Act is housed by the of Health.

3.1.3 Service provision

Water Works Act

The Water Works Act (1995) is the principle law for water service provision, implying that all policies, regulations, administrative actions, strategic plans and all actions by sector institutions must be consistent with the provisions and content of this Act. The Act provides for the establishment of Water Boards, water supply and sewerage service areas and for the administration of such areas. Five Water Boards have, so far, been established. Two of the Boards – Blantyre and Lilongwe Water Boards – serve Malawi's two cities and their peri-urban areas. The other three Boards (Northern, Central and Southern Region Water Boards) serve the respective regional cities, towns and commercial centres (Botomani, 2023). The Act describes the institutional structure that governs water supply and sanitation. Under Section 6, the Boards are responsible for, among others, the promotion and construction of facilities for water supply and water-borne sewerage sanitation in areas under their jurisdiction. The Act is housed by the Ministry responsible for Water and Sanitation.

Local Government Act

The Local Government Act (1998) implements Malawi's decentralization and devolution of powers, and services delivery to local governments. Section 21 empowers local governments to draw up plans for the social, economic and environmental development of the areas within their authority. Local governments are responsible for water development (provision and distribution). The Act (Sections 24 and 103) also empowers local governments to establish, maintain and manage services for the collection, removal, treatment and the disposal of solid and liquid waste. It also gives power to councils to come up with by-laws on sanitation and waste, and enforce penalties if there is any breach of the laws. The Act is housed by the Ministry responsible for Local Government.

3.1.4 Service standards

Environment Management Act

The Environment Management Act (2017) establishes policies and standards related to environmental management and establishing an environmental fund. The Act provides the legal basis for the protection and management of the environment, conservation and the sustainable use of natural resources. Under sections 38 and 56, the regulation of waste collection, transport and safe disposal is allocated to local authorities. The Act further mandates the local authorities to formulate standards and control the waste management chain. Part IV of the Act spells out the Environmental Impact Assessment (EIA) process that all project developers are required to comply with. The Act also gives mandate to the Malawi Environment Protection Authority (MEPA) to establish and manage buffer zones near environmental protection areas. Under powers given in the EIA, the Environment Management (Waste Management & Sanitation) Regulations (2008) were formulated. The Regulations have a major implication in waste management regimes that local authorities may put in place. The

Act is housed by the Ministry responsible for Environmental Affairs with the Department of Environment being the lead institution to ensure compliance.

Water Resources Act

The Water Resources Act (2013) provides for the management, conservation, use and control of water resources; for the acquisition and regulation of the rights to use water; and for matters connected therewith. Specifically, Section 4 sets appropriate standards for the control, protection, management and administration of water resources, and regulation of activities that affect use or management of water resources. The development of water resources for domestic use is also covered by the Act. The Act promotes the rational management and use of Malawi's water resources. The Act obligates the responsible Minister to have the National Water Policy in place. Under the Act, the National Water Resources Authority (NWRA) was established to, inter alia, regulate water resources use through processing, issuing, monitoring and enforcing permits for water abstraction, wastewater discharge, borehole drilling, construction of hydraulic structures such as dams, among others. The Act also gives mandate to the NWRA to see to it that disposal of effluents or drainage from any household, factory, trade premises or other premises is done in such a manner that will prevent any such effluent or drainage from reaching surface or groundwater causing pollution. The Act is housed by the Ministry of Water and Sanitation.

Waterworks (Lilongwe Water Board) (Water-Borne Sewerage Sanitation) By-Laws, 2023

This bylaw was gazetted in July 2023, under the Waterworks Act (1995). This bylaw empowers the Lilongwe Water Board (LWB) in the management of waterborne sanitation and its related infrastructure in its gazetted water supply area. Among others it discusses the connection procedures, eligibility, obligations and prohibitions. It also guides the Board in the management and operation of wastewater treatment plants and related discharge limits, highlighting related penalties and fines where applicable and where there is non-compliance.

Local Government (Lilongwe City Council) (Onsite Sanitation and Municipal Sewage Management) By-Laws, 2023

This bylaw was also gazetted in July 2023; however, it is under the Local government Act (1998). It empowers and is managed by the Lilongwe City Council (LCC) in the management and operation of onsite sanitation. This bylaw stipulates the Councils' obligations to provide onsite sanitation services under its local authority. Other functions and roles include regulating emptying of OSS units, registration and licensing of service providers and cancelling of such licences where there is non-compliance. The bylaw also highlights obligations and operational guidelines for service providers and their personnel.

3.2 Planning

3.2.1 Service targets

The Malawi vision 2063, envisions the provision of clean water, sanitation, and sanitary services at the household and communal levels being essential for a healthy population. In order to encourage the adoption of safe water and sanitation practices at the individual and household level, the government commits to take the initiative and mobilize partners and communities. This will involve managing and disposing of liquid and solid waste more

effectively, as well as encouraging the use of upgraded and easily accessible sanitary facilities in all public areas as well as households.

In order to encourage excellent sanitation and hygiene practices, volunteer community service projects and awards for cities, municipalities, and local communities will be introduced. Beyond this, the government commits to create water networks for residential, commercial, and agricultural use.

4 Stakeholder Engagement

An iterative process of literature analysis, consultations, and review of other SFDs produced in other cities and towns around the country as well as other case studies was used to build the data gathering methods for this study. Key informant interviews (KIIs), Focus Group Discussions (FGDs), secondary literature, and field observations were the data sources needed to construct this initial level of SFD, in accordance with the recommendations of the SFD Promotion Initiative (2018). As a result, this study took into account prior research on FSM as well as a general understanding and assessment of the sanitation scenarios in Lilongwe City through secondary data sources, including published and unpublished government documents such as master plans, detailed project reports, census reports, and reports on city sanitation, among other related studies and publications, similar to what other partners in development have accomplished.

Concurrently, utilising OSS systems, stakeholders covering slum dwellers or informal settlements and other locations were identified for the goal of gathering data. Thus, in order to establish consensus in the development of this SFD report, a strategy and related questionnaires were developed for engagement with government officials, emptiers, field observations on prevalent system operations, feedback from informants, and efficiency of treatments systems (through wastewater sampling and analysis). Additionally, FGDs with stakeholders were established, conducted, and used.

4.1 Key Informant Interviews (KIIs)

KIIs were used and involved in the collection of data from “expert sources” known as key informants to complement FGDs, household questionnaire and laboratory analyses and results.

KIIs had the advantage of permitting an in-depth exploration of issues and were useful in understanding various aspects of OSS, FSM, and wastewater management that had a bearing on the success of this study. Key informants were selected based on their potential role, experience in and knowledge of OSS, FSM and wastewater management in Lilongwe city. Specifically, however, the study paid particular attention to interviewing among other key stakeholders, the residents, FS handlers, tanker operators, OSS private business operators (Emptiers Association of Lilongwe members), Lilongwe City Council, Lilongwe Water Board (Sewage Attendants, Supervisors and Managers), Ministry of Water and Sanitation, Ministry of Forest and Natural Resources, Ministry of irrigation and Water Development, and other stakeholders as were identified during the study.

4.2 Focus Group Discussions (FGDs)

FGDs were used or conducted with stakeholders at community level, and or their place of work or operation. These targeted managers, supervisors, community leaders and other players as were identified during the study. The FGDs have the advantage of providing a relatively less intimidating context to participants. This enabled us to discuss freely their views and experiences; and they allowed reflection on viewpoints, made individual ideas clearer, which resulted in gaining deeper insights into the issues being investigated. Checklists of issues to be explored were developed accordingly. The FGDs consisted of 5 to 10 people, selected purposively for their first-hand information.

4.3 Questionnaire (administered)

A digital household questionnaire was administered to residents to collect data on socio-economic characteristics, types of containment, treatment methods, disposal options and methods, possible reuse options, cost of treatment and or transportation for further treatment.

Taking into account the targeted population of 1,225,395, a sample size was determined that would maximize the margin of error, confidence levels, and financial and time constraints. The Taro Yamane (1967) formula ($n=N/(1+N(e)^2$) was used to determine the sample size, with a 7% margin of error and a 95% confidence level ($n=1,225,395/(1+1,225,395(0.07)^{\wedge 2}$) n=204). The sample size of 204 is obtained by the calculation above; however, a nonresponsive rate of 6% was assumed, resulting in a sample size of 216 households.

Appendix 7.2 illustrates how a set number of households were chosen for each income level (high, middle, or low). This allowed for a categorical stratification of the sample size into different population densities and settlement types, such as informal, peri-urban, and urban settlements. No particular criteria were applied in the selection or identification of respondents, despite the fact that the study aimed to capture gender issues and increase representativeness and inclusivity.

The questionnaire was in English however was translated into Chichewa (a local language commonly spoken in the area of study) during the actual interviews. The response from each questionnaire was transmitted and uploaded or stored using *KoboCollect* platform (Mkwezalamba and Kabika, 2023).

4.4 Observation

This method was used under this study because it is an unobtrusive means to collect data, and facilitates the collection of sensitive data, including operational conditions and functionality of OSS, FSM and wastewater management in the area of study. To verify the information gained through other means, it was helpful to observe sanitation facilities and services. Assessing the equipment utilized, household actions, and labour involved at each stage of the Sanitation Service Chain (SSC) (containment, emptying, transport, treatment, and end-use or disposal) is helpful. The efficacy of operations and procedures employed throughout the SSC can also be learned through observation (SFD Promotion Initiative, 2018).

When the onsite sanitation technologies were being emptied, it was planned and carried out to observe the emptying and transfer processes. Households, as well as emptying and transportation service providers, gave their consent for the observational study to be conducted.

In order to ensure the SFD production manual's recommendations for engaging with stakeholders are adhered to, the visit to the treatment plant or disposal site which was taken, was arranged through the institution responsible for managing the plant. These observations were accompanied by a checklist and data sheets to ensure all relevant aspects of OSS, FSM and wastewater management assessment are covered.

5 Acknowledgements

The author would like to thank the following for their support as rendered during the preparation of this report (Table 3).

Table 3: Acknowledgement of stakeholders.

Stakeholder Name	Contact Person *Phone, Email, Website, Address*
Lilongwe City Council (LCC)-Director of Health and Social Welfare Services	Vitto Mulula +265999239817 vmulula@gmail.com
Lilongwe Water Board-Project Implementation Unit-Sewerage Network Engineer	Chimango Mweso +265998142510 chimangomweso@gmail.com
Lilongwe Water & Sanitation Project (LWSP) Project Support Unit-Project Coodinator	Eng. Cleaverson Nyando +265991194049 cknyando@yahoo.co.uk
Ministry of Water & Sanitation	Peter Chipeta-Deputy Director-Water Supply +265999899119 chipeta99@yahoo.co.uk Harold Chirwa-Principal Sanitation Officer +265888396111 harold.chirwa@gmail.com Mrs Getrude Makuti Botomani-Deputy Director-Sanitation +265999746501 gertrudemakuti@gmail.com
Private Vacuum Tanker Operators Association-Lilongwe Chapter	James Longwe-Chairperson +265995416466 Haig Sawasawa-Vice Chair Person +265888540026
Water and Sanitation Network-Policy & Advocacy Officer	Hopeson Chaima +265881771767 Hopeson.chaima@gmail.com

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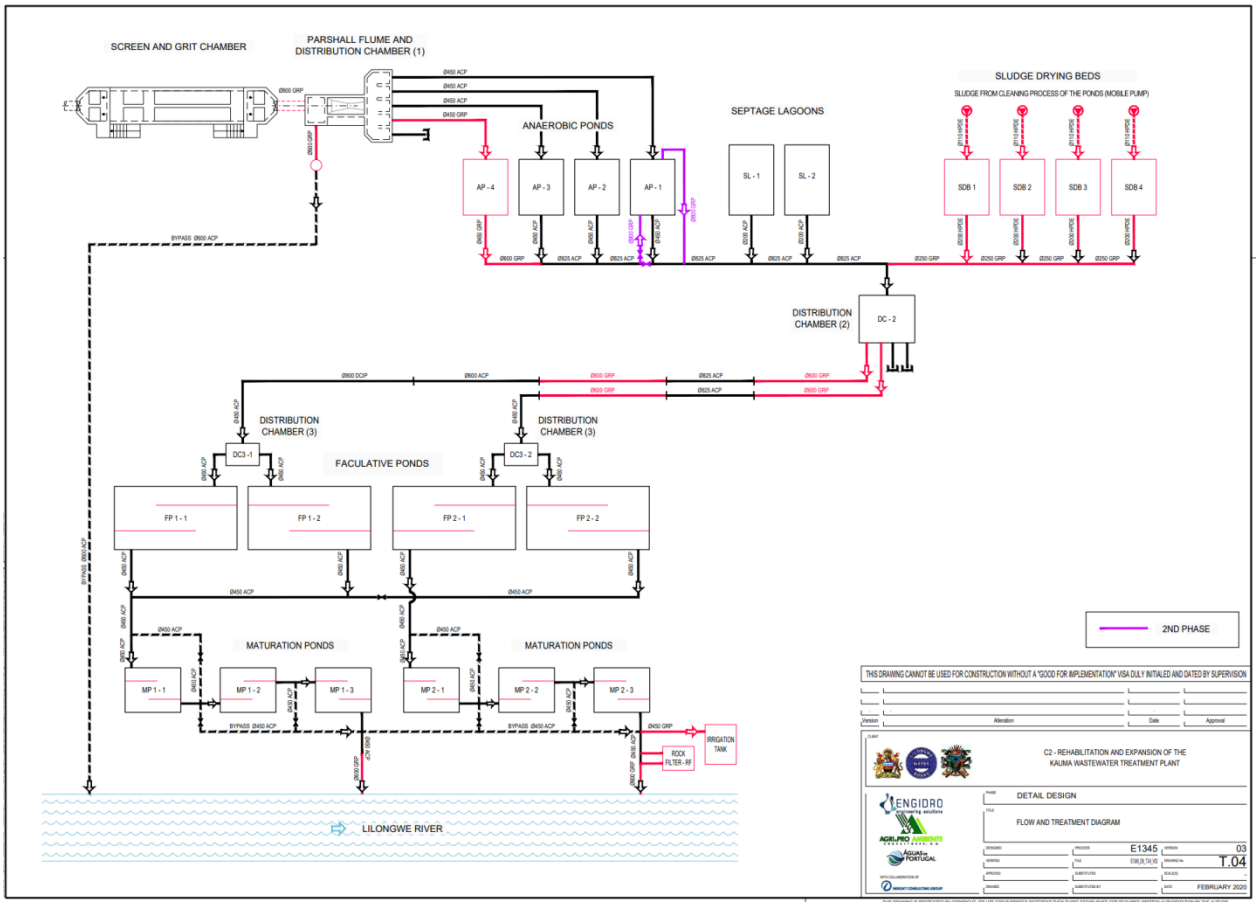
7 Appendix

7.1 Appendix 1: Flow and Treatment Diagram of the Lilongwe WWTP (Engidro:2019)



7.2 Appendix 2: Number of Households per Income Level

Ward Name	Ward Code	Sampled Area	Sampled Codes	Income Level	Sampled Size
Chigoneka	CHG	47/1	CHG47/1/001-12	High	12
Chigoneka	CHG	47/2	CHG47/2/013-24	High	12
Chigoneka	CHG	47/3	CHG47/3/025-36	High	12
Chigoneka	CHG	47/4	CHG47/4/037-48	High	12
Mbidzi	MBI	1	MBI1/1/049-60	Middle	12
Chinsapo 1	CS1	57	CS1/57/061-72	Low	12
Chinsapo 2	CS2	46	CS2/46/073-84	Low	12
Nyama	NYA	12	NYA/12/085-96	High	12
Nyama	NYA	11	NYA/11/097-108	Middle	12
Mariya	MAR	49/1	MAR49/1/109-120	Middle	12
Mariya	MAR	49/2	MAR49/2/121-132	Middle	12
Mariya	MAR	49/3	MAR49/3/133-144	Middle	12
Mariya	MAR	49/6	MAR49/6/145-156	Middle	12
Phwetekere	PHW	36	PHW/36/157-168	Low	12
Mtandire	MTA	56	MTA/56/169-180	Low	12
Mtsiliza	MTS	56	MTS/56/181-192	Low	12
Kabwabwa	KAB	25	KAB/25/193-204	Low	12
Mgona	MGO	51	MGO/51/205-216	Low	12
					216

SFD Lilongwe, Malawi, 2024

Produced by:

University of Zambia, Phyllis George Mkwezalamba

Editing:

University of Zambia, Joel Kabika PhD.

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