RRR-Project

From Research to Implementation

Component 1 – Waste Supply and Availability

Report – Kampala

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Abbreviations

Abbreviation	Explanation
AIW	Agro-industrial Waste
BOD	Biochemical Oxygen Demand
CEDAT	College of Engineering, Design, Art and Technology
CIDI	Community Integrated Development Initiatives
COD	Chemical Oxygen Demand
CV	Calorific Value
DM	Dry Mass
FAO	Food and Agriculture Organization
FC	Faecel Coliform
FS	Faecal Sludge
FSM	Faecal Sludge Management
FSTP	Faecal Sludge Treatment Plant
FWT	Fichtner Water & Transportation
GiZ	Deutsche Gesellschaft für internationale Zusammenarbeit
GPS	Global positioning system
HE	Helminth Eggs
KCC	Kampala City Council
KCCA	Kampala Capital City Authority
KfW	Kreditanstalt für Wiederaufbau
KSMP	Kampala Sanitation Master Plan
KSP	Kampala Sanitation Plan
KUPSIP	Kawempe urban poor sanitation project
Max	Maximum
Min	Minimum
MSW	Municipal Solid Waste
MUK	Makerere University Kampala
MW	Market Waste
NEMA	National Environmental Management Authority
Netwas	Network for Water and Sanitation
NWSC	National Water and Sewerage Corporation
OSS	On-site sanitation
PEA	Private Emptier Association
PPP	Public-Private-Partnership
RRR	Resource, Recovery, Reuse
SD	Standard Deviation
SWM	Solid waste management
SWMS	Sold Waste Management Strategy
TCS	Truck counting study
TKN	Total Kjehldahl Nitrogen
TP	Total Phosphorous
TS	Total Solids
TSS	Total Suspended Solids
TVS	Total Volatile Solids
UBOS	Ugandan Bureau of Statistics
UDDT	Urine Diverting Dry Toilet
VIP	Ventilated Improved Pit
WfP	Water for People
WSP	Waste Stabilization Pond
WW	Wastewater
WWTP	Wastewater Treatment Plant

1. Introduction

This report was completed by Sandec as part of the “Resource, Recovery and Reuse – From Research to Implementation” project, and presents results of the “Waste Supply and Availability” analysis that was conducted in Kampala, Uganda. This chapter gives an overview of the considered waste streams, objectives of the analyses and sources of information. Chapter 2 contains background information on Kampala’s population size and density, as well as a stakeholder mapping of key institutional and private stakeholders involved in waste management. The following chapters then present results of the analysis for each of the following waste streams:

- Municipal solid waste (MSW), Chapter 3
- Market waste (MW), Chapter 4
- Wastewater (WW), Chapter 5
- Faecal sludge (FS), Chapter 6
- Agro-industrial waste (AIW), Chapter 7
- Animal waste (AW), Chapter 8

The specific objectives of the analyses in Kampala were to:

- Calculate quantities and characteristics of the defined waste streams
- Analyze and summarize the current waste management of Kampala
- Present the accessibility of the defined waste streams, and provide preliminary findings on the potential for the implementation of waste-based business models

The information for this report was collected through review of secondary data, interviews, field observations and collection of primary data. Sources included:

- Existing reports from Kampala Capital City Authority (KCCA) and research institutes working in the field of waste management and sanitation,
- On-going PhD and MSc. research through interviews and review of students’ publications,
- Collection of raw data from public utilities,
- Conducting interviews with experts,
- Field data measurements for quantities of faecal FS (i.e. truck counting study).

2. Overview of Kampala

This chapter presents background information on Kampala to provide a general understanding of the size, population density, geographical location and layout of the city, and the involvement of key stakeholders in the sector.

2.1 City Boundaries

The country of Uganda consists of 111 districts. Kampala District serves as the boundary for this study for the management and generation of waste streams. Wakiso District surrounds Kampala District and is relevant in terms of agricultural crop production and transient population, but not included within the city boundaries for the analysis of waste quantities and characteristics. As shown in Figure 1, Kampala is divided up into five divisions: Central, Kawempe, Makindye, Nakawa and Rubaga Division. These five divisions are further divided up into “parishes”, and the parishes are further divided up into “zones” for a total of 2,959 zones in Kampala.

Figure 1: Boundaries of Kampala City and the five divisions that make up the city

2.2 Population

The estimated population of residents in Kampala for 2012 is 1,723,200 (UBOS, 2012). Table 1 presents the number of residents living within each of the five divisions of Kampala. It is important to note that the daytime population is estimated to be at least double the resident population, with some estimates going as high as 4,000,000 people [1]. This can be explained by the fact that work labor is coming into the city from surrounding districts. Especially the commercial and industrial areas are affected immensely by these transitory populations. A map of these areas is shown in Appendix 10.5.

The last census in Kampala was undertaken in 2002 and values for the current population are extrapolated from that census. Population estimates are conducted by the Ugandan Bureau of Statistics (UBOS), who is responsible for all statistical matters in Uganda.

Table 1: Population of the five Kampala divisions in 2012 (UBOS, 2012).

Division	Population
Central	127,600
Kawempe	379,900
Makindye	439,300
Nakawa	348,700
Rubaga	427,700

It is estimated that more than 60% of Kampala's population live in urban slum areas, characterized by informal settlements and resulting in poor waste management and sanitation infrastructure [2]. Additionally, slums have a high rate of growth in population, estimated to be as high as 9.6% in the fastest growing parish of Bwaise III [3]. In Kampala, the low-income areas tend to be situated in valleys with difficult access and a high probability of flooding. Figure 2 presents population densities of all the parishes in Kampala. It is apparent that parishes with high population densities are also characterized by low-income residents (compare Appendix10.6, Appendix 10.7).

Population size and densities are often used to calculate waste generation in urban areas. This is difficult for Kampala for several reasons:

- The last official census is from 2002
- There is a transitory daytime population
- There are many types of sanitation technologies
- The distribution of different types of development

Therefore, population size and density are not used for the calculation of waste quantities. However, context specific factors are elaborated if influential for waste generation and characteristics.

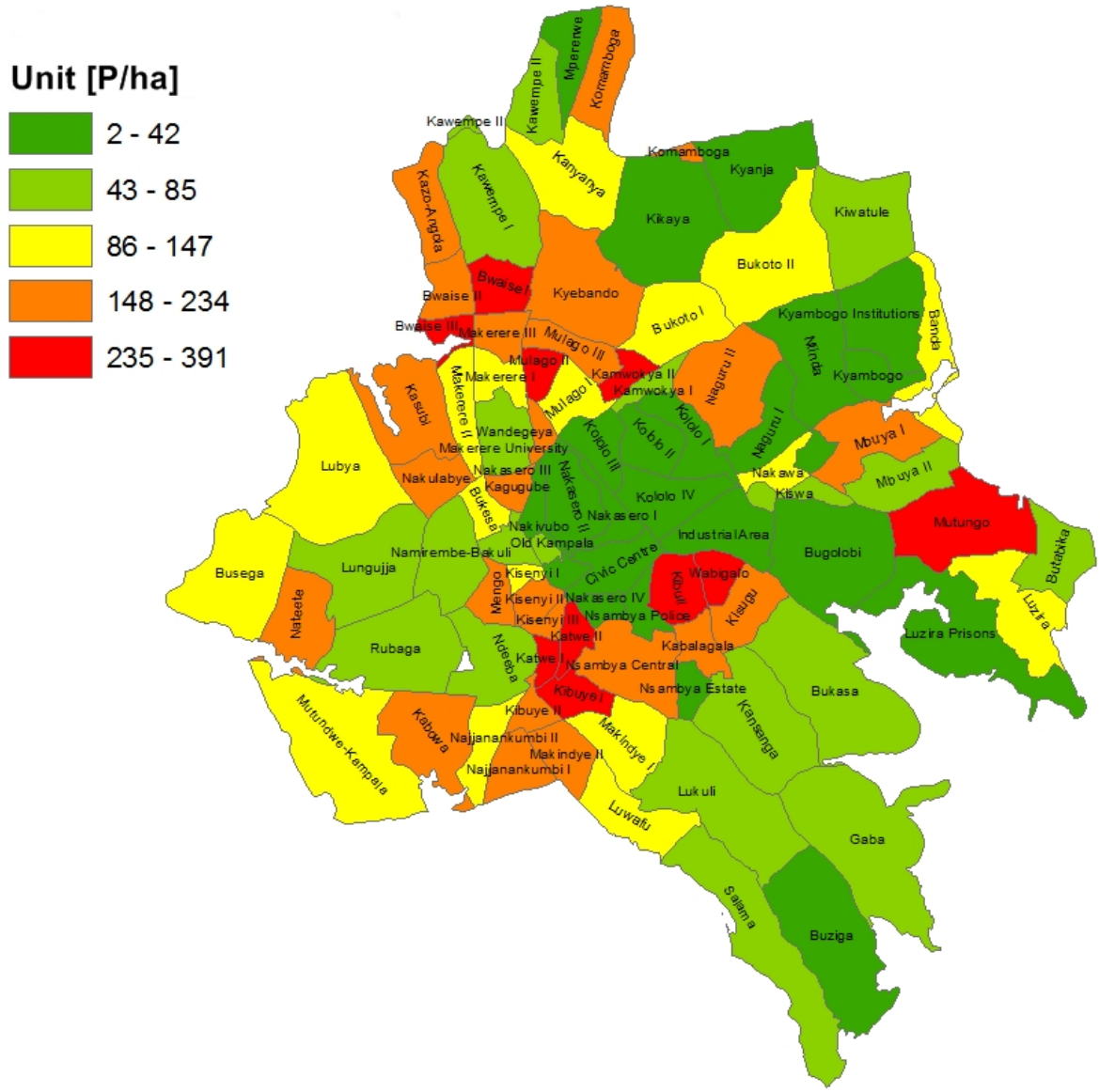

Figure 2: Population density of the parishes in Kampala as a projection for 2013.

2.3 Stakeholder mapping

For this study, key stakeholders that are involved in the management of the waste streams were identified and are presented in Figure 3. The size of the circles represents the relative level of importance in the sector for this study. This section briefly describes the role of each stakeholder to provide an overall understanding of the sector. More detailed institutional analysis is being conducted by other partners within the RRR project. Appendix 10.1 lists all stakeholders interviewed in this study.

Makerere University Kampala (MUK)

Makerere University is the oldest University in Uganda with approximately 40,000 students. It is regarded as one of the best Universities in Africa. The Department of Agriculture and BioSystems Engineering and the College of Engineering, Design, Art and Technology (CEDAT) have several on-going research projects in the field of waste management and sanitation.

Public utilities

The roles of public utilities in the provision and management of water, sanitation, and solid waste management are often not clearly defined in Kampala. The following agencies have the described roles in collection, regulation and enforcement.

The KCCA was established in 2010 by the Ugandan Parliament as a legal entity that replaced the former Kampala City Council (KCC) and is mandated with provision of services in the city that enables an environment that supports development (Health, Waste Management, Education, Gender Mainstreaming, Youth and Community Development, Probation and Social Welfare, Credit Facilities). The important role of KCCA regarding this study is in the fields of onsite sanitation and solid waste management.

The National Water and Sewerage Corporation (NWSC) is responsible for the provision of water and sewerage services in large towns Uganda. NWSC is directly linked to the Ministry of Water and Environment and is the main entity responsible for the Kampala Sanitation Master Plan (KSMP) of 2004.

The National Environmental Management Authority (NEMA) is responsible for licensing all private businesses that are dealing with waste. This includes domestic waste, as well as industrial, chemical or construction waste. NEMA is directly linked to the Ministry of Water and Environment.

A gap in faecal sludge management (FSM) exists, where the management of on-site sanitation is not clearly defined within the public utilities and was not regarded as a management issue for many years.

Private companies

Several private waste management companies evolved in Kampala during the last decade, dealing mainly with MSW and FS collection which is regarded as a lucrative business. More important is the fact that these private companies are closing an existing gap in service provision. The set-up of the Private Emptiers Association (PEA) will be explained in more detail in Chapter 6.

International agencies and consultants

Many international NGOs, research institutes, and development agencies and banks are active in Kampala. Important stakeholders within the framework of this report are the German Development Bank (KfW) as a co-funder and project leader of the KSMP; the German Development Corporation (GiZ) as a direct collaborator and research link to KCCA; and Fichtner Water and Transportation as the leader of the ongoing implementation works of WW and FS treatment plants.

Local and international NGOs

The local NGO Community Integrated Development Initiatives (CIDI) is currently implementing the Kawempe urban poor sanitation project (KUPSIP). It is implemented by CIDI in collaboration with NWSC; KCCA and Netwas Uganda and aims at providing affordable and sustainable sanitation infrastructure and services to improve hygiene and environmental sanitation in five parishes of Kawempe Division. The three year project with a € 1 million grant, funded by the African Development Bank under the African Water Facility, started in July 2013 and plans to establish more than 1,500 sanitation facilities including the components of hygiene and sanitation promotion, hygiene and sanitation infrastructure, faecal sludge management, reuse and knowledge management [4]. An international NGO with a local office in Kampala and working in the sector of onsite sanitation is Water for People (WfP). With the idea of turning sanitation into a small business they brought the Gulper to Kampala, an innovative tool that enables the emptying of inaccessible onsite sanitation facilities. WfP together with Captiva, a local business development support and marketing firm, trained and recruited

entrepreneurs and supported them with a developed business model to start their own business. By 2014, ten entrepreneurs have started a Gulper business and served 5,091 household during 2013 [5].

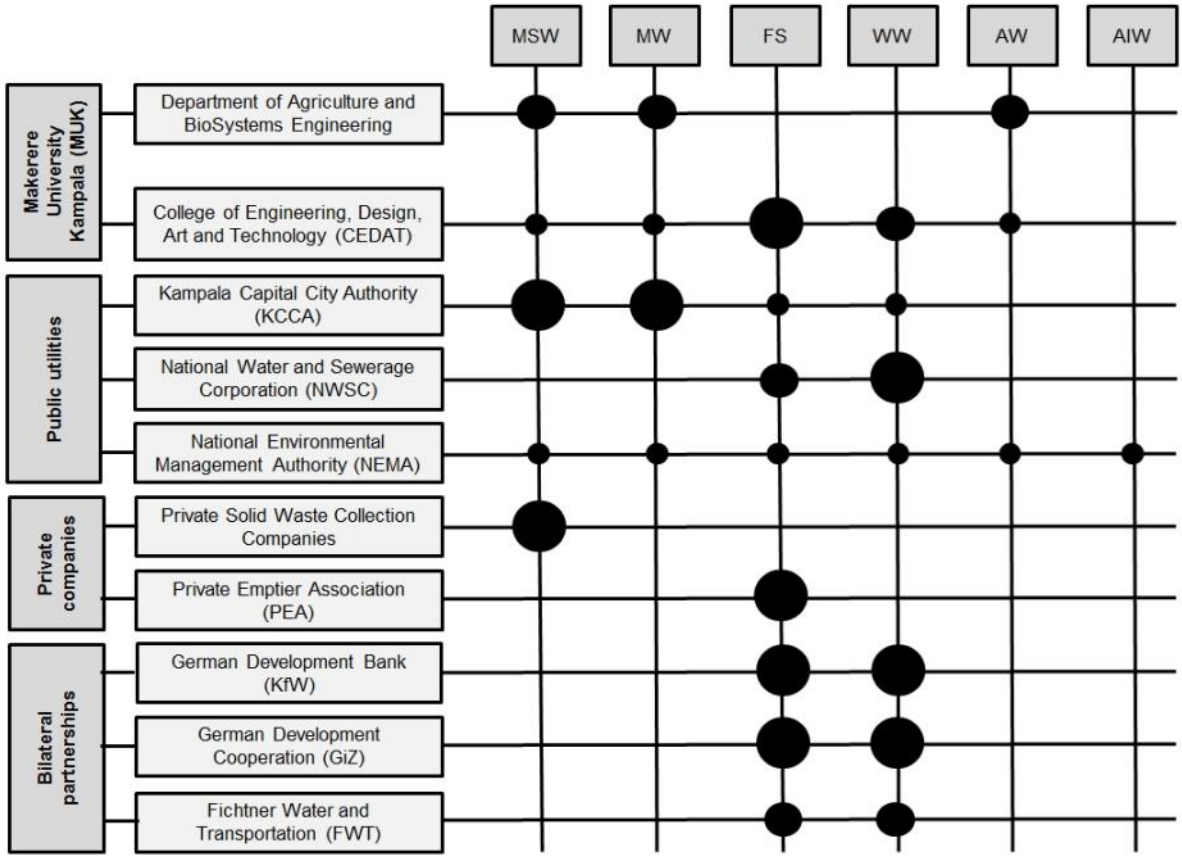

Figure 3: Stakeholder involvement and importance for the different waste streams.

3. Municipal Solid Waste

The information in this chapter presents quantities and characteristics of MSW at the household level. Other solid waste streams are analyzed in separate chapters. The focus lies on understanding Kampala's strategy for solid waste management (SWM) and presenting the main findings on solid waste generation and management.

3.1 Solid waste management

KCCA is authorized by Section 5 of The Public Health Act, Cap. 281 to ensure collection and management of MSW. KCCA has contracted several private companies for MSW collection to improve collection rates. Those private companies collect waste mainly from the high-income areas of the city. Low-income households are served by KCCA.

MSW is collected together and not separated by waste stream. It is then disposed of directly at the Kiteezi Landfill 12 kilometers north of Kampala (see Figure 4). The utilization of the landfill at Kiteezi has surpassed its capacity and KCCA is in the process of identifying a new landfill site. There are currently no facilities for any other form of treatment or handling of MSW (e.g. composting, recycling).

A Solid Waste Management Strategy (SWMS) for Kampala was first published in 2002 and a revised edition was published in 2006. This chapter compares the information provided in the SWMS with on-going research at Makerere University and cross-checks the information with up-to-date information that was collected during interviews with officials at KCCA.

Figure 4: Google earth illustration of Kampala, showing the City Centre and the Kiteezi Landfill

3.2 Solid waste collection rates

It is estimated that only around 40% of the total generated waste in Kampala is collected and transported to the Kiteezi landfill [6]. This is a result of several factors, such as:

- Large population (around 60%) living in low-income areas which waste collectors cannot access due to narrow roads, alleys and pathways
- MSW collection is considered to be not affordable for low-income households. Additionally, people are in general not willing to pay for the service, because MSW collection is expected to be a free service provided by the government
- Collection of MSW is financially not sustainable for KCCA and the services are not effective

3.3 SWMS 2006

The SWMS was first published by KCC in 2002 and a revised version in 2006. The objectives of the SWMS were the following:

1. Characterization of MSW (composition of waste)
2. Estimation of MSW Quantities
3. Identification of available technologies suitable for waste disposal for Kampala
4. Development of a cost recovery model for SWM in Kampala

The SWMS also includes findings from a socio-economic survey. This is not evaluated here because it is not related to quantification of mass flows, but could serve as a good source of information for other components of the RRR-Project such as “Institutional Analysis” and “Financial Analysis”.

In 2006 the monthly MSW generation was estimated to be 42,000 tons, of which 15,000 tons were collected and the rest either remained uncollected or was disposed of by other means. For example, there are private collectors in Kampala, which are not registered with KCCA but are directly paid by the community for the collection of the waste. This makes regulations and supervision difficult as these private collectors operate illegally, in some cases dumping the MSW during the night in undeveloped/ empty plots, people’s gardens, roadsides and swamps [7]. Table 2 shows the composition of the waste in 2006.

Table 2: MSW composition at Kitezi Landfill for 2006 and 2001. Adapted from [7]

Type of Solid Waste	Percentage (June 2006)	Percentage (2001)
Paper & Board	10.7	5.4
Glass	1.8	0.9
Metal	0.4	3.1
Plastic	11.8	1.6
Organics	74.0	83.5
Textiles	0.9	not captured
Construction +Special Care Waste	0.4	not captured
Street Debris	-	5.5
Total	**100**	**100**

The estimations within the SWMS 2006 were made based on a refuse collection study in Makindye Division in the year 2000. The study estimated a waste generation of 1 kg per person per day [8].

Table 3 presents the scenario that was created for the years of 2006 to 2016. The calculations are based on population growth and are shown here for comparison.

Table 3: Solid Waste generation estimated for 2006 to 2016. Adapted from [7]

Year	Population	Daily Waste Generation / tons	Monthly Waste Generation / tons
2006	1,397,583	1,400	42,000
2007	1,449,293	1,450	43,500
2008	1,502,917	1,500	45,000
2009	1,558,525	1,560	46,800
2010	1,616,190	1,620	48,600
2011	1,675,989	1,680	50,400
2012	1,738,001	1,740	52,200
2013	1,802,307	1,800	54,000
2014	1,868,992	1,870	56,100
2015	1,938,145	1,940	58,200
2016	2,009,857	2,000	60,000

3.4 KCCA Landfill data

This section presents records from the Kiteezi landfill provided by KCCA. The raw data shows all MSW that was delivered to the landfill between May and December 2012 and is analyzed and presented as daily, monthly and yearly accumulation. As shown in Table 4, an average of 633 tons of MSW per day is delivered to the landfill by official KCCA collection trucks. In addition, another 311 tons per day are delivered by private collection companies. Therefore, the overall daily amount of MSW received by the Kiteezi Landfill is 946 tons.

A study of legal and illegal dumping locations in Kampala has shown that only 40% of the total generated amount of MSW is actually collected and transported to Kiteezi Landfill. Based on that, the total generation of MSW would be 2,357 tons per day, which equals to 70,710 tons per month and is 31% more than projected by the SWMS for 2013 [6].

DAILY

Table 4: Quantity of MSW collected daily by KCCA [9]

Average /t·d^{-1}	SD /t·d^{-1}	Min /t·d^{-1}	Max /t·d^{-1}
633	67	307	795

MONTHLY

The data presented in Figure 5, was collected as raw data through interviews of officials at KCCA and analyzed by division and monthly collection rates. This figure only includes the MSW that is collected by KCCA because the amount of waste collected by private companies within the divisions is unknown. The graph illustrates that in the Central Division more MSW is collected between the months of May to August, compared to the months of September to December. Although the reasons are unknown, this could be due to construction works within this area, since Central Kampala is the

industrial, commercial and institutional hub of the city. The fluctuations within the other divisions appear to be more regular.

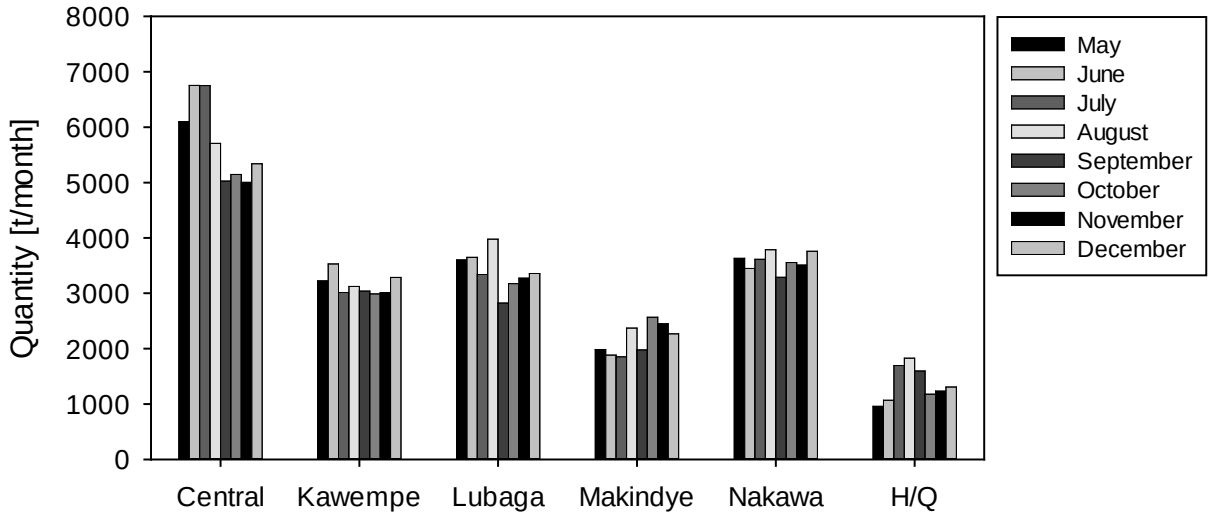

Figure 5: MSW collected by KCCA and disposed of at the Kiteezi Landfill between May and December 2012 [4]

The raw data obtained from KCCA for private collection companies was only available as a sum over all divisions and is presented in Figure 6. Over the time period from May to August, MSW collection decreased slightly but shows an increase towards the end of the year and particularly in December. The reason for that could be a coincidence but it could also be hypothesized that more private companies are entering the market of MSW collection. However, the average of this data can be regarded as representative for waste quantities collected by private companies.

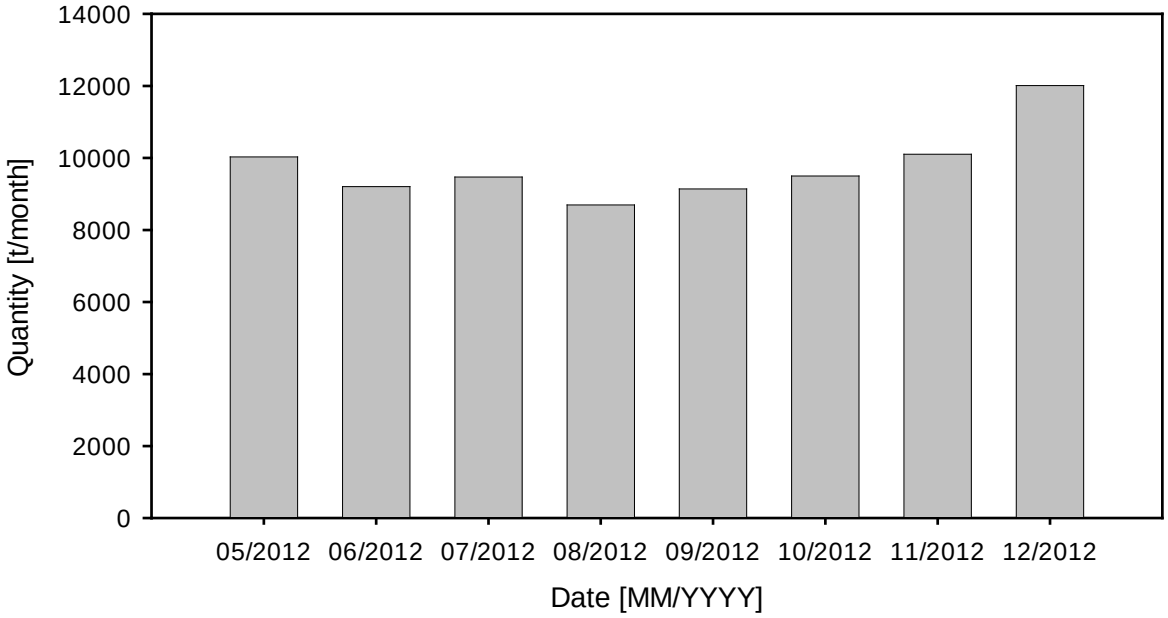

Figure 6: MSW collected by private collection companies and disposed of at the Kiteezi Landfill [9]

On average, 67% of the total daily MSW that is delivered to the Kiteezi landfill is collected by KCCA while 33% is collected by private companies. Figure 7 compares the data based on monthly quantities and shows that towards the end of 2012 the proportion of waste collected by private companies had a higher proportion than at the beginning of the year. This could be another indicator for the increasing privatization of the market. A list of all private companies that are dealing with solid waste in Uganda and are licensed by the NEMA are presented in Appendix 10.2.

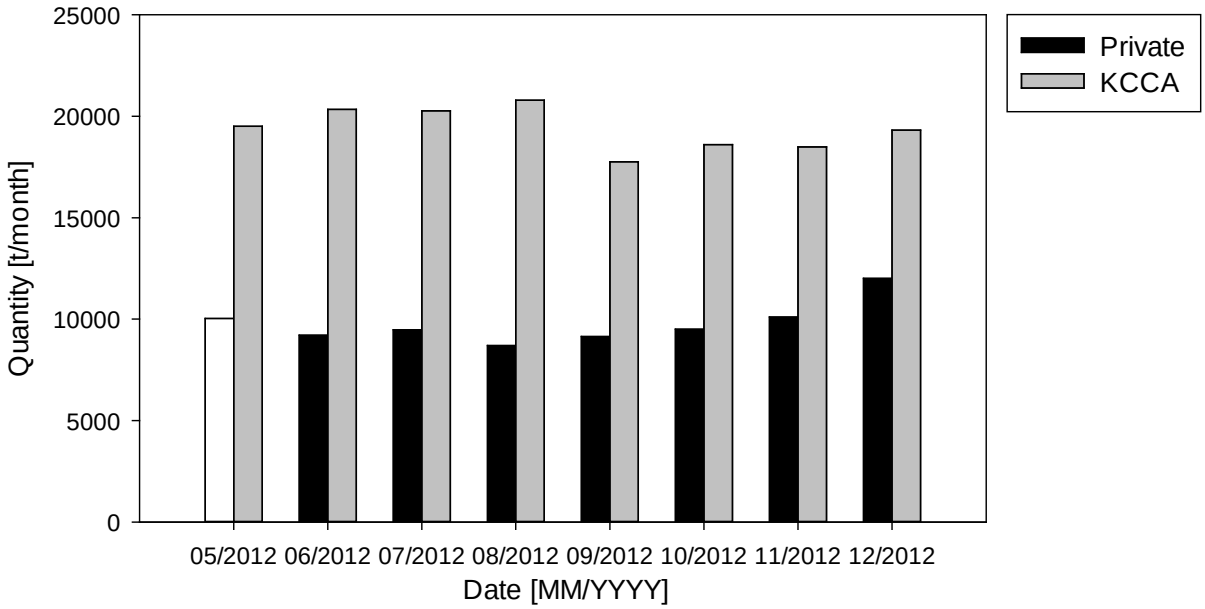

Figure 7: MSW collected and disposed of at the Kiteezi Landfill by private collection companies and KCCA [9]

WEEKLY

Table 5 presents the quantities of waste KCCA collects weekly within the different divisions of Kampala. It is apparent that the greatest amount of MSW is collected from Central Kampala. Table 6 summarizes both privately and publicly collected MSW.

Table 5: Weekly amount of MSW collected by KCCA from the 5 different division including statistical parameters [9]

Division	Average /t·wk^{-1}	SD /t·wk^{-1}	Min /t·wk^{-1}	Max /t·wk^{-1}
Central	1,273	249	329	1,696
Kawempe	701	141	171	955
Lubaga	756	150	216	1,017
Makindye	482	114	130	649
Nakawa	794	151	186	1,167

H/Q	302	105	90	629

Table 6: Weekly amount of MSW collected by KCCA and private companies and disposed of at the Kiteezi Landfill [9].

Collector	Average /t·wk^{-1}	SD /t·wk^{-1}	Min /t·wk^{-1}	Max /t·wk^{-1}
KCCA	4,308	737	1122	5,975
Private	2,171	392	569	3,003

3.5 Comparison

In Table 7 the data originating from the SWMS 2006 and collected from KCCA is compared with the findings of Kinobe et. al. While the SWMS data is calculated based on a production of 1 kg/person/day and a population size of 1,802,307 people, the KCCA and Kinobe et. al. results entailed the collection of primary data. Kinobe et. al collected the data between July 2011 and June 2012 and the data received from KCCA covers the time period between May and December 2012 Based on the consistency of the results of Kinobe et. al. with the calculations that were made based on the data that was received from KCCA, the accuracy is validated because they were collected during two different time periods.This also indicates that the quantities of collected waste are stable and haven't increased significantly between July 2011 and December 2012. All of the references also identify that the total amount of waste that remains uncollected is 60%. However, during an interview with officials at KCCA they estimated that only 40% remain uncollected [10]. Evaluating these figures in reality is difficult, because data about the quantities of waste that are delivered to the Kiteezi landfill do not necessarily mean that this is the only collected waste. As mentioned before, unlicensed private companies collect waste and dump it illegally, which means that some quantities of collected waste are not registered by the data obtained from the Kiteezi landfill. For the purpose of this report, a conservative estimate of 60% uncollected waste is used as to not overestimate the generation of MSW in Kampala.

Table 7: Summary of MSW quantities calculated from three different references.

<	SWMS 2006		Kinobe et. al.		KCCA	
Period	collected	uncollected	collected	uncollected	collected	Uncollected
Daily	720	1,080	945	1,418	943	1415
Monthly	21,600	32,400	28,350	42,525	28,290	42,435
Yearly	259,200	388,800	340,200	510,300	339,480	509,220
Total (yearly)	648,000		850,500		848,700	

3.6 Origin of waste

Figure 8 presents the proportion of MSW that is collected by KCCA within the different divisions. It again is apparent that most of the solid waste (30%) is collected from the central area. Around 51% of

the waste is collected from Kawempe, Lubaga and Nakawa together (each around 17%), while 11 and 7% get collected from Makindye and H/Q, respectively.

While Kawempe is the poorest of all divisions with a population of a 379,000, Central Kampala is the wealthiest of all districts with a population of around 127,600. Although Central Kampala only has half the number of residents that are living in Kawempe, the amount of MSW that is produced and collected is almost double. This can be explained by the fact that it is the hub of business activity and the transient daytime population is higher by multiple times [11]. In addition, low-income households generally produce less waste compared to high-income households, with an estimated average of 0.30 kg/capita/day and 0.66kg/capita/day, respectively [12]. Furthermore, it can be hypothesized that waste generated from low-income households has a higher proportion of biodegradable components compared to waste from high-income households and business districts. This can be explained by economic wealth, since more plastics and other non-biodegradable material are used in high-income households [13]. Different compositions of organic waste in addition to total quantities are very important to consider when it comes to the evaluation of certain feasible business models (e.g. compost or co-compost).

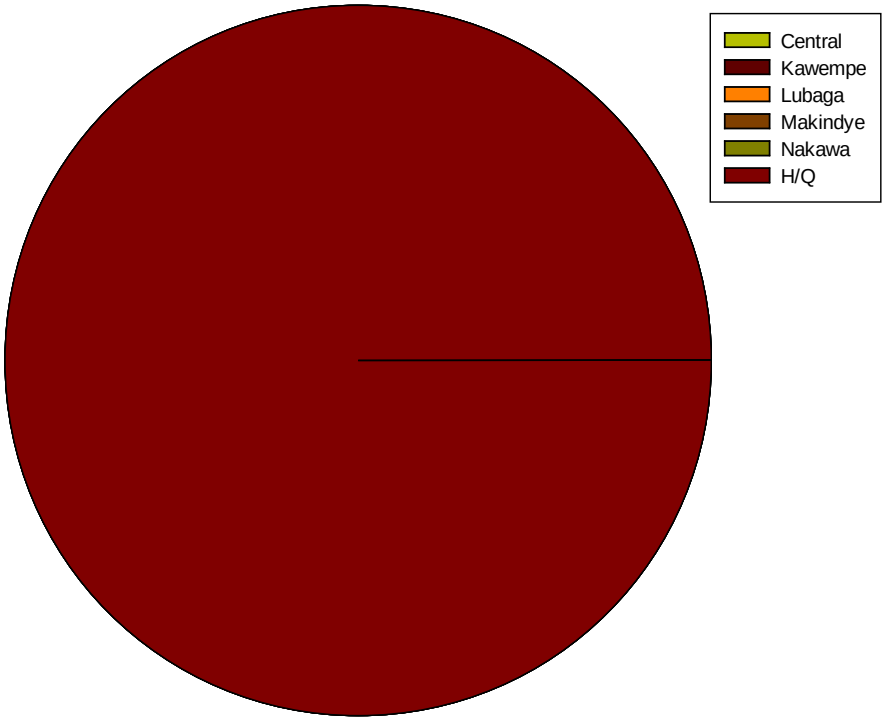

Figure 8: MSW, collected by KCCA, from the different Divisions in Kampala. Created based on raw data received from KCCA.

3.7 Waste collection system

MSW in Kampala is collected by KCCA and private collection companies. KCCA has installed decentralized temporary storage sites in order to decrease transport costs. Waste gets collected, is taken to a storage site and afterwards transported to the landfill by KCCA trucks. Kinobe et. al. studied and mapped out the waste collection system in Kampala in 2012 and have identified three types of storage sites within the city district within the city district [6]:

- Category 1: Legal temporary storage sites (demarcated by KCCA and collected)
- Category 2: Illegal temporary storage sites (not demarcated by KCCA but still collected)
- Category 3: Open dumpsites (Not collected. Often burned by a designated person)

The study identified a total of 227 storage sites, of which 133 belong to Category 2, 59 to Category 3 and 35 to Category 1. The fact that there are 59 open dumpsites around the city illustrates why such a high proportion of generated waste remains undelivered to the Kiteezi landfill, even though taken care of at the household level. Table 8 illustrates how the storage is distributed in the five different divisions of Kampala. Kawempe division has the highest amount of open dumpsites, resulting in a high quantity of uncollected waste. Furthermore, Kawempe is a low-income area and as mentioned before, waste originating from there has a high proportion of organics that are biodegradable. The fact that the waste remains largely uncollected could provide an opportunity to introduce a new collection system as part of a future business model.

Table 8: Open, illegal and legal dumpsites in the five divisions of Kampala, adapted from [6].

Category	Kawempe	Rubaga	Nakawa	Central	Makindye
Open	24	13	1	1	3
Illegal	57	21	15	21	19
Legal	8	6	14	6	1
Total	89	40	30	28	23

Figure 9 illustrates all of the dumping sites in Kampala. It is apparent that most of the sites are close to main roads and next to drains. Most of these dumpsites are illegal, although the MSW is still collected by KCCA. They are often very hard to access, which adds another challenge and level of complexity to the collection of MSW. Within the low-income areas several informal groups have started to collect MSW. However, it is still only practiced at a very low rate. The collectors receive money for collecting MSW but then dump the waste on illegal or open dumps. KCCA has started to sub-contract private collection companies which has shown to be very effective, but still leaves the problem that private companies work towards profit maximization and therefore only collect waste within higher-income areas that are able to afford a door to door collection service [6].

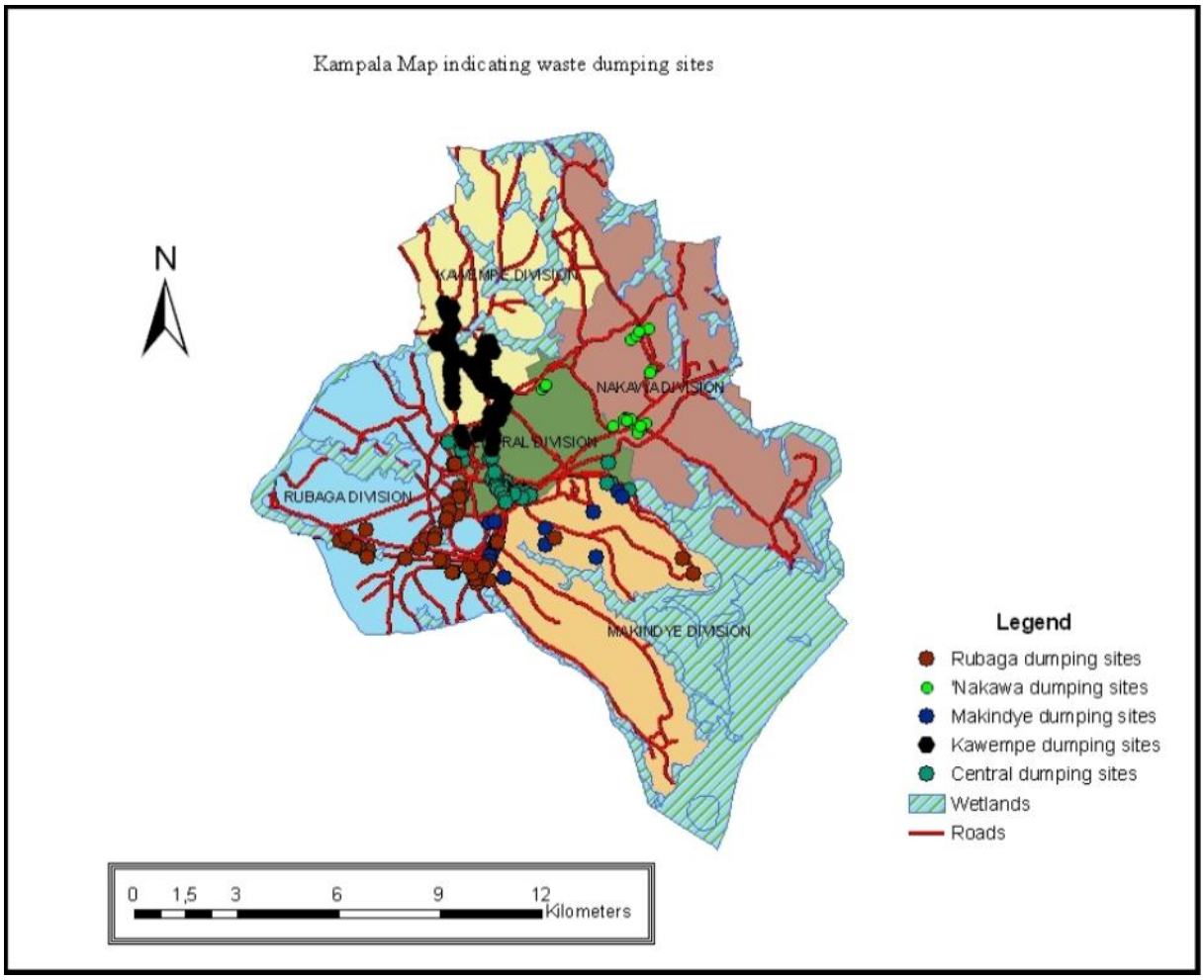

Figure 9: Mapping of dumping sites in the 5 divisions of Kampala. Created by [6].

In Kampala waste is collected from four different kinds of areas [6]. An average of 582 tons/day is from poor areas, 169 tons from high income areas, 105 tons from business centers and 90 tons from market areas. This results in a sum of 946 tons of waste per day, which also correlates with the values reported in Section 3.5

Four different types of areas were identified, with different characteristics of waste collection services [6]:

- Model 1: Households in low-income areas
- Model 2: High-income areas and Institutions
- Model 3: City center and business area
- Model 4: Markets, public parks, street sweepings, drainage channels

In Model 1 waste is stored and accumulated at the household until a quantity of around 30 to 50 kg is reached. The households brings the accumulated waste to a storage site, which in most cases is illegal, but as mentioned above still collected by KCCA trucks. This set-up is known as the “community self-loading system”, where it is the responsibility of the household to transport the waste to a temporary storage site [6].

The collection system of Model 2 differs in the sense that high-income areas and institutions are usually serviced by private collection companies, because the households are able to afford the service. Waste is stored on-site or brought to a legal dumping place and then collected on a daily to

weekly basis. Private collection companies provide the households with polythene bags for storage and collection [6].

Model 3 describes the waste management of the city center and business areas, where private companies are doing door-to-door collection service and have developed a system of color coded bags. Companies are distributing a waste collection bag, which has a specific color that indicates who the fees are paid for and therefore is responsible for the collection. In some cases this creates a challenge for KCCA when unreliable collection companies leave the waste uncollected or dump it at the next designated legal KCCA dumping place [6].

Model 4 describes the market places and other public areas. In total there are 13 big markets within the five divisions of Kampala. The waste management and collection is undertaken by KCCA, while the administrative unit of each division is responsible for its own markets. Waste from this category is of high value due to its large proportion of organic material, but un-effective management and communication often result in the waste not being collected [6]. Quantities and locations of market wastes are elaborated further in Section 4.

Most of the waste is collected from the low-income areas described by model 1. The reason for that is simply the fact, that most of Kampala's population is categorized as low-income. There are no official numbers of which percentage is in this category and due to the fact that the last census was in 2002 it is difficult to state the proportion in 2014. However, a map of all parishes and the respective income category exists and can be found in Appendix 10.6.

Table 9: Quantities of MSW, collected from the different areas (models) in Kampala[6]

Model 1 /t·mo^{-1}	Model 2 /t·mo^{-1}	Model 3 /t·mo^{-1}	Model 4 /t·mo^{-1}	Total /t·mo^{-1}
17,449	5,059	3,139	2,700	28,346
62	18	11	10	100

3.8 Fluctuation of waste

Figure 10 presents the fluctuations of waste that were delivered to the Kiteezi landfill over the time period between May and December 2012. Some data is missing from August 2012, which explains the data points showing very low or zero waste collection[10]. As shown in Table 4 the amount of MSW collected by KCCA and dumped at the Kiteezi Landfill is on average 633 ± 67 kg/d. The minimum value for the given time period was 307 and the maximum 795 kg/d. The waste collection rates are fairly stable despite some days with very low collection rates. This can be explained by missing data and/or holidays, where the collection of waste is less than during normal working days.

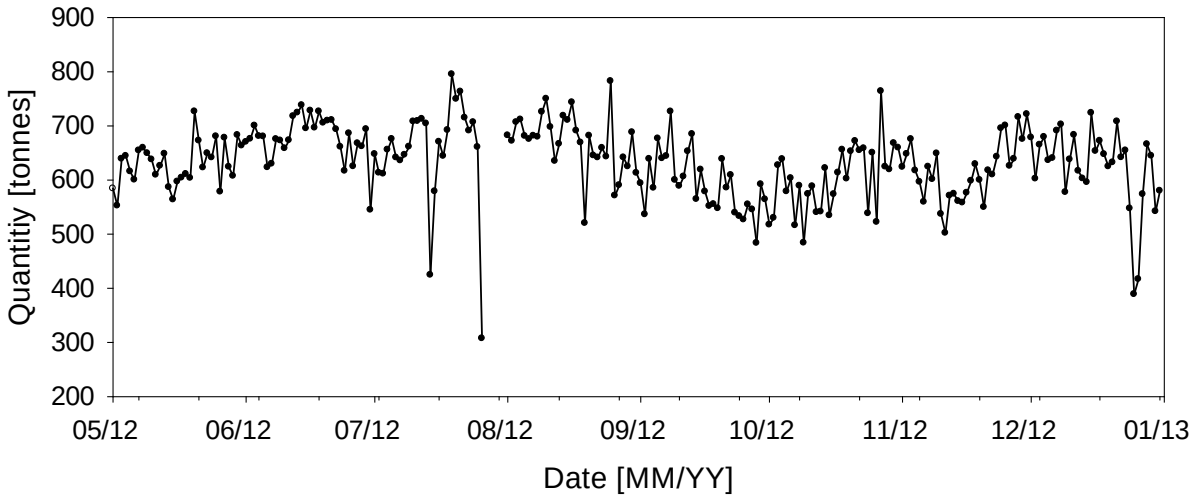

Figure 10: Daily amount of waste that gets collected by KCCA and dumped at the Kiteezi Landfill

3.9 Waste composition

Physical composition

Multiple studies have been conducted on the composition of MSW in Kampala, each with a different approach and methodology and location for sampling, which results in variable reported values. Solid waste differs from the point of source to the final dumping at the landfill. Also, income level and areas characterized as business, industrial and institutional areas have an influence on the solid waste composition. Household waste from low-income areas is higher in bio-degradable compounds compared to high income areas, while business industrial and institutional areas produce a higher amount of plastics and other non-biodegradable material [13].

A comprehensive study by Komakech et. al. has analyzed MSW that is dumped at the Kiteezi Landfill. This study gives the best overview of the characteristics of the waste that is actually collected and available for any type of RRR re-use option. The sample size ensured statistical validity, and the waste was mixed and homogenized when sampled, meaning it was representative. Furthermore, it is a challenge to characterize waste that remains uncollected. The characterization study was undertaken from June 2011 to July 2012, ensuring that both the rainy and dry season were monitored. MSW was sampled from trucks serving the different divisions, ensuring that all parameters that could influence the solid waste quality are covered [14].

The proportions of waste reported by Komakech et. al. are shown in Table 10. The fraction of organics and therefore biodegradable waste ranged from 90 to 95% within the five divisions versus another study that reported the proportion of organics at 74% with a much higher proportion of plastics, paper and cardboard (SWMS 2006). It can be hypothesized that over time waste pickers have identified the value of materials that can be recycled, like plastic and cardboard, and therefore sort out the waste before it arrives at the Kiteezi Landfill. Furthermore it was expected that the Central Division would generate a lower amount of organics compared to the other divisions, since it is the commercial and institutional district. This again is an argument for the fact that valuable products are sorted out before the waste is collected. Another important factor is that several markets are within the Central Division which might contribute to the high organic fraction [14].

Table 10: Waste composition of trucks that deliver MSW to the Kiteezi Landfill. Adapted from [14].

Division	Organic	Hard plastics	Metals	Papers	Soft plastics	Glass	Textiles& Leather	Others
	%	%	%	%	%	%	%	%
Nakawa	91.0	2.0	0.1	1.2	3.9	0.5	0.6	0.6
Makindye	95.0	1.1	0.1	0.7	2-0	0.3	0.3	0.6
Kawempe	92.9	1.6	0.1	0.7	3.2	0.7	0.3	0.5
Central	91.9	1.7	0.2	2.1	2.4	0.7	0.4	0.7
Rubaga	89.8	2.4	0.2	1.9	3.6	0.6	0.7	0.7

Chemical composition

As reported in Table 11 Kampala's MSW has also been characterized by the chemical composition including Moisture Content, Nitrogen, Phosphorous, Potassium and the Calorific Value [14]. This information is valuable for technical assessment when selecting the most appropriate technologies. Evaluating the results based on wet and dry months it becomes obvious that months with a total monthly rainfall above 150 mm not only have higher moisture content but also a lower mass of nutrients. Not only does the higher amount of rainwater and therefore moisture have an influence on the nutrient concentration but also the dry season is usually the time for harvesting crops. Therefore crop residues could have an impact on the nutrient mass within the MSW [14]. The composition of MSW was additionally characterized over the different divisions, and the results are reported in Appendix 10.3.

Table 11: Chemical composition of MSW in Kampala. Adapted from [12].

Month	Moisture Content /%	Nitrogen /g·kg DM^{-1}	Phosphorus /g·kg DM^{-1}	Potassium /g·kg DM^{-1}	CV /kcal·kg DM^{-1}
February[3]	67	1.85	0.3	3.14	3,886
April[4]	77	1.35	0.24	0.69	4,421
June[2]	72	1.86	0.24	2.54	4,227
July[1]	68	2.18	0.3	2.92	3,735
Aug 01	69	2.14	0.27	2.36	4,051
October[2]	75	1.4	0.24	0.61	3,976
December[1]	70	2.47	0.33	3	4,596
Mean	71	1.89	0.27	2.18	4,127

[3]Dry months. Total rainfall < 100 mm per month
[4]Wet months. Total rainfall > 150 mm per month

3.10 Further information

KCCA is currently undertaking studies to find the best mode of operation for the collection of MSW. They are re-evaluating the complete SWM service chain from collection to landfilling. Private companies collect the waste from middle- and high-income areas, because these households can afford the service fees. A list of all solid waste collection companies is included in Appendix 10.2. KCCA collects the solid waste from low-income households without charging service fees, as they see it as a service for the population. KCCA delivers 67% of all delivered MSW to the Kiteezi landfill. Some low-income Households do actually pay for the collection of their waste for an applied fee of around 1,000 UGX (=0.4 USD)[10].

Opportunities to use MSW for the production of compost and fertilizer appear to be good. KCCA is highly supportive of this idea. However, a unique plan for Kampala would need to be developed, which takes all constraints like affordability, access, rush hour traffic and distance into account. The executive director has the idea of placing a composting plant far outside of Kampala, since the demand for fertilizer lies at the farmer's level and not within the city [10]. Additionally, KCCA is investigating to find land for a new landfill since the current landfill is scheduled to reach its full capacity in approximately five years

3.11 Conclusions

These results indicate that theoretically there is currently 943 tons of MSW are available per day, as that is the amount that is delivered to a centralized landfill. The organic fraction that is available varies between 698 t/d and 896 t/d (depending on the source). The energy and nutrient recovery potential per kg dry mass MSW delivered to the Kiteezi landfill is presented in Table 12. The individual parameters are the mean figures of the results that are presented in the prior chapters. The ownership of this waste lies at KCCA and some kind of PPP agreement would be needed to implemented a business model that utilizes this waste.

Table 12: Nutrient and energy recovery potential from MSW delivered to the Kiteezi landfill.

Parameter	Unit	Quantity
Collected MSW	t/d	943
DM	t/d	272
N	kg/d	515
P	kg/d	75
K	kg/d	593
CV	GJ/d	4700

An assumption was made that 60% of the MSW in Kampala remains uncollected. If a business model was implemented that created a value for MSW, the daily amount that is collected and delivered to a site would potentially increase. Another option could be a business model that supports a private waste collection company with the capacity to treat the waste to recover nutrients or energy. Although locations of illegal dumping sites were evaluated, the characteristics are not well known and the waste remains at scattered throughout decentralized locations. These overall conclusions are summarized in Figure 11.

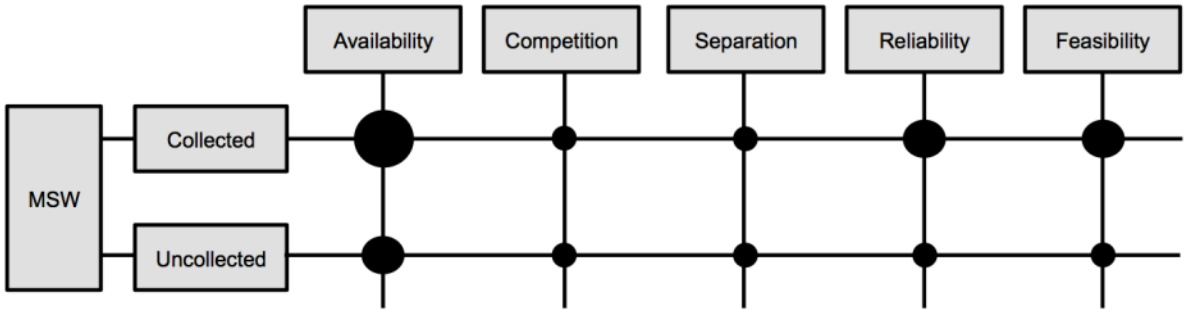

Figure 11: Rating of the feasibility of MSW as an input product for RRR business models

4. Market Waste

Presented in this chapter is MW as a fraction of the MSW that was analyzed in Section 3. This section focuses on the main food markets in Kampala, which have higher volumes of trade compared to small-scale community markets. Quantities and characteristics of MW and locations of markets are presented.

4.1 Main Food Markets in Kampala

Kampala has around 56 municipal food markets. A study by Kinobe et. al. identified eight locations (parishes) , which have at total of 13 main food markets. The largest food markets in Kampala are in the parishes of:

1. Nakasero
2. Kamokya
3. Nateete
4. Kiseka
5. Kalerwe
6. Nakawa
7. St. Balikuddembe (Owino)
8. Kasubi

The parishes of Kampala, market locations and market waste collection points are shown in Figure 12. In addition, the GPS coordinates of the markets are presented in

Table 13.

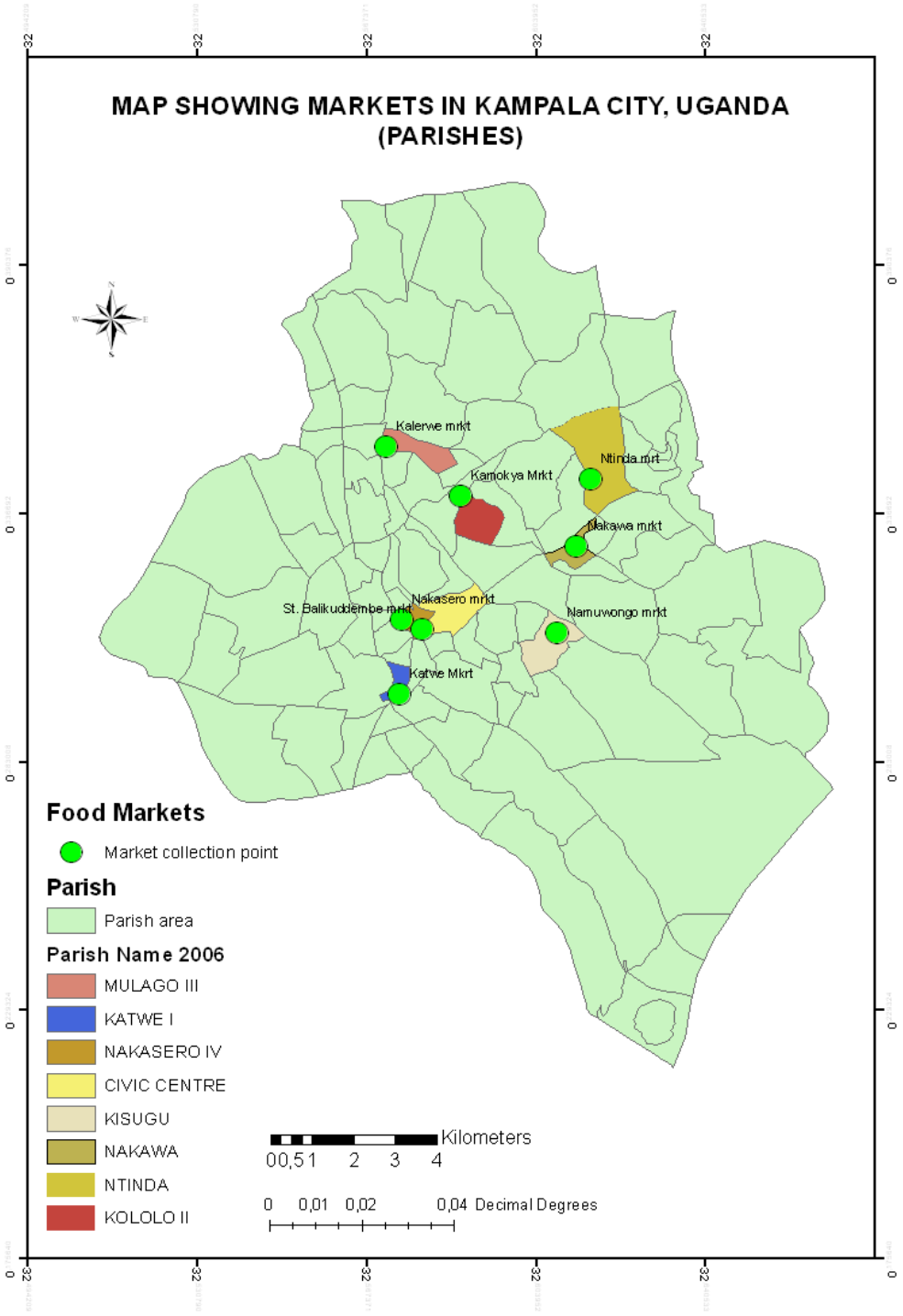

Figure 12: Markets and market waste collection points in Kampala. Provided by Kinobe et. al.

Table 13: Collection points of the different markets in Kampala. Provided by Kinobe et. al.

Point	Site	Northings	Easting
1	Nakasero Market	34448	453213
2	Nakivubo Apples Tower	34705	452706
3	Kalerwe Market	38840	452327
4	Kalerwe Market inside	38826	452376
5	Namuwongo Market	34375	456432
6	Katwe highland	32921	452652
7	Kamokya Market a	37638	454114
8	Kamokya Market	37685	454167
9	Ntinda Market	38062	457239
10	Nakawa Market	36502	456775
11	Nakawa Market a	36442	456906
12	Nakawa Market b	36405	456849
13	Nakawa Market c	36477	456951

4.2 Field visits

During this study, site visits were made to Nakawa, Nakasero and St. Balikuddembe to understand the waste management situation. At Nakawa market it was observed that waste is swept and heaped in piles, which are then collected by KCCA with wheel barrows at collection points in the market. The waste is then transported to a general collection point, where KCCA has placed two containers, each with a capacity of 9.4 tons. The waste is stored in these containers and regularly transported to the Kiteezi Landfill.

The market waste consists mainly of organic material, for example cassava peelings, green leaves, rotten food, pineapple stems, mango leaves, food baskets, maize covers and packaging paper. The collection scheme is the same for all 13 identified markets with the exception of Nakasero and St. Balikuddembe market. These two are denser with less land area. The waste is collected by the individual vendors, then packaged in sacks and taken to a collection point, where a container with the capacity of 8.2 tonnes is located at Nakasero market, while no such container could be identified at St Balikuddembe market (compare Figure 13).

Figure 13: Picture of an informal waste collection point at St. Balikuddembe market in Kampala in November 2013. Photo credit: Lars Schoebitz.

The waste that is collected from the markets by KCCA is taken directly to the Kiteezi landfill for disposal. However, market waste is a valuable product for animal feed and farming, and large quantities of the waste are removed by individuals for re-use purposes. At Nakasero market, for example, sacks of banana peelings and cabbage leaves are collected and mainly used as animal feeds. Many markets also have individuals collecting reusable perishables like onions, tomatoes and potatoes and other food items, which are either recycled into the market for sale, or taken home for personal consumption. Vendors and experts have mentioned several times that a trend occurred during the last years, where banana peels gained attraction by farmers as a use for animal feed and that almost all banana peels are reused these days. The current price for a bag of banana peels is: 4,000 UGX (1.60 USD). The bag is of the type, which is normally packaged with 100 kg of rice or maize meal. As the density of banana peels is not the same as of rice, it is difficult to tell the weight. Measuring products in bags instead of kg is a common practice at the markets in Kampala [1].

4.3 Daily production of market waste

During the site visits it was apparent that market waste was not collected more than once or twice a week. At Nakawa it had been four days since the last collection and the containers were overflowing, resulting in waste continuing to be dumped next to the containers in equal quantities to the capacity of the containers. This qualitative observation leads to an estimate of around 9.4 tonnes of market waste produced daily at Nakawa.

Table 14 presents data that was collected from KCCA, who recorded the quantities of collected market waste that was delivered to the Kiteezi landfill from six selected markets. Additionally, Table 15 presents the quantity of waste that was collected at St Balikuddembe and Kasubi market between January and June 2012 and delivered to the Kiteezi landfill. While the quantities of waste collected at St. Balikuddembe market were quite stable, it can be observed that the market waste collected at Kasubi increased over the year. The reason for this is unknown, but it could be due to Kasubi market being a trading center for major crops which are only grown during specific seasons of the year. Another possibility is that the value of a specific crop was observed and that it is now reused in some manner.

Table 14: Quantity of waste that was collected at six selected markets in Kampala during June 2012. (KCCA, 2012)

Division	Market	/t·mo^{-1}	/t·d^{-1}
Central	Nakasero	1020	34
Central	Kiseka	738	24
Central	Kamokya	207	7
Rubaga	Nateete	564	18
Nakawa	Nakawa	543	18
Kawempe	Kalerwe	897	29

Table 15: Quantity of waste that was collected at St Balikuddembe and Kasubi market between January and June 2012, two of the largest markets in Kampala. (KCCA, 2012)

Market	Month	/t·mo^{-1}	/t·d^{-1}
St. Balikuddembe	June	791	26
	May	729	24
	April	797	26
	March	814	26
	February	721	23
	January	729	24
Kasubi	June	684	22
	May	625	20
	April	528	17
	March	384	12
	February	331	11
	January	192	6

Table 16 Quantity of market waste delivered to Kiteezi Landfill between July and September 2013. (KCCA, 2013)

Month	/t·mo^{-1}
July	2803
August	2515
September	2104

4.4 Composition of the market waste

A study was conducted to analyze the characteristics of market waste from 60 markets[15]. Five markets were selected as being representative based on the quantity of waste generated and the spatial distribution in Kampala. The selected markets were Kibuye, St. Balikuddembe, Kalerwe, Nateete and Nakawa. Except St. Balikuddembe market, each of the selected markets were also located on a major agricultural produce supply route from rural areas to the city and its suburbs. It can be assumed that St. Balikuddembe market was selected because it is the biggest market in the Central Division of Kampala. The sampling was done over a 12-month period with one sampling

campaign per month. During the study several fractions of the market waste were analyzed for the major plant nutrients of total N, P and K [15].

Although this study is almost ten years old, the results are valuable as it is the only comprehensive study that has been conducted over an extended period of time. The results can be regarded as representative because the consumption habits have not changed significantly during the last ten years [16].

Physical Composition

The composition of the market wastes is presented in Table 17. 90 % was of crop origin dominated by banana residues (34%), of which banana leaves were 63%, pseudo stems 21%, peels and peduncles 9 and 7%, respectively. The remaining components were fruit wastes (16%), vegetable matter (14%) and maize (8%). Smaller quantities of bean residues (5%), sugarcane residues (4%) and sweet potato vines (4%) were identified as well as a mix of potato and cassava yams (3%).

The fraction of vegetable and fruit wastes also varied widely over the study period and among the different markets. A fraction of 2% of polythene was the main material that could be found among the non-biodegradables.[15].

By volume, Kalerwe market produced the highest amount of waste with a total of 1548 tonnes per month. This was followed by Nakawa and Nateete market with around 950 tonnes and lastly St Balikuddembe and Kibuye market with 754 and 444 tonnes, respectively. As shown in the previous section, these quantities are much higher than the quantities of 2013, meaning the volume of market waste are declining even as the city is growing. These results could be another indicator for more on-going re-use of market waste materials, or that more people are shifting from markets to shopping at supermarkets and malls.

Table 17: Market waste components and quantities at five markets in Kampala. Adapted from [15].

Market Component	Kalerwe /t·mo^{-1}	Nateete /t·mo^{-1}	St. Balikudembe /t·mo^{-1}	Kibuye /t·mo^{-1}	Nakawa /t·mo^{-1}	Total /t·mo^{-1}
Banana residues	528	489	288	176	439	1920
Vegetable waste	197	190	83	103	121	694
Maize residues	399	44	110	28	97	678
Fruits	149	116	187	29	131	612
Bean waste	64	86	43	41	27	261
Sugarcane waste	131	20	11	38	49	249
Sweet potato vines	80	23	32	29	78	242
Total	1548	968	754	444	942	4656

NPK Composition

Results of the NPK analyses as percent are presented in Table 18, and by annual mass in Table 19. The figures represent mean values for the five markets in the study. Vegetable waste had the highest N and P concentrations, while banana residues and vegetable waste had the highest concentration of Potassium. The results illustrate that large amounts of NPK are available that are not being utilized.

Table 18: Nutrient fraction in the major crop waste components across the study markets in Kampala. Adapted from [15].

Component	N % of total	P % of total	K % of total
Banana residues	1.22	0.19	3.98
Vegetable waste	2.32	0.27	3.67
Maize residues	1.16	0.16	1.21

Table 19: Nutrient content of major crop waste components per year in Kampala. Adapted from [15]

Component	N /kg·yr^{-1}	P /kg·yr^{-1}	K /kg·yr^{-1}
Banana residues	23,436	3,650	76,457
Vegetable waste	16,101	1,874	25,471
Maize residues	7,859	1,084	8,198
Total	47,396	6,608	110,126

4.5 Conclusions

The collected data reveals a high variation for MW quantities depending on the reference. Similarly to MSW, it was not always apparent if the studies were presenting the quantities of waste that are collected, or that are actually delivered to the Kiteezi Landfill. Quantities were evaluated for the 13 largest food markets in Kampala, and that value is between 2100 and 4656 tons/mo. Extrapolating this number to all 56 existing markets is difficult, as the size in proportion to large food markets is not known. The advantage of MW is the almost non-existent inorganic (2%) fraction. Therefore, the suitability for nutrient and energy recovery are high. It was identified that there is currently ongoing and increasing reuse of MW as a source for animal feed. This represents a competition for other uses of MW and gives the waste a value. KCCA ultimately owns the MW since they are responsible for the collection and treatment. If trucks that solely deliver market waste to the Kiteezi landfill could be identified, the recovery of nutrients could be feasible (e.g. composting, briquetting). Another feasible option is to arrange a PPP agreement with KCCA, which incorporates the collection and management of MW from selected markets. Figure 14 summarizes the overall findings.

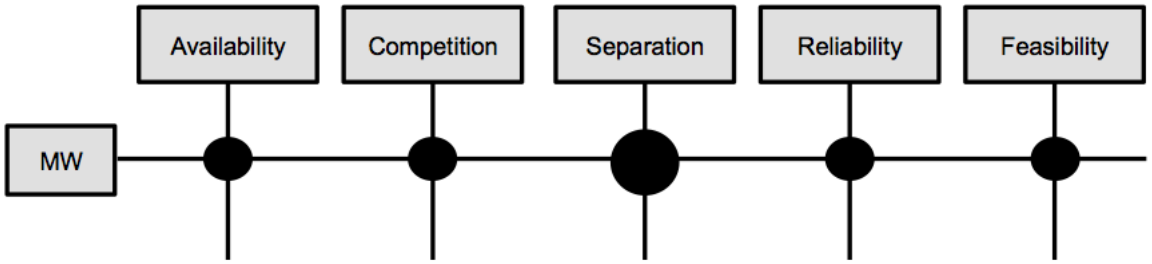

Figure 14: Rating of the feasibility of MW as an input product for RRR business models.

5. Wastewater Management

Covered in this section is the current status of wastewater management in Kampala, including treatment capacity and the influent and effluent characteristics of the largest WWTP in Kampala. Future plans for expansion of the WW infrastructure, and estimates of WW volumes for 2013 are also presented. Water management and irrigation in Kampala are presented briefly for their relevance to water reclamation.

Faecal sludge management comprising sanitation technologies that are not connected to the sewer are covered in the next chapter.

5.1 Stakeholders in wastewater management

NWSC developed the KSMP in cooperation with Beller Consult, Mott MacDonald and M&E Associates in 2004. This master plan lays out the future vision for sanitation including wastewater and faecal sludge management, infrastructure and technology development and implementation until the year 2030. At that time, a lot of in-depth analyses of the current sanitation situation was conducted for the KSMP. The analyses that were done are still the most comprehensive and reliable source of information regarding sanitation in Kampala. In 2008, a feasibility study of the KSMP was conducted and published as the Kampala Sanitation Plan (KSP). The KSP was carried out by Fichtner Water & Transportation and M&E Associates in collaboration with NWSC. Feasibility studies of different technical solutions for wastewater and faecal sludge treatment plants (e.g. Waste Stabilization Ponds, FS drying beds, trickling filter, etc.) were part of the KSP, as well as where to best place treatment facilities. As part of the KSMP in-depth analysis on the current usage of onsite sanitation technologies, and the transport and collection of faecal sludge were made, as well as the characterization of FS, which is covered in more detail in the next chapter. Up until now, these figures are what have been used to design and build treatment plants in Kampala.

5.2 Sanitation coverage

Based on data in the KSMP, Figure 15 shows a break-down of the types of sanitation technologies used at the household level and what percentage of wastewater goes to the sewer. Overall, 76,700, or 6.4% of residents of Kampala have flush toilets and are connected to the sewer, while around 240,000 or 17.5% of residents have a flush toilet that is connected to a septic tank. The most commonly used onsite sanitation technologies are pit latrines, which are used by approximately 950,000 or 69.8% of residents. Figure 15 does not distinguish between people that have lined VIP latrines and those that are using unlined pits. In 2004, 37,000 or 6.2 % of residents still had no access to sanitation facilities.

Within the framework of the KSP it was estimated that connections to the sewer had increased to 7.5% of Kampala's population [17]. No more recent data is available than the KSP.

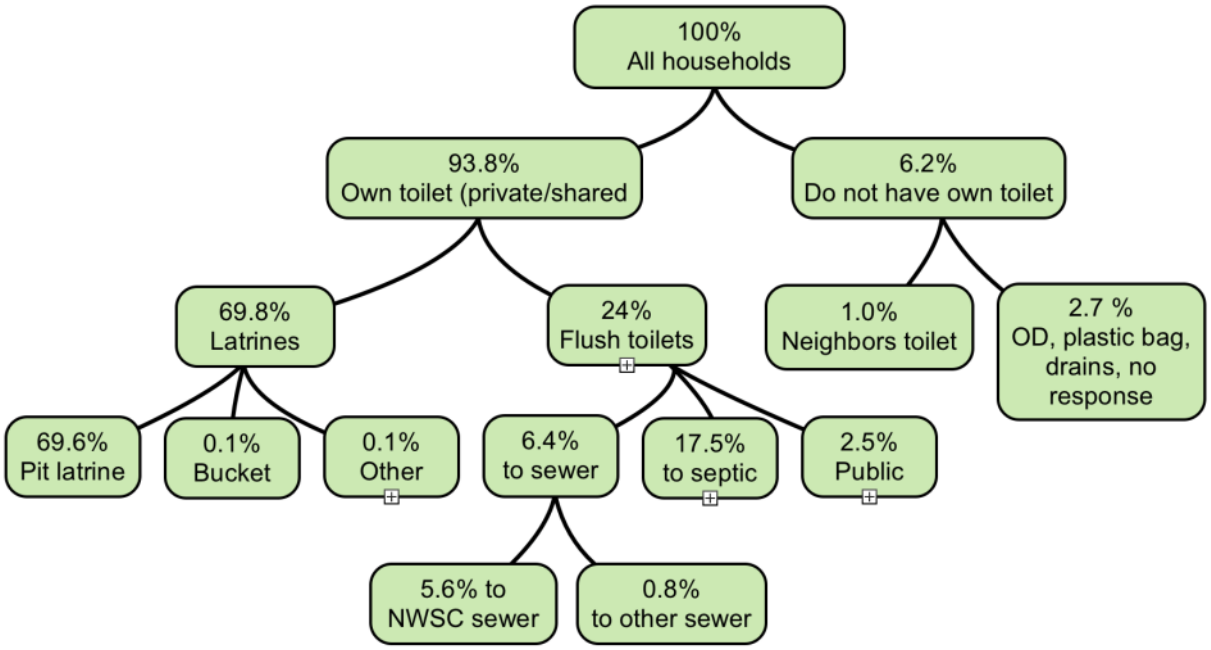

Figure 15: Breakdown of coverage of onsite sanitation technologies and wastewater management in Kampala. Adapted from [18].

5.3 Wastewater

5.3.1 Current treatment capacity

Kampala currently has three operating wastewater treatment plants (WWTPs), which are described in Table 20. The waste stabilization ponds (WSPs) in Naalya consists of two anaerobic, one facultative and one maturation pond and are able to treat 1000 m^3 of wastewater per day. The effluent is discharged to Naalya valley wetland, and there is no official end-use of treated wastewater. However, small-scale farmers have started to use the effluent for irrigation of agricultural crops.

The WSPs in Ntinda consist of one anaerobic, one facultative and one maturation pond, with the effluent going to a wetland and a treatment capacity of 1000 m^3/day. There is no official end-use of treated wastewater, but informal reclamation is common. Pictures of both WWTPs can be found in Appendix 10.8 and 10.9.

The Bugolobi WWTP is Kampala's biggest treatment plant with a capacity of 12,000 m^3/d. The treatment plant is currently not functioning well, due to broken settling tanks and an overload of solids from faecal sludge being discharged to the WWTP influent. This is a result of on-going construction at the site, with the faecal sludge settling tanks currently not being operational. Not all trickling filters are working and that the domes for anaerobic digestion have been decommissioned a long time ago. The effluent of the WWTP enters the Nakivubo Channel, which drains into Lake Victoria, causing health risks and eutrophication.

Table 20: Existing WWTPs in Kampala.

Location	Capacity in m^3/d	Technology
WWTP Bugolobi	12,000	Settling Tanks, Anaerobic Digestion, Trickling Filter
WSP Naalya	1,000	Waste Stabilization Ponds
WSP Ntinda	1,000	Waste Stabilization Ponds

5.3.2 Future plans

The KSMP and KSP provide detailed plans for the future of Kampala's wastewater management and increasing the sewer coverage of the city. In 2008, three new WWTPs were planned, two of the sites also with faecal sludge treatment plants. However, more recent information obtained through interviews indicates that plans have changed. The only treatment plant that is under construction now is the Lubigi WWTP with a capacity for wastewater of 5000 m^3/d and 400 m^3/d for faecal sludge. Plans for all other plants have been abandoned or postponed. During an interview with officials, the following information was gathered [19]:

- The treatment plant that was planned in Nakivubo will now be built at the existing site in Bugolobi and will be able to treat 45,000 m^3/d
- The existing Bugolobi WWTP will be rehabilitated and able to treat 11,000 m^3/d
- It is planned to extend the sewer network to cover 14% of the population within the next three years

Lubigi WWTP/FSTP

The process flow of the Lubigi WW and FSTP is presented in Figure 16. FS gets delivered by trucks, while WW flows into the treatment plant through a constructed sewer network. The first treatment step for FS is a screening to separate solid waste material from the semi-liquid influent. After that, two sedimentation and thickening tanks separate the liquid part from the settleable solid part. The thickened FS is pumped to one of the 19 covered FS drying bed. Each drying bed has its individual FS storage area, where the sludge. Similar to FS, the first treatment step for WW is a screening and grit removal. The WW flows into two anaerobic ponds and is co-treated with the liquid effluent of the FS thickening tanks. A third anaerobic pond was constructed to ensure the treatment capacity while desludging one of the other two anaerobic ponds. The WW sludge is pumped to uncovered WW sludge drying beds and after drying stored at the dried FS storage area. The effluent of the anaerobic ponds flows into two facultative ponds and the accumulated WW sludge is managed the same way as described for the anaerobic ponds. The treated liquid effluent of the facultative ponds then flows into the Lubigi channel. Currently, no plans exist for the end use of dried WW and FS. As of November 2013 the WWTP was still under construction, including the sewer network and household connections. It is planned that the WWTP will be commissioned by March 2014. Figure 17 shows photos of the on-going sewer line construction works. Photos of the construction works of Lubigi WWTP/FSTP are presented in Appendix 10.10

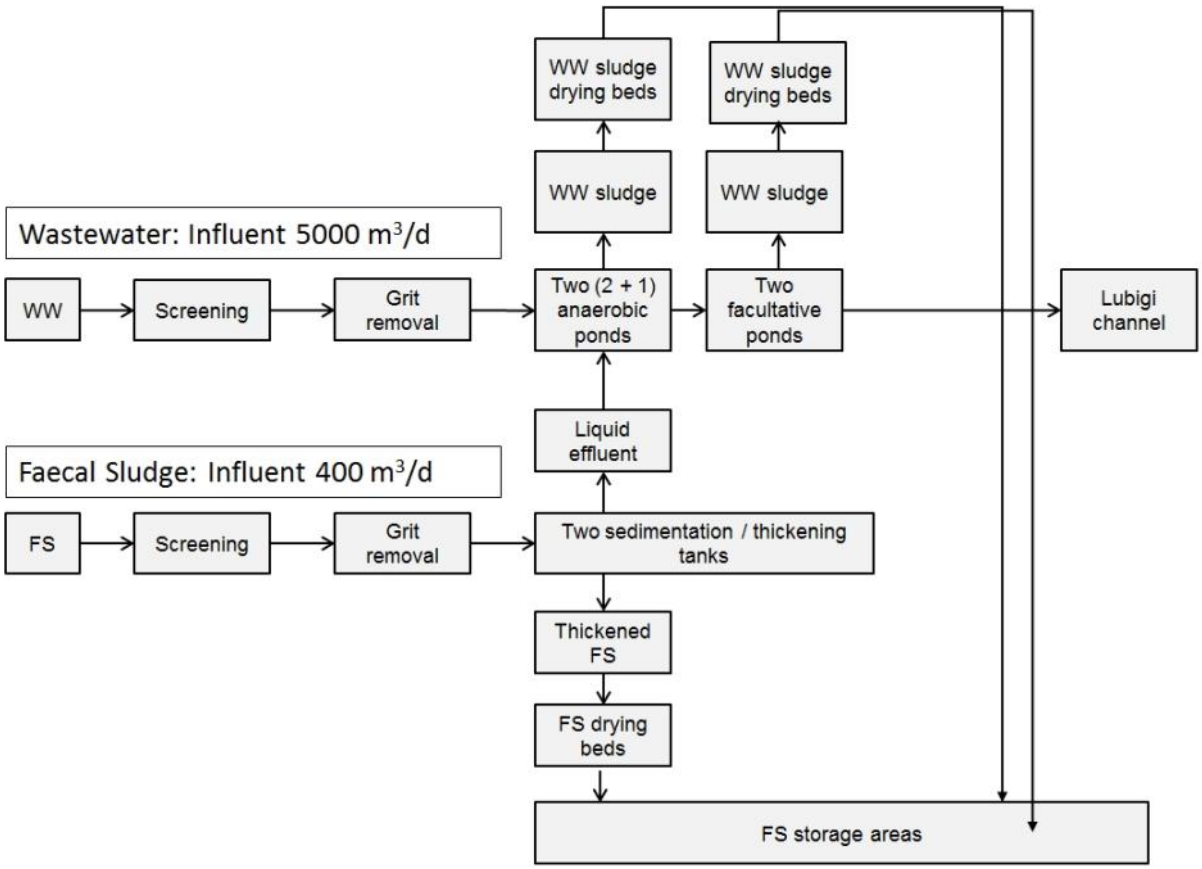

Figure 16: Process flow of the Lubigi WW and FSTP under construction.

Figure 17: Construction of sewer lines in Kampala. November 2013. Photo credit: Lars Schoebitz

5.3.3 Quality of treated wastewater

Characteristics of the treated wastewater from the Bugolobi WWTP are presented in Table 21. The values are for between January 2012 and March 2013 with a total sample number of 51 samples, performed by weekly sampling. As the treatment plant is not fully functional, the effluent values are above discharge limits and recommended values for reclamation in agriculture.

In Table 22 the total average over the whole time period is presented and compares the effluent values with the effluent discharge regulations that were defined by the National Environmental Act of 1999. The results verify that the treatment plant is not fully operational. The average influent concentration of PO_4 during 2012 was consistently less than 10 mg/L, whereas the values for 2013

increased to 30 mg/L. Raw domestic wastewater in low- and middle-income countries typically has values from 4-15 mg/L [20]. Although discharge standards for PO_4 were the only that were met, the discharge limit in Uganda of 10 mg/L is high compared to discharge limits in Europe (e.g. Germany 1 to 2 mg/L [21]). This poses a threat on the environment, since high PO_4 concentrations in water bodies cause eutrophication (compare Figure 18).

Figure 18: Water pollution at Miami Beach, Lake Victoria, Kampala. March 2013. Photo credit: Lars Schoebitz

The NWSC treatment plant for drinking water provision is located in Gaba, which is situated only about four km from the location where the Nakivubo Channel which carries the effluent of the Bugolobi WWTP enters the lake. This increases the treatment costs linked to the provision of safe drinking water. It is planned to rehabilitate the Bugolobi WWTP in order to meet the discharge limits[19, 22].

Table 21: Treatment performance of the Bugolobi WWTP between January 2012 and March 2013. (NWSC, 2013)

Parameter	Year 2012[5] /mg·L^{-1}	Year 2013[6] /mg·L^{-1}	Total Average /mg·L^{-1}	Total std. dev. /mg·L^{-1}
BOD influent	369	520	408	137
BOD after prim. treatment	254	240	250	103
BOD after second. treatment	152	128	146	74
BOD effluent	108	85	102	66
Removal efficiency	**71**	**84**	**75**	**-**
COD influent	691	1119	800	327
COD after prim. treatment	512	526	515	244
COD after second. treatment	333	267	316	201
COD effluent	240	177	223	172
Removal efficiency	**65**	**84**	**72**	**-**
NH3 influent	26	60	34	22
NH3 after prim. treatment	19	62	30	22
NH3 after second. treatment	13	49	22	18
NH3 effluent	9	45	19	19
Removal efficiency	**65**	**25**	**44**	**-**
TSS influent	344	436	368	203
TSS after prim. treatment	185	399	207	128
TSS after second. treatment	113	219	140	75
TSS effluent	82	152	100	57
Removal efficiency	**76**	**65**	**73**	**-**
PO4 influent	10	24	13	7
PO4 after prim. treatment	8	23	11	7
PO4 after second. treatment	7	15	9	5
PO4 effluent	6	12	7	4
Removal efficiency	**78**	**50**	**73**	**-**

Table 22: Wastewater effluent values compared with local discharge limits. (NWSC, 2013)

n=51 Parameter	Total Average /mg·L^{-1}	Discharge limit /mg·L^{-1}
BOD effluent	102	50
COD effluent	223	100
NH3 effluent	19	10
TSS effluent	100	100
PO4 effluent	7	10

[5] weekly sampling, n=39
[6] weekly sampling, n=12

5.3.4 Quantity

Although only 6.4% of the population of Kampala is estimated to be connected to the sewer, a substantial amount of wastewater is generated daily. Based on a forecast for 2013 for the KSP, it was estimated that daily around 64,294 m^3 are generated. Table 23 shows a breakdown of the districts where the wastewater is coming from. About 2/3 of the daily produced wastewater is domestic wastewater, while the remaining wastewater comes from institutional, commercial and industrial sources. These calculations are based on many assumptions but are considered to be reasonable estimates.

Table 23: Wastewater generation forecast for 2013 based on KSP 2008 [17].

Origin Unit	Domestic /m³·d^{-1}	Institutional /m³·d^{-1}	Commercial /m³·d^{-1}	Industrial /m³·d^{-1}	Total /m³·d^{-1}
Central	3,141	664	8,246	1,877	13,928
Kawempe	7,235	1,344	0	400	8,979
Makindye	11,140	968	742	235	13,085
Nakawa	11,132	2,144	350	5,453	19,079
Rubaga	6,708	1,672	0	842	9,223
Total	39,357	6,792	9,338	8,807	64,294

5.4 Irrigation and water management in agriculture

The climate of Uganda is equatorial with regional variations in annual temperature, humidity and rainfall. Precipitation varies from 750 mm/yr in the northeast to 1,500 mm/yr in high rainfall areas. Kampala's annual average rainfall is around 1,200 mm/yr, while the southern/central part of the country receives heavy precipitation with two rainfall peaks in March-May and August-November with no pronounced dry season in between [23] .

In 2002, 30% of the total area of Uganda was cultivated. 70% of the total cultivated area was arable land and 30% under permanent crops. The total water withdrawal in 2002 was 300 million m^3, of which 120·million m^3 where used for irrigation and livestock. This corresponds to 0.5 % of the actual renewable water resources [23].

Different methods for irrigation exist and can range from small-scale irrigation with buckets in urban farming to large-scale mechanical irrigation systems. The total water managed in 1998 was 0.8% of the total cultivated area [23]. The Uganda Census of Agriculture 2009 reports that irrigation was practiced by less than one percent of the agricultural households, implying that irrigation in agriculture is mainly through rainwater [24].

5.5 Conclusions

The estimated quantity of treated WW in Kampala in 2013 was approximately 64,000 m^3/d, of which 40,000 m^3/d originated from domestic sources. Nevertheless, the WW is mixed domestic and industrial WW, which has an effect on the suitability of using treated WW or sludge for agriculture depending on the level of treatment. The current WWTPs generate a total effluent quantity of 14,000 m^3/d, which currently is discharged into wetlands and channels, and finally into Lake Victoria. With the current configuration of treatment plants, the effluent is difficult to access, which could be a problem for reclamation of the WW. In addition, informal reuse is already being practiced which would create competition for the effluent. Ongoing and current projects are increasing the WW

infrastructure, including treatment plants and sewer networks.. If WW reclamation is to occur in the future, the time to think about it is now, as the associated infrastructure would need to be included in the plant design and construction. NWSC currently has no plans for the implementation of WW reclamation. The accessibility for treated WW is low, as farmers are located far away from the location of the WWTPs and the water would need to be piped long distances. Almost 99% of the cultivated area in Uganda is irrigated by rain water. Therefore it can be expected that treated WW does not have a high market demand. An option for the implementation of RRR business models could be to have partially treated WW, providing a safe product in terms of pathogen removal, but only partially remove the nutrients from the WW (e.g. Anaerobic Baffled Reactors). The findings of this chapter are summarized in Figure 19.

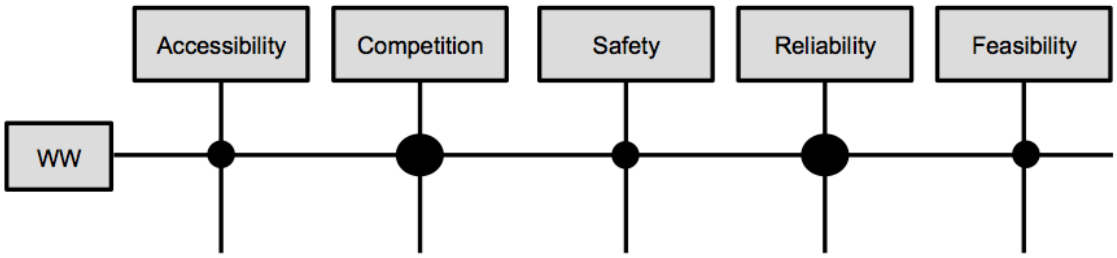

Figure 19: Rating of the feasibility of WW as an input product for RRR business models.

6. Faecal Sludge (FS)

This chapter contains information on FS generation, collection and logistics of transport. The distribution of types of OSS technologies and characteristics and quantities of FS are presented.

6.1 Introduction

As shown in Figure 15, 93.6% of the population of Kampala is served by on-site sanitation (OSS) systems [17]. In this report, OSS refers to all sanitation technologies that are not connected to the sewer system. In general, in Kampala these technologies are VIP latrines, unlined pit latrines, septic tanks, Ecosan toilets and Urine Diverting Dry Toilets (UDDT). Ecosan toilets, VIP and unlined pit latrines are typically dry systems without a flush, whereas septic tanks systems typically do have a flush toilet. The management of FS from OSS systems is a major challenge in Kampala, as they are typically built without consideration of how they will be emptied once they get full. They are also frequently difficult to access for collection and transport trucks due to narrow alleys and pathways in informal settlements. Furthermore, the FS from dry and flush systems have different characteristics due to the dilution with flush water. An entire Faecal Sludge Management (FSM) service chain is needed for the sustainable management of FS.

6.2 FS Quantification

Information provided in 2004 the KSMP on the number and /or types of OSS in Kampala provide the most up-to-date information that is available. Quantifying FS in Kampala is very difficult, and hence current values have been forecast for 2013 based on these values, as illustrated in Table 24. Accurate information on quantities and characteristics is very important for the appropriate design of any FS treatment or processing technology. As part of the KSP a demand and forecast assessment for FS quantities and characteristics was conducted. It is based on a step-by-step approach, which is explained in detail in Section 4 of the KSP 2008. This section highlights the main outcomes of the assessment.

Several basic assumptions were made in order to calculate the amount of FS that will be produced in Kampala until the year 2033. These assumptions include:

- Population forecast
- Urban development forecast
- Land-Use distribution
- Water demand assessment
- Wastewater generation forecast

The methodology for the FS production and characteristics includes:

- Assessment of Distribution of on-site sanitation systems
- Assessment of FS production and characteristics
- Assessment of FS collection rate

This information was then used to calculate the current and future volumes and characteristics of FS that will need to be collected, transported and treated at FS treatment facilities.

The following sections present the resulting numbers, and then validate the information with collected primary data.

Current distribution of OSS systems

As part of the KSMP, a detailed household survey was carried out to assess the existing situation of OSS usage with 10,000 households in 2003. Based on this, assumptions were made for the existing land-use distribution. OSS facilities that were considered are the following:

- Septic tank
- VIP latrine
- Pit latrine (unlined pit)
- Raised pit latrine
- Public toilet
- Other (bucket latrine, plastic polyethylene bags (kavera) and open defecation)

As shown in Figure 15 in Section 5.2, these systems account for 93.6% of the population of Kampala. The types of systems are fairly well correlated to income categories and land-use distribution. The results of this analysis are presented in Table 25.

FS accumulation and collection

Assumptions were made for what the FS accumulation rates are for the different types of OSS. These could be used together with the distribution of types of systems in Table 25 to determine the total quantity of FS generated in Kampala. The results of this evaluation are presented in Table 24. The forecast for 2013 for accumulated and collected FS was 742 and 369 m^3/d, respectively. The collection rate of FS was estimated with records of NWSC and by evaluating the trips that were made by FS collection trucks of the PEA.

Table 24: Use of OSS, accumulation and collection rate of FS in Kampala in 2013. Adapted from [18].

2013 System	OSS usage /%	Acc. Rate	Collect. Rate
Septic tank	27.6	375	228
VIP latrine	26.1	130	56
Pit latrine	36.9	135	28
Pit latrine raised	5.4	40	4
Public Toilet	2.8	62	53
Other	1.2	-	-
Total	**100**	**742**	**369**

Table 25: Distribution of OSS use in the year of 2013. Created by [18]

Description			Sanitation System Unsewered Area					
			Septic tank	VIP latrine	Pit latrine	Pit latrine raised	Public toilet	Other
			[%]	[%]	[%]	[%]	[%]	[%]
Residential	High income - Low density		75%	20%	5%	0%	0%	0%
	Medium income - Medium density	Valley / areas 1-2	40%	30%	25%	5%	0%	0%
	Medium income - Medium density	Hill / areas 3-4	40%	30%	30%	0%	0%	0%
	Low income - High density	Valley / areas 1-2	20%	35%	40%	5%	0%	0%
	Low income - High density	Hill / areas 3-4	20%	35%	45%	0%	0%	0%
	Informal settlements	Valley / areas 1-2	5%	20%	40%	25%	5%	5%
	Informal settlements	Hill / areas 3-4	5%	20%	65%	0%	5%	5%
	Peri-urban area	Valley / areas 1-2	15%	25%	55%	5%	0%	0%
	Peri-urban area	Hill / areas 3-4	15%	25%	60%	0%	0%	0%
	Institutional residential		30%	35%	30%	5%	0%	0%
	Institutional		70%	20%	0%	0%	10%	0%
	Commercial		75%	10%	0%	0%	15%	0%
	Industrial		75%	25%	0%	0%	0%	0%

FS Characteristics

A FS characterization study was also undertaken as part of the KSP, the results are presented in Table 26. For the characterization study, 82 samples were taken during the emptying process of the FS collection and transport trucks. The following conclusions were made, which are also consistent with available literature [17].

- FS from septic tanks is more dilute than FS from latrines, especially for TS, ammonia and phosphorous
- There is no significant difference between the characteristics of VIP latrines and raised VIP latrines
- Public toilet sludge has characteristics typical of relatively fresh “high strength” sludge, especially for COD, ammonia and phosphate concentrations. However, in this study the TS, TVS content and the BOD concentrations were lower than expected. Also, some of the VIPs had similar characteristics to public toilet sludge, which could be explained by a high emptying frequency
- The FS was generally well stabilized with a TVS content ranging from 40% to 55%, except for sludge from VIP latrines which was in the range of 70 to 73%

Table 26: Characteristics of FS delivered to the Bugolobi WWTP. Analyzed by and adapted from [17]

Parameters	Unit	Septic tank	VIP latrine	Pit latrine	Pit latrine raised	Public toilet
TS	mg/l	22'000	30'000	40'000	30'000	35'000
TS	% TS	2.2%	3.0%	4.0%	3.0%	3.5%
TVS	mg/l	9'900	19'500	18'000	18'000	24'500
TVS	% TS	1.0%	2.0%	1.8%	1.8%	2.5%
TVS	% of TS	45%	65%	45%	60%	70%
COD	mg/l	10'000	30'000	35'000	30'000	30'000
BOD	mg/l	1'400	5'500	5'000	5'000	6'000
COD / BOD	-	7.14	5.45	7.00	6.00	5.00
TKN	mg-N/l	1'000	3'400	5'000	3'400	3'750
NH_4^+	mg-N/l	400	2'000	2'500	2'000	3'000
TP	mg-P/l	150	450	500	450	400
HE	no./l	4'000	30'000	40'000	30'000	30'000
FC	no./100 ml	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05

6.3 Logistics and finances of FS transport

Logistics

The PEA is a professional organization of FS collection and transport companies in Kampala. Being the main responsible party for the collection and transport of FS, they have the best overall understanding of the logistics of FS transport. The following section is based on an interview with members of the PEA [25]. In total, there are 110 members of the PEA with 45 trucks, and 75% of all collection and transport FSM businesses in Kampala belong to the association. In addition to the PEA,

KCCA also has seven trucks, of which six are currently operating. There are also two schools in Kampala that own and operate their own trucks. Other trucks that do not belong to the PEA include a hotel, the army, the police and two private companies each with one truck.

Finances

The Bugolobi WWTP is the only legal place in Kampala for the discharge of FS. It is maintained by the NWSC, and they charge a fee for the discharge of FS depending on the volume of the truck. When FS collection and transport trucks arrive at Bugolobi, they pay the discharge fees, which are registered in a logbook by NWSC. Furthermore, truck drivers are able to pay the fees by cash or mobile money (e.g. MPesa). This is the only record that NWSC keeps of the incoming trucks

The 45 trucks that are members of the PEA are all owned by private companies. Business owners usually buy imported vacuum trucks from overseas, and then hire a truck driver and a helper. There are around ten truck drivers in Kampala that own and operate their own trucks. The owner of the truck is responsible for all major costs and services (e.g. tires, vacuum pumps, hosepipes, etc.). For members of the PEA an example of a typical distribution of funds for collection and transport operations are:

- Total emptying fee paid by the household: 180'000 UGX (= 72 USD)
- Fraction to driver for services: 10'000 (= 4 USD)
- Fraction to PEA for membership: 10'000 (= 4 USD)
- Fraction to NWSC for discharge fee: 10'000 (=4 USD)
- Fraction for fuel costs: 40'000 (16 USD)
- Fraction to owner of truck: 110,000 (44 USD)

The driver is paid on a per emptying basis, they are not paid a salary in addition to this commission. When the owner of a truck registers it with the PEA they pay a onetime registration fee in addition to the per emptying fee. This fee is 650,000 (260 USD) UGX for trucks that are larger than 5 m^3 and 400,000 UGX (= 160 USD) for trucks smaller than 5 m^3. The business owner can also hire truck drivers through the PEA for additional 7'000 UGX/week. These fees are the only revenue stream of the PEA, and the directors work on a voluntary basis. The fees go for health insurance and maintaining the infrastructure of the PEA. All members of the PEA have free monthly health exams, vaccinations, and financial insurance for their families in case they get sick or die. Although workers are responsible for their own protective gear. As a result, most workers not protect themselves and are exposed to high health risks. Micro-credits are also given to truck owners in case the trucks need to be repaired, although members of the PEA typically have adequate mechanical knowledge to repair the trucks and so they usually do not need to go to repair shops.

The fees that are charged for emptying at the household level are calculated based on the cost of fuel, depreciation of equipment, and the overall time that is required for the operation. All FS collections within a five mile diameter of Bugolobi are typically a standard price, while everything outside this diameter has increasing fees. Other factors that determine the emptying price include accessibility, number of trips to empty the system, size of the truck, volume of sludge emptied, and the type of OSS that is emptied. No difference in fee structure exists for low-, middle- or high-income households; they are all charged the same fee. Frequently low-income households cannot afford the emptying service, and as a result in informal settlements FS typically is emptied manually directly into the environment.

As an example, presented in Table 27, is the typical fee structures for collection and transport of FS. This information is based on the records of the PEA and is a total of 444 m^3 per day, which is greater than the 200 and 300 m^3 reported by NWSC indicating that much more FS is delivered than previously thought.

Table 27: Daily collected Faecal Sludge and created revenues from trucks operated by the Pit Emptier Association. The number of two trips per day is an estimated average per truck.

				FEES			
Capacity /m^3	**Number of trucks -**	**Trips per day -**	**Sludge collected /m^3*d^{-1}**	**VIP latrine /UGX**	**Unlined pit /UGX**	**Septic tank /UGX**	**Revenue /UGX*d^{-1}**
1.8	2	2	7.2	70'000	120'000	70'000	346'667
2.5	1	2	5	80'000	150000	80'000	206'667
2.7	3	2	16.2	90'000	170'000	90'000	700'000
3	2	2	12	100'000	180'000	100'000	506'667
4	25	2	200	120'000	200'000	120'000	7'333'333
4.5	1	2	9	140'000	230'000	140'000	340'000
6.5	2	2	26	180'000	300'000	180'000	880'000
7.2	2	2	28.8	180'000	300'000	180'000	880'000
10	7	2	140	180'000	300'000	180'000	3'080'000
42.2	**45**	**18**	**444.2**				**14'273'333**

End use of FS

Currently, 100% of the FS that is collected by the PEA is delivered to the Bugolobi FSTP. The PEA would like to develop the use of FS for agriculture, but this will require education as there is currently low acceptance by farmers. Direct application of FS in agriculture is not practiced and is not legal. By law, the sludge has to be discharged at the FSTP.

Challenges

The sludge from unlined pits is often very compacted and needs to be diluted with water in order to remove the FS. Solid Waste inside the pits is separated during the emptying procedure with the use of rakes. Solid waste in pits is pervasive, and is problematic for the PEA because it blocks their hosepipes and can destroy their vacuum pumps. Compacted FS is also common at the bottom of septic tanks. When this occurs, this FS is removed manually with shovels.

Another challenge faced by truck owners is the supply of spare parts, especially vacuum pumps. The parts are usually imported from Japan or Dubai because the hosepipes that are sold locally are of very poor quality and often break. Importing spare parts is slow and can take up to three months.

6.4 NWSC data

NWSC maintains records of the trucks that discharge FS at the Bugolobi FSTP. Each truck enters the treatment plant through a gate and has to pay a fee depending on the volume of the truck's tank. The records presented in Table 28 are for the number of trucks in January to June 2013. The daily average volume of FS that NWSC reports is delivered to the WWTP is 238 ± 32 m^3/d. This number correlates

with other sources such as the KSMP 2004 and the KSP 2008, but shows discrepancy in comparison to values reported by the PEA.

Table 28: Weekly number of trips and average quantity from data records of NWSC.

Week No.	Trips Sum	Average Quantity /m^3*d^{-1}
1	338	251
2	480	264
3	480	269
4	403	227
5	452	246
6	509	272
7	484	266
8	517	274
9	548	279
10	466	245
11	516	271
12	504	272
13	404	234
14	28	236
15	-[7]	225
16	-[7]	279
17	-[7]	225
18	266	233
19	491	223
20	550	264
21	481	228
22	408	199
23	323	184
24	405	212
	Average	238

6.5 Truck counting study

Due to the discrepancy in the above reported values of FS that is delivered daily to Bugolobi, a truck counting study was conducted to verify the values. To also learn more about the origin of FS that is delivered, the source and volume of FS from each truck was also collected. The weeklong study was conducted twice to verify the results, once between the 15th and 21st of April 2012 and the second time between the 6th and 12th of May 2013.

[7] Data was not available

6.5.1 Methodology

Interviews were conducted with truck drivers at the entrance to Bugolobi when they arrived to discharge FS. A questionnaire was developed to determine factors such as source of FS, age of FS, type of OSS, etc. FS was collected from single and multiple households, public toilets, institutions, industries, hotels and restaurants. The full questionnaire can be found in Appendix 10.11. The value on the FS volume gauge on the back of the truck was recorded, and drivers were asked whether or not their tank was full. The recorded volumes in this study are based on those values, and actual volumes were not measured.

6.5.2 Results

The study results are presented in Figure 20. The results for the first and second weeks were very similar, indicating that they are representative. During week 1 a total amount of 4,030 m^3 FS was delivered to Bugolobi, and during week 2 4,055 m^3, which represented 780 trucks week 1 and 812 trucks week 2. The volume of FS is lower on Sundays because Bugolobi is only open until 1 PM on Sundays. These results indicate that the volume of FS reported by KCCA and the PEA are actually much lower than the volumes that are in reality being discharged.

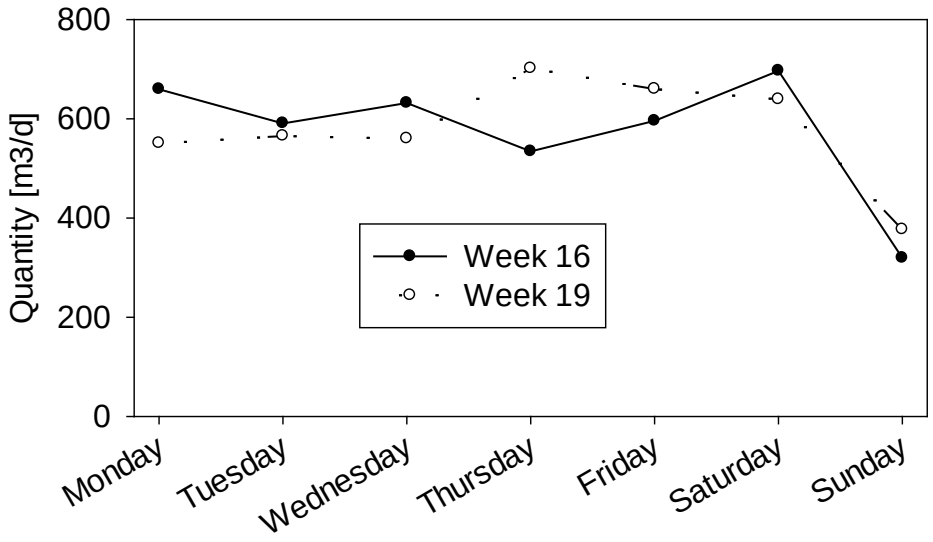

Figure 20: Amount of sludge collected daily during week 16 and 19 in 2013.

Types of OSS systems

The types of OSS systems that were recorded during the truck counting study are presented in Figure 21. There are slight differences between the two weeks, but on average more septic tanks than VIP latrines were emptied, and only twice weekly unlined pits. The results do not correspond to the values estimated by the KSMP, where significantly more VIP and unlined pit latrines require emptying services. This can be explained by the fact that septic tanks in Kampala are in general not only easier to access but also that the households owning septic tanks are likely to belong to a high-income category while households using VIP and unlined pit latrines are not able to pay the emptying fees (compare Table 25). Even though unlined pits are common, they are difficult to empty and access and so are not emptied as frequently. In addition, they are mostly utilized by low-income household who cannot afford emptying services.

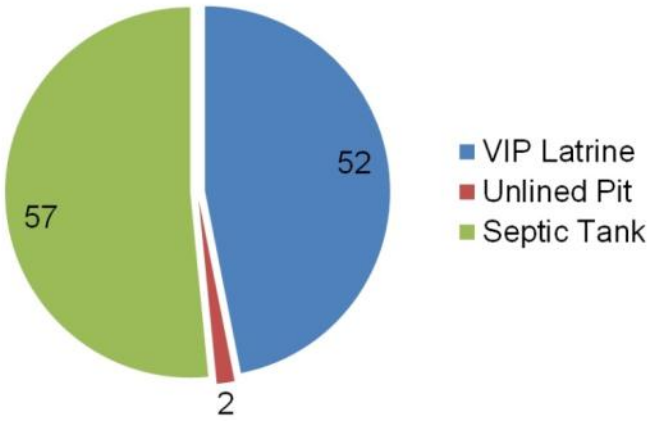

Figure 21: Average number of OSS emptied daily, based on data from 2 weeks.

Truck Ownership

During the truck counting study, truck ownership was assessed and is presented along with volumes discharged in Table 29. Truck ownership results correspond to those provided by the PEA. The "Gulper" business indicates semi-mechanical emptying of FS in informal settlements, which is then delivered to Bugolobi by flatbed truck in barrels.

The daily recorded values are shown in Table 30. The trucks deliver very different volumes of FS depending on the type of business. The "Gulper" or "other" category representing schools and private industry that maintain their own FS systems had on average only one trip. Whereas six of the trucks made between 51 and 60 trips and collected almost one third of the overall FS during this period. Out of these six trucks, two belonged to KCCA and four to private businesses. This illustrates the great potential a private business person has when entering the FSM business in Kampala.

Table 29: Truck ownership calculated from the truck counting survey.

Ownership	Trucks	Quantity /$m^3 \cdot d^{-1}$
Gulper	5	2
KCCA	6	86
Private	43	455
School	3	11
Other[8]	7	24

[8]Other refers to the army, hotel and police which each own one truck and four additional trucks owned by different companies.

Table 30: Categories of trips that have been done over a period of 2 weeks.

Trips No.	Trucks No.	Volume /% of
1	8	1
2 to 10	11	5
11 to 20	4	5
21 to 30	15	21
31 to 40	17	33
41 to 50	3	7
51 to 60	6	29

Regional distribution of FS

The location of OSS systems where the FS was collected is reported in Table 31. 73.5 % of the trips were to the five divisions of Kampala, and 11 % to the Wakiso District. The results show that despite the Central Division, which was 7.9%, the percentages are similar (13% to 20%). The distribution by parishes which each had at least ten trips is presented in Table 32, together with the average income category in those parishes. The analysis of income categories was done based on data that was collected from KCCA and can be found in Appendix 14.4. The results show that most of the trips were made to Kamwokya Parish, which is in Central Division, indicating that the largest contribution of FS to Bugolobi is from the Central Division.

Table 31: Spatial Distribution of quantities and trips during 2 weeks.

Division	Quantity /$m^3 \cdot (14 \cdot d)^{-1}$	Trips /No. of	Quantity /% total	%Trips /% total
Buziga	4	1	0.0	0.1
Central	**461**	**126**	**5.7**	**7.9**
Kawempe	**1158**	**235**	**14.3**	**14.8**
Kisugu	3	1	0.0	0.1
Lubaga	31	5	0.4	0.3
Makindye	**1482**	**276**	**18.3**	**17.3**
Mukono	84	12	1.0	0.8
Nakawa	**1740**	**327**	**21.5**	**20.5**
Packwach	20	2	0.2	0.1
Rubaga	**1046**	**207**	**12.9**	**13.0**
Wakiso	910	179	11.2	11.2
Unregistered	1164	221	14.4	13.9
SUM	**8102**	**1592**	**100**	**100**

Table 32: Spatial distribution of quantities of collected FS and trips during two weeks. Including the income categories as the percentage of population that lives within the respective parish.

Division	Parish	Trips /No. of	Quantity /$m^3 \cdot (14 \cdot d)^{-1}$	high /% of pop.	medium /% of pop.	low /% of pop.	very low /% of pop.
Central	Kamwokya	82	246	0	50	50	0
Kawempe	Kawempe	57	347	0	5	85	10
Kawempe	Bwaise	36	149	0	0	100	0
Makindye	Kansanga	32	148	30	30	30	10
Makindye	Kibuli	25	111	0	0	70	30
Kawempe	Kalerwe	22	97	0	30	70	0
Rubaga	Kabowa	20	71	0	50	20	30
Makindye	Ggaba	18	83	60	30	5	5
Kawempe	Kyebando	18	79	0	10	85	5
Wakiso	Bweyogerere	17	91	-[7]	-[7]	-[7]	-[7]
Nakawa	Kireka	16	87	-[7]	-[7]	-[7]	-[7]
Nakawa	Kitintale	15	59	0	20	10	70
Makindye	Kabalagala	14	70	0	0	50	50
Makindye	Kisugu	14	67	0	30	40	30
Makindye	Katwe	13	86	0	20	20	60
Kawempe	Kisaasi	13	67	0	30	70	0
Nakawa	Bugolobi	12	70	90	0	0	10
Nakawa	Bukoto	12	65	0	90	10	0
Kawempe	Kanyanya	12	52	0	30	70	0
Wakiso	Kajjansi	11	73	-[7]	-[7]	-[7]	-[7]
Makindye	Kibuye	11	63	0	0	90	10
Central	Kololo	8	43.6	100	0	0	0

6.6 Conclusions

Quantity

The results of the truck counting study indicate that there are discrepancies in the amount of FS that is recorded and reported by different sources. The values reported by NWSC, the KSP, and this study are presented in Table 33 for comparison. It is also evident that not all FS generated in Kampala is delivered to Bugolobi, as only half the FS in the truck counting study came from households, but households contribute to much more than 50% of the total FS generated in Kampala [18]. These results indicate that if a valuable end use of FS was identified, that even more FS than the ~600 m^3/day collected daily at Bugolobi could be collected.

Table 33: Comparison of the data that was received from NWSC with the results of the TCS.

Data	Week	Trips /No.	Volume /$m^3 \cdot d^{-1}$
NWSC	16	196[9]	279
TCS	16	780	576
NWSC	19	491	223
TCS	19	812	582
KSP 2008	-	-	369

Accessibility

The currently collected FS will be delivered to a centralized treatment plant in 2014. This increases the end use potential significantly, while a PPP partnership would be needed as technically NWSC owns the FS. Furthermore, depending on the intended enduse, it would need to be evaluated if the produced end-product needs further treatment to ensure appropriate pathogen reduction and safe handling. Depending on the identified end use, the feasibility for implementation in terms of accessibility appears to be high.

Competition

The competition for collected FS is low, as there currently are no existing end uses . However, the competition for uncollected FS is high as the PEA is the leading organization for FS collection and transport. It is not recommended to implement a business model that includes transport and collection unless it is with the PEA. Otherwise, a business model could be implemented based on the amount of FS that is already collected.

Reliability

The reliability of available FS was ranked as “medium,” as it can be assumed that Kampala in the future will continue to at least partly rely on OSS systems. Furthermore, the city is constantly growing and it can be assumed that rather more than less FS will be produced in the future. If the collection and transport of FS from inaccessible areas can be improved, the volume of collected FS will increase further.

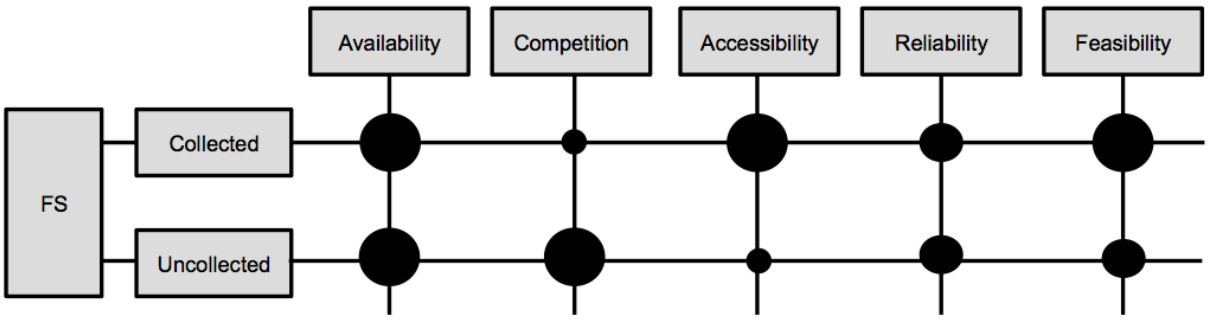

Figure 22: Rating of the feasibility of FS as an input product for RRR business models.

[9] During this week not all trips but the volumes were recorded.

7. Agro-Industrial Waste (AIW)

Agro-Industrial waste is mainly produced in the peri-urban areas of Kampala, where agro processing industries are located. Several types of industries exist, the main ones are poultry, cattle farming, cash and food crop production. Although several studies on agriculture and farming have been done over the past years, there is very little known about the waste generation and/or the use of it. A list of identified agro-processing industries is attached in Appendix 10.8.

7.1 Production of agricultural products

Uganda's main export cash crops are coffee, tea and tobacco. Table 34 presents the total production of cash crops for the years between 2008 and 2012. Table 35 shows the production rates of selected food crops in Uganda.

Table 34: Uganda's production of main export cash crops (UBOS, 2013)

Year	Coffee	Tea	Tobacco
2008	218,781	45,680	29,040
2009	195,871	48,663	18,846
2010	166,968	49,183	27,138
2011	191,379	35,194	28,444
2012	186,126	50,915	31,090

Table 35: Production of selected food crops in Uganda, 2011 - 2012

Crop	2011	2012
Plantain Bananas (all types)	4,699	4,503
Cereals		
Millet	257	244
Maize	2,551	2,734
Sorghum	437	336
Rice	233	212
Wheat	23	20
Root Crops		
Sweet potatoes	1,798	1,852
Irish	180	185
Cassava	2,712	2,807
Pulses		
Beans	915	870
Field peas	17	12
Cow peas	12	10
Pigeon peas	13	13
Others		
Groundnuts	327	295
Soya beans	32	23
Simsim	142	124
Sunflower	265	230

The Uganda Census of Agriculture was undertaken between 2008 and 2009 and gives socio-economic background information of the agricultural sector for all 80 districts of Kampala. Table 36 shows the total production of major crops, as it was evaluated within the census. Kampala's production rates are low compared to the other districts of Central Uganda, because it is an urban area. Kampala District is surrounded by Wakiso District and other nearby districts are highlighted in bold in Table 36: Another district with a high amount of agricultural crop production is Mubende District at the border of the Western Region of Uganda. It can be assumed the high availability of land and good climate conditions are the reason for that.

Table 36: Total production of major crops by district of Central Uganda (UCA 2008/09)

District	Plantain bananas /t·y^{-1}	Finger millet /t·y^{-1}	Maize /t·y^{-1}	Sorghum /t·y^{-1}	Rice /t·y^{-1}	Sweet potatoes /t·y^{-1}	Irish potatoes /t·y^{-1}	Cassava /t·y^{-1}
Kalangala	531	0	776	0	0	4,343	0	7,950
Kampala	**3,004**	**0**	**245**	**0**	**0**	**796**	**0**	**1,054**
Kayunga	14,657	710	18,107	130	207	29,221	0	33,867
Kiboga	65,380	46	34,875	58	251	7,969	916	14,186
Luwero	**37,534**	**0**	**29,849**	**0**	**362**	**15,741**	**77**	**39,732**
Lyantonde	38,588	513	3,675	0	0	1,148	4,905	4,093
Masaka	195,218	108	82,287	115	0	33,757	106	64,965
Mityana	**34,150**	**0**	**13,321**	**85**	**0**	**8,346**	**944**	**9,666**
Mpigi	**114,653**	**3**	**19,578**	**76**	**12**	**21,478**	**362**	**39,219**
Mubende	204,109	627	171,089	350	0	36,274	1,483	41,188
Mukono	**36,026**	**160**	**18,882**	**15**	**837**	**37,501**	**0**	**41,669**
Nakaseke	**27,511**	**138**	**6,375**	**29**	**58**	**10,786**	**48**	**13,771**
Nakasongola	1,632	9,674	14,835	0	0	66,419	0	49,405
Rakai	139,314	151	18,213	1,313	0	9,002	3,539	14,589
Ssembabule	98,643	1,605	12,446	358	0	6,294	158	12,744
Wakiso	28,884	0	5,287	149	447	23,200	753	21,712
Total	1,039,834	13,735	449,858	2,678	2,174	312,405	13,291	409,810

7.2 Use of AIW

A number of industries, shown in Appendix10.8 are using AIW for energy production, especially saw dust, cotton husks and coffee husks. Most clay and cooking oil industries are using coffee husks as a fuel, due to their high calorific value and the ease of blowing them into the kilns. Clay industries in Kampala include Uganda clays, Lweza clays and Panafric clays along Entebbe road. TAWSI, a cooking oil industry in Kawempe division, uses cotton husks as fuel for the manufacturing process. Coffee husks are also imported from neighboring countries like Tanzania to meet the high demand. Some agricultural sites that are providing the husks are Mityana (71 km), Mutukula (221 km), Mbale (221 km) and Bukoba in Tanzania (300 km). Other sources of waste for fuel production are rice husks, palm oil husks and groundnut husks [31]. Besides the clay industries, there are aquaculture farms using feeds like sliced banana peelings and yam leaves. Ugachick, for example, has an aquaculture farm and in addition to the food crop residues also uses chicken gut as a feed source for the fish [26]. Kampala Jellitone Suppliers Ltd. is a company that produces briquettes from agricultural residues, such as rice husk, coffee husks, maize stalks, peanut husks and sawdust.Kakira Sugar works, the largest manufacturer of sugar in Uganda is using the fibrous residue from the process of sugar cane, known as “bagasse” to generate electricity. In Tiribogo, a small-scale community project uses maize cobs to generate electricity through the process of gasification. Besides the above, little is known about the quantities and use of AIW. Interviews have revealed that most of the waste is used on-site as an organic fertilizer [26]

7.3 Conclusion

Conclusions regarding AIW for the feasibility of RRR business models are difficult to make based on the limited information. However, from the available data it is apparent that most AIW is not produced within the boundaries of Kampala City. Instituting business models with AIW would therefore need to consider being in place in the districts surrounding Kampala, but potentially based on the endproducts, could sell it in Kampala. This would have to be carefully researched though, as it would result in high transportation costs and hence potentially prices for endproducts that could not compete with the price for traditional products.

8. Animal Waste (AW)

Although several studies on AW and the use of animal manure for agriculture in Uganda have been carried out, none of them have been large scale or focused on Kampala City. However, Komakech et. al. has recently completed a comprehensive study focusing on the five divisions of Kampala with the following objectives [27]:

- Mapping of Animal Farms
- Establishing feeds used for the animals
- Determining manure generation and management in the different divisions of Kampala

Due to the comprehensive nature of this study, it was used together with observations in the field, and the expertise of local RRR partners as the main source of information for this report. Komakech et al identified and interviewed 1,300 farmers within the urban boundaries of Kampala, with mapping of respective global positioning system (GPS) coordinates. Table 37 shows the distribution and number of farms and animals per division. The most common are poultry, followed by pigs, cattle, goats and sheep. Kawempe and Rubaga have the greatest number of farms followed by Makindye and Nakawa. Central has the smallest number of farms due to it being the most urban area of Kampala (compare Table 38) [27]. Within the study, there was no differentiation for the given type of poultry. However, a livestock market study by Foundation Agriterrra in 2012 revealed that 95% of the existing poultry livestock for meat production are chickens, not including birds kept for egg production. Even though a larger amount of beef is produced in Uganda, chicken are more common in Kampala because they are relatively easy to keep in urban areas. In Kampala, chicken are usually purchased while still alive and then slaughtered by the consumer at home. Another reason for the high number of chickens is high egg consumption [28].

Ugachick Poultry Breeders is the biggest commercial chicken farm in Uganda and is located 15 kilometers north of Kampala. Production is 120,000 chickens per week 90,000chicks per week, and they also sell eggs. Ugachick has a slaughterhouse (or abattoir) where chickens are killed prior to sale. These chickens are produced for large-scale production for supermarkets, in comparison to ones sold alive at markets as mentioned above. The company also has factories in other main towns like Jinja and Mbarara. It is one out of three farms in Kampala which can be described as a large scale unit (flock size over 5,000). Farms with a flock size of 500 to 5000 are defined as medium-scale units, owned by individuals, companies or farmers' groups, while farms with a flock size of 100 to 500 are defined as small-scale units, mainly household/family owned units [29].There are currently only three

farms in this category and only Ugachick would qualify as Sector 1[10] by the Food and Agriculture Organization of the United Nations (FAO)[30].

Kawempe and Rubaga, two of the five divisions of Kampala, have the lowest per capita income in the city and therefore more people keep animals as a food source [27]. Nakawa Division in Kampala has a higher proportion of poultry than other divisions due to the fact that there are large scale poultry farms with an average flock size of 2500on 45 farms. Farms in other divisions have on average a flock size of around 300 chickens per farm [27].

Comparing the figures of Table 37 with the numbers of the livestock census of 2002 shows that the data collected by Komakech et. al. is around five to ten times lower. The reason for this might be an overestimation of the livestock census because of using a different methodology, where a projection of only 15.1 % of the farms were done while Komakech et. al. analyzed all existing farms in Kampala [27]. While the livestock census focuses on Uganda as a country, Komakech et. al. analyzed Kampala city. All registered farms were visited for data collection. Numbers could have been underestimated as non-commercial, unregistered farms were not included in the study, whereas the livestock census did include them.

[10] Industrial integrated system with high level of biosecurity and birds/products marketed commercially (e.g. farms that are part of an integrated broiler production enterprise with clearly defined and implemented standard operating procedures for biosecurity)

Table 37: Number of animals and farms within the five divisions of Kampala. Adapted from [27].Waste production calculated based on average manure production per animal.

	Sheep		Goats		Cattle		Pigs		Poultry	
	Animals	Farms	Animals	Farms	Animals	Farms	Animals	Farms	Animals	Farms
Central	19	4	53	9	62	14	51	3	299	6
Kawempe	96	24	960	128	1630	296	1200	107	75400	176
Makindye	19	8	500	50	610	97	740	33	11900	57
Nakawa	21	6	480	71	620	86	5800	48	113000	45
Rubaga	57	21	1100	199	930	185	1200	150	47300	57
Total	212	63	3093	457	3852	678	8991	341	247899	341
Waste Production /tons·yr^{-1}	85	-	3402	-	31972	-	17083	-	5950	-

Table 38: Number of Farms in the five divisions of Kampala. Adapted from [27]

Division	No. of Farms
Central	36
Kawempe	731
Makindye	245
Nakawa	256
Rubaga	612

Table 39: Animal units in the five divisions of Kampala. Adapted from [27].

Division	Animal Units[11]	Units/farm
Central	63	3
Kawempe	1900	4
Makindye	590	5
Nakawa	2100	11
Rubaga	1300	3

8.1 Animal Waste Management

Reuse of animal manure

The end-use of animal manure in Kampala happens on a relatively small scale. 60% of the overall animal waste that is produced remains unused and is discarded (compare Table 40).This could be because the value of animal manure for urban agriculture has not yet been discovered at the small-scale farmer's level yet, or that small-scale farms are not using manure because they are not growing crops. Furthermore, Komakech et. al. observed that only a small percentage (1%) of the discarded waste is actually transported to the Kiteezi landfill. As a result, the majority of uncollected waste is

[11] One animal unit is equal to one dairy cow or three cattle, or 10 sheep, goats and pigs, or 100 poultry 31. Komakech, A.J., et al., *Maps of animal urban agriculture in Kampala City.* Agronomy for Sustainable Development, 2013.

discharged to drains and open spaces, causing human and environmental health risks. 32% of animal manure is utilized as a fertilizer in agricultural crop fields [27]. The potential to increase reuse of animal manure exists, but behavior change and education in dealing with the manure are needed for this process.

Table 40: End-use of animal manure in the five divisions of Kampala, compiled from [27].

	Waste usage (%)									
Division	**Discarded**	**Donated**	**Heaped**	**Sold**	**Use in Village**	**Dumped**	**Biogas**	**Pig Feed**	**Burnt**	**Fertilizer**
Central	50	5	5	9	32	-	-	-	-	-
Kawempe	42	5		2	-	4	1	-	1	44
Makindye	22	10	3	11	-	-	3	1	9	41
Nakawa	53	-	-	-	-	-	-	-	-	47
Rubaga	85	-	-	-	-	-	-	-	-	15
Total	59	3	0	2	1	1	1	0	1	32

Spatial distribution of animal farms

Figure 23 shows the distribution of animal farms in Kampala. Some differences can be seen when looking at the disparity of the animal categories. Animal farms in Rubaga Division are mixed in the northern parishes, such as Kasubi, Nakulabye and Lubya. These Parishes are also characterized by low- to very low-income households, where it can be assumed that farming is undertaken mainly on a small-scale household basis. The Parishes Busega, Natete and Lungujja have a high amount of poultry farms. Farms in the parishes of Mutundwe, Kabowa and Najjanankumbi solely have cattle as livestock.

Animal Farms in Kawempe division are very disperse, whereas a lot of manure is reused in the parishes of Komamboga and Kikaya. As mentioned above, most of the farms in Nakawa Division are commercial poultry farms. Analyzing Figure 23 reveals that most of the farms are in Kyanja Parish and Figure 24 illustrates that in this parish most of the manure is utilized as fertilizer/soil conditioner. This can be explained by a project that was launched by the former Kampala City Council, where around six ha of land was committed for the construction of a new low-income and sustainable urban settlements integrating urban agriculture [32]. It shows that the reuse potential of manure as a fertilizer is realized, but incentives and education are needed for wider-scale uptake.

Makindye division has the lowest percentage (22%) of animal waste being discarded. Besides the use for fertilizer (41%), the rest of the waste is donated (10%), sold (11%) or used for Biogas production (3%). Animal Manure that is donated and sold also finds some kind of reuse, but isn't directly reused as a fertilizer on the fields that are surrounding the farms [27].

High usage of animal manure as a fertilizer in Kawempe, Makindye and Nakawa is due to the ownership of fairly large pieces of land which allow farmers to engage in animal farming as well as crop production.

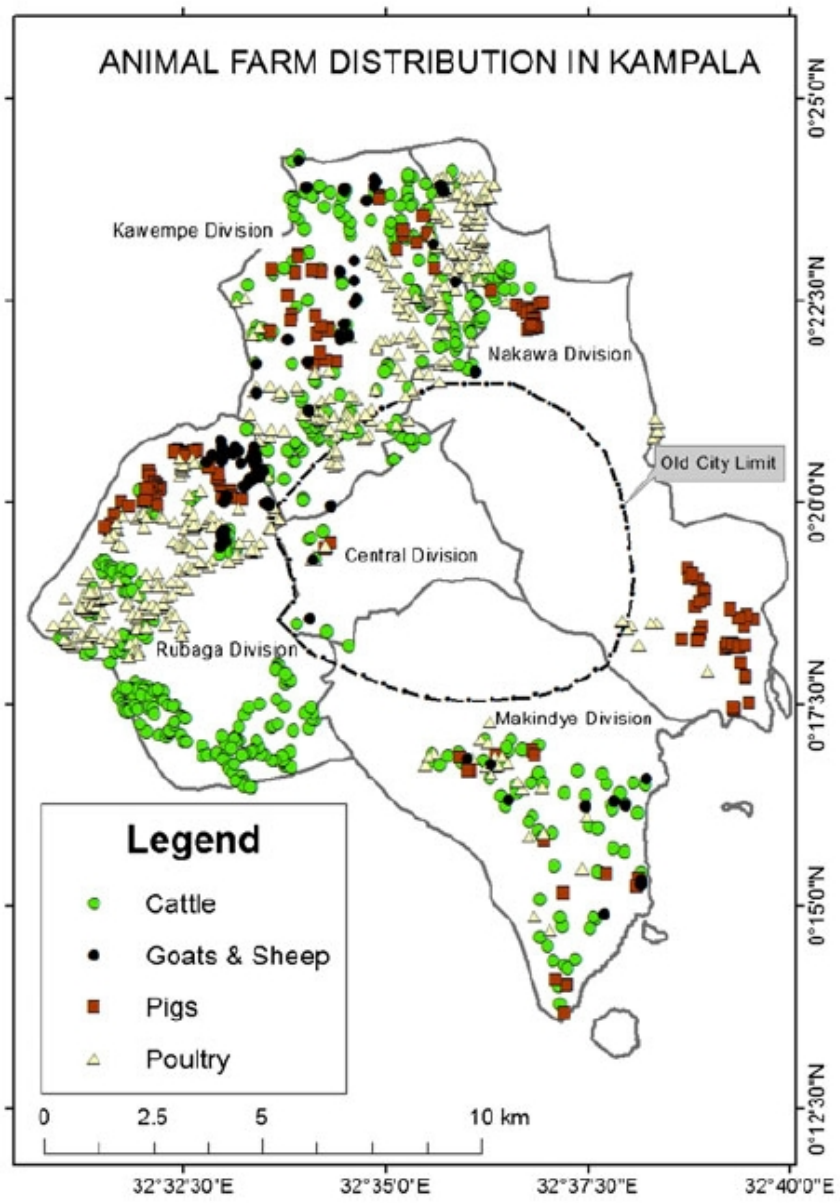

Figure 23: Distribution of animals farms in the five divisions of Kampala. Created by [27].

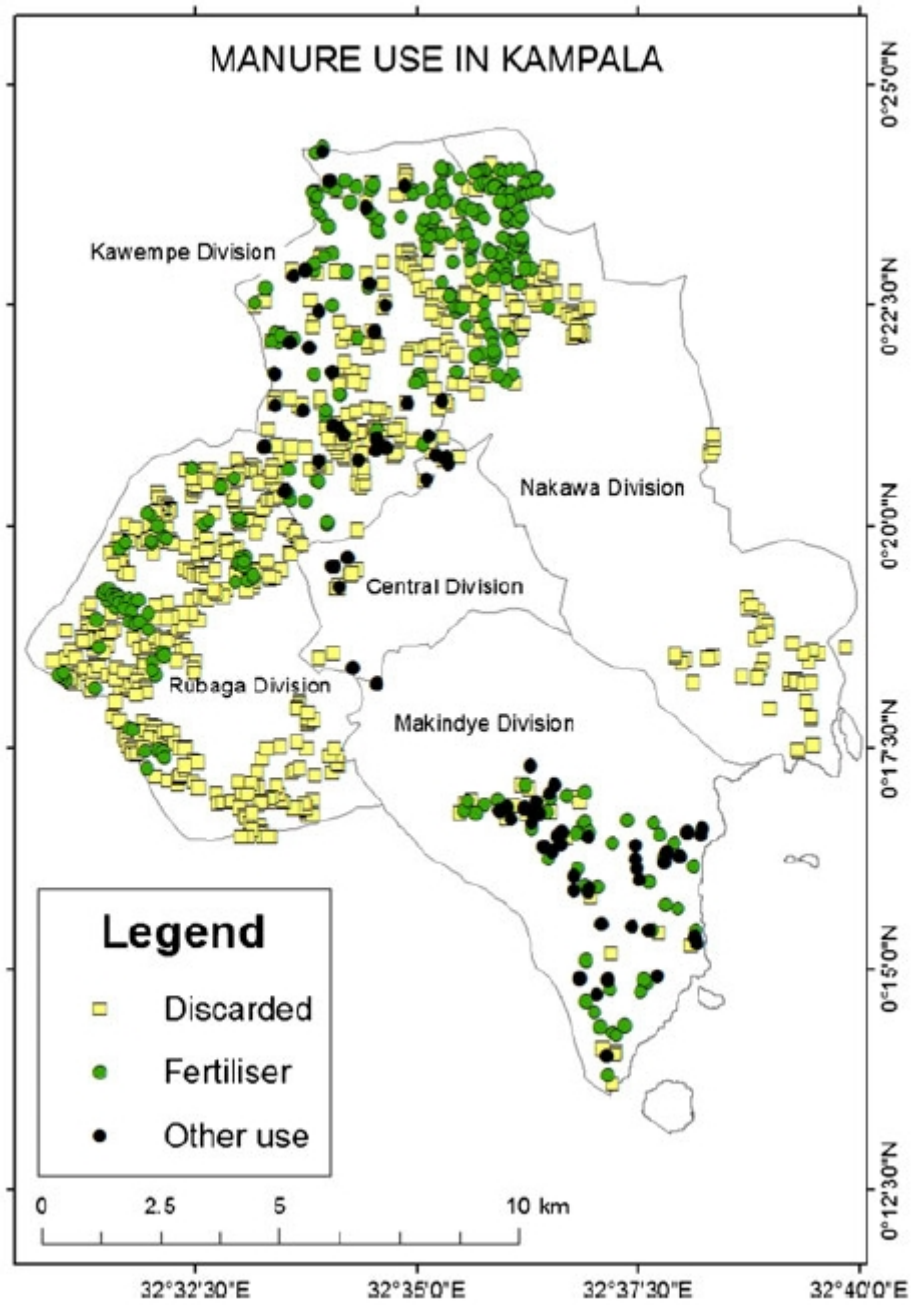

Figure 24: Animal Waste Management in the five divisions of Kampala. Created by [27].

8.2 Conclusion

Urban animal husbandry at the household level is a common practice in Kampala to ensure food security. Despite that, Kampala also has various large scale animal farms. The overall estimated quantity of generated manure is 58,492 tons/yr produced at 1,880 farms, which calculates to an average of 85 kg per farm per day. Most farms are concentrated in the north-eastern part of the city within the more peri-urban areas of Kampala. 60% of the overall generated manure remains unused, but potential for nutrient recovery exists as it is already practiced in the city. The potential for energy recovery could be increased where only 4% is used so far. Although the competition for AW is rather low, the accessibility of it appears to be difficult, since most of the farms are small-scale and individual households would need to be approached in order to collect the waste. More feasible would be to

approach the large-scale production facilities, for example, Ugachick, which lies outside of the city boundaries. The findings are summarized in Figure 25.

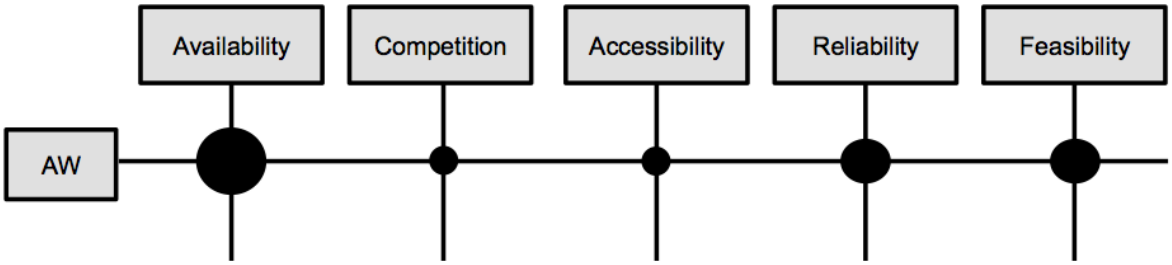

Figure 25: Rating of the feasibility of AW as an input product for RRR business models.

9. Acknowledgements

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Swiss Agency for Development and Cooperation

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Swiss Tropical and Public Health Institute

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Makerere University

Department of Agriculture and BioSystems Engineering

College of Engineering, Design, Art and Technology

Kampala Capital City Authority

National Water and Sewerage Corporation

Private Emptier Association Uganda

German Development Cooperation (GiZ)

German Development Bank (KfW)

Fichtner Water and Transportation

Ugandan Bureau of Statistics

10. Appendix

10.1 List of important stakeholders

Name	Organization	Position
Christopher Kanyesigye	NWSC	Manager Quality Control
James Miiro Maiteki	NWSC	Sewerage Services Manager
Jafari Matovu	PEA	General Secretary
Dr. James Semuwemba	KCCA	Deputy Director, Public Health and Environmental
Dr. Onesmus Semalulu	NARL-NARO	Researcher
Eng. Patrick Twesige	NWSC	Project Manager
Alice Silich-Salburg	KfW	Senior Project Manager WatSan
Dr. Mohammed Babu	NWSC	Manager Research
Allan Komakech	MUK	PhD Student
Prof. Noble Banadda	MUK - Dept. of Agricultural and BioSystems Engineering	Professor and Head of Department
Joel Kinobe	MUK - Dept. of Agricultural and BioSystems Engineering	PhD Student
Norman Ntalo	UBOS	GiS Officer
Julius Schlagenauf	GiZ	WASH Coordinator
Fredrick Tumusiime	GiZ	Senior Advisor
Daniel Smith	Water for People Uganda	
George Drummond	Water for People Uganda	Placement Engineer
John Seryazi	EU Delegation	Operations Officer at European Commission
Richard Musisi	Captiva Africa	Sanitation Marketer
Frank Millsopp	Water for People Uganda	Program Manager
Cate Zziwa Nimanya	Water for People Uganda	Country Director
Kyomugisha Salome Trinah	Ministry of Water and Environment	Environmental Health Officer
Sherina Munyana	Water for People Uganda	Communications Manager
Charles Sekajja	Bukedde News	Reporter
Juliet Waiswa	New Vision News	Reporter
Josephine Asasira	KCCA	GiS Manager
Eberhardt Schulte	FWT	Project Manager
Anja Kramer	KfW	Director of KfW Office Kampala
Najib B. Lukooya	WasserCluster-WCL	Consultant
Callist Tindimugaya	Ministry of Water and Environment	Commissioner

Francis Kisitu	Ministry of Water and Environment	

10.2 List of Private Collection Companies

LICENSED WASTE HANDLERS IN UGANDA, 2012-2013

NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY (NEMA)

THE NATIONAL ENVIRONMENT (WASTE MANAGEMENT) REGULATIONS, 1999)

LIST OF LICENSED WASTE HANDLERS IN UGANDA

The Technical Committee on Pollution Licensing, in exercise of the powers conferred on it by the National Environment (Waste Management) Regulations, 1999, in its 12th sitting, issued the following listed companies/persons licenses to store or transport wastes or own/operate waste treatment/disposal facilities.

The licenses are valid for one year **(01 December 2012- 31 November, 2013)**

NO.	LICENSEE	ADDRESS AND CONTACT INFORMATION	TYPE OF LICENSE	WASTE HANDLED
TRANSPORTATION OF DOMESTIC /MUNICIPAL SOLID WASTE				
1.	T&D Cleaning Limited	Plot 16, Entebbe Kitoro road P.O Box 10146 Contact Persons: Managing Director Tel: 414669860 Mob: 0712 839237	Transportation	Domestic waste
2.	Green Hope Uganda limited	P.O Box 9244, Kampala Mob:0772 486398 0712 776622	Transportation	Domestic waste
3.	Kibanyi and sons company limited	Plot14 Kanjokya street P.O Box 7668 Kampala Tel: 0702 366790 0775 424855	Transportation	Domestic waste
4.	Jua Kaali Nakivubo Shauriyako Association	Plot 54/56 William street P.o Box 30554 Kampala Tel: 0753895745	Transportation	Domestic waste

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		0782206802		
5.	Kikuubo business community limited `	P.O Box 511 Kampala Tel: 0772 503765	Transportation	Domestic Waste
6.	Pilling Environment Limited	P.O Box 35641 Kampala Tel: 0782319778 0789 696781	Transportation	Domestic waste
7	Globe clean services	Plot 318, Old Kira rd, Kamwokya-Kampala	Transportation	Domestic Waste
8	Koyinawo trading company limited	P.O. Box 1341 Mbarara Tel: 0752 422860	Transportation	Domestic Waste
9	Eco Projects Ltd	Plot 133, Portbell rd, Luzira P.O Box 4994 Kampala Tel: 0772332108	Transportation	Domestic waste
10	Bin-It Services	Plot 89, Kira rd, Kamwokya P.O box 1730 Kampala	Transportation	Domestic waste
TRANSPORTATION OF INDUSTRIAL /HAZARDOUS WASTE				
11	Array Services limited	P.O Box 16125 Kampala Tel: 0312517749, 0701840969	Transportation	Hazardous waste
12	Specialised Technical services ltd	P. O Box 11022 Kampala Uganda. Tel: 0414510360	Transportation	Used Oils
13	Scrap Center (U) Ltd	Mussajjallubwa Road, Off Rubaga road. 0772436856	Transportation	Scrap materials
14	Epsilon (U) Ltd	Plot 1413, Mbogo Road P.O. Box 12647 KAMPALA 0414 252 076	Transportation	Hazardous wastes
15	Green Label Services Ltd	P.O Box 40303 Kampala. Tel: 0414532235	Transportation	Hazardous waste

	16	Bio Waste Management (U) Ltd	Plot 64, Kisanjufu, Kyampisi, Mukono district. Tel: 0772482448	Transportation	Hazardous Waste
	17	Maziba Holdings Ltd	P.O.Box 5565, Kampala Contact person: Samuel Seguya, Tel: 0772588058	Transportation	Scrap materials
	18	Eco Projects Lt	Plot 133, Portbell rd, Luzira P.O Box 4994 Kampala Tel: 0772332108	Transportation	Hazardous Waste
	STORAGE OF HAZARDOUS WASTE				
	19	CNOOC Uganda limited	P.O. Box 3673 Kampala	Storage	Hazardous waste (Drill Waste)
	20	Episilon (U) Ltd	Plot 1413, Mbogo Road P.O. Box 12647 KAMPALA 0414 252 076	Storage	Hazardous waste
	21	Hariss International Ltd	Plot83, Bombo rd, Kawempe P.O Box24972 Kampala	Storage	Hazardous waste
	OWN/OPERATE A WASTE TREATMENT/DISPOSAL FACILITY				
	22	Quality chemical industries limited	P.o Box 32871 Kampala Tel:0776 997647	Own/Operate a Waste treatment facility (incinerator)	Industrial effluent
	23	NLS Waste Services	Plot 17 Martyrs Way Ntinda Ministers' Village Tel: 0772 400995	Own/Operate a waste treatment plant	Medical waste
	24	Bio Waste	Plot 64, Kisanjufu, Kyampisi, Mukono district. Tel: 0772482448	Own/Operate a waste treatment plant.	Medical waste
	25	Mukono Municipality Council	P. O. Box 201 Mukono	Katikolo Village, Mukono	Compost/municipal waste disposal plant
	26	Jinja Municipal	P. O. Box 720 Jinja	Masese cell,	Compost/municipal waste

	Council		Jinja Municipality.	disposal plant
27	Mbale Municipal Council	P. O. Box 931 Mbale	Doko cell, Mbale Municipality.	Compost/municipal waste disposal plant
28	Soroti Municipal Council	P. O. Box 109 Soroti	Aminit Cell, Soroti Municipality	Compost/municipal waste disposal plant
29	Lira Municipal Council	P. O. Box 119 Lira	Aler Village, lira Municipality	Compost/municipal waste disposal plant
30	Fort-Portal Municipal	P. O. Box 29 Fort- Portal	Kitere cell, Fort-Portal Municipality.	Compost/municipal waste disposal plant
31	Kasese Municipal Council	P. O. Box 54 Kasese.	Railway cell, Kasese Municipal Council	Compost/municipal waste disposal plant
32	Kabale Municipal Council	P. O. Box 144 Kabale	Kirengere Village, Kabale Municipal council	Compost/municipal waste disposal plant
33	Mbarara Municipal Council	P. O. Box 290 Mbarara	Rwentondo cell,Mbarara Municipal council	Compost/municipal waste disposal plant

END

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10.3 Chemical Composition of MSW

Location	Month	M_C (%)	Nitrogen (g/Kg DM)	Phosphorus (g/Kg DM)	Potassium (g/Kg DM)	Gross_EC (Kcal/kg DM)	Organic waste quantity (kt)[1]
Nakawa	July	71.7 ± 6.6	2.47 ± 0.25	0.31 ± 0.07	2.71 ± 1.24	3500 ± 100	3.6

Nakawa	August	68.6 ± 3.3	2.19 ± 0.44	0.23 ± 0.11	2.02 ± 0.81	4300 ± 2100	3.3
Nakawa	October	72.8 ± 2.5	1.24 ± 0.59	0.25 ± 0.11	0.73 ± 0.38	3900 ± 400	2.8
Nakawa	December	66.7 ± 2.0	2.84 ± 0.13	0.46 ± 0.03	2.13 ± 1.17	5500 ± 100	3.1
Nakawa	February	65.6 ± 4.2	1.79 ± 0.74	0.37 ± 0.05	1.8 ± 0.26	4000 ± 400	3.7
Nakawa	April	76.4 ± 2.3	1.38 ± 0.23	0.2 ± 0.02	0.58 ± 0.18	5000 ± 1000	4.2
Nakawa	June	72.7 ± 1.7	1.06 ± 0.05	0.21 ± 0.01	0.75 ± 0.19	3500 ± 1100	3.5
Makindye	July	71.0 ± 6.1	2.17 ± 0.69	0.31 ± 0.02	2.95 ± 1.14	3500 ± 400	2.9
Makindye	August	69.3 ± 4.2	2.14 ± 0.58	0.32 ± 0.11	2.74 ± 0.97	3800 ± 800	3.4
Makindye	October	72.9 ± 4.2	1.33 ± 0.19	0.26 ± 0.04	0.7 ± 0.26	3300 ± 1000	2.6
Makindye	December	68.7 ± 6.2	1.84 ± 0.30	0.29 ± 0.28	3.72 ± 0.11	4600 ± 1200	2.7
Makindye	February	67.4 ± 3.7	1.66 ± 0.37	0.26 ± 0.09	3.88 ± 0.28	4000 ± 1000	2.0
Makindye	April	78.1 ± 0.5	1.38 ± 0.01	0.21 ± 0.04	0.6 ± 0.03	4900 ± 1200	2.1
Makindye	June	74.7 ± 0.7	1.7 ± 0.31	0.14 ± 0.08	0.6 ± 0.16	3600 ± 1400	2.7
Kawempe	July	67.8 ± 1.7	2.19 ± 0.45	0.27 ± 0.03	3.32 ± 1.23	3800 ± 300	3.0
Kawempe	August	69.4 ± 3.9	1.97 ± 0.43	0.27 ± 0.10	2.27 ± 0.92	4200 ± 1000	3.4
Kawempe	October	71.2 ± 12.2	1.24 ± 0.12	0.21 ± 0.02	0.45 ± 0.09	4400 ± 40	2.5
Kawempe	December	72.7 ± 0.3	2.68 ± 0.04	0.29 ± 0.05	2.84 ± 1.41	4400 ± 20	3.0
Kawempe	February	67.1 ± 2.3	1.29 ± 0.11	0.32 ± 0.13	2.62 ± 0.93	4400 ± 900	3.0
Kawempe	April	75.9 ± 1.7	1.37 ± 0.17	0.31 ± 0.02	0.74 ± 0.12	4900 ± 700	3.5
Kawempe	June	72.4 ± 0.4	1.89 ± 0.91	0.27 ± 0.00	0.63 ± 0.16	4000 ± 1300	3.1
Central	July	63.5 ± 0.1	2.05 ± 0.72	0.26 ± 0.04	3.08 ± 0.61	4000 ± 200	5.1
Central	August	69.0 ± 3.9	2.22 ± 0.51	0.31 ± 0.13	2.55 ± 1.13	4000 ± 900	5.0
Central	October	77.7 ± 2.2	1.31 ± 0.13	0.22 ± 0.03	0.53 ± 0.02	4100 ± 1200	4.5
Central	December	72.4 ± 4.5	2.66 ± 0.38	0.3 ± 0.11	2.99 ± 1.44	3400 ± 30	5.5
Central	February	68.9 ± 1.1	2.41 ± 0.22	0.33 ± 0.06	4.11 ± 0.23	3900 ± 500	5.3
Central	April	75.8 ± 0.7	1.09 ± 0.38	0.21 ± 0.06	0.89 ± 0.00	4200 ± 1500	6.6
Central	June	67.3 ± 5.9	2.3 ± 0.87	0.24 ± 0.03	0.59 ± 0.08	4800 ± 500	5.4
Rubaga	July	68.4 ± 1.8	2.0 ± 0.44	0.35 ± 0.02	2.51 ± 0.54	3900 ± 200	3.1
Rubaga	August	69.6 ± 4.2	2.16 ± 0.53	0.21 ± 0.10	2.22 ± 0.94	3900 ± 700	2.8
Rubaga	October	79.5 ± 0.6	1.9 ± 0.75	0.26 ± 0.01	0.63 ± 0.19	4200 ± 1000	2.6

Rubaga	December	69.3 ± 5.9	2.32 ± 0.35	0.32 ± 0.10	3.33 ± 1.58	5000 ± 300	3.2
Rubaga	February	65.1 ± 3.4	2.1 ± 0.50	0.22 ± 0.05	3.3 ± 0.86	3100± 800	3.1
Rubaga	April	76.9 ± 1.5	1.5 ± 0.20	0.28 ± 0.01	0.65 ± 0.21	3000± 200	2.8
Rubaga	June	71.4 ± 0.9	2.35 ± 0.29	0.33 ± 0.11	2.15 ± 0.25	5200 ± 30	3.0

10.4 Animal mapping

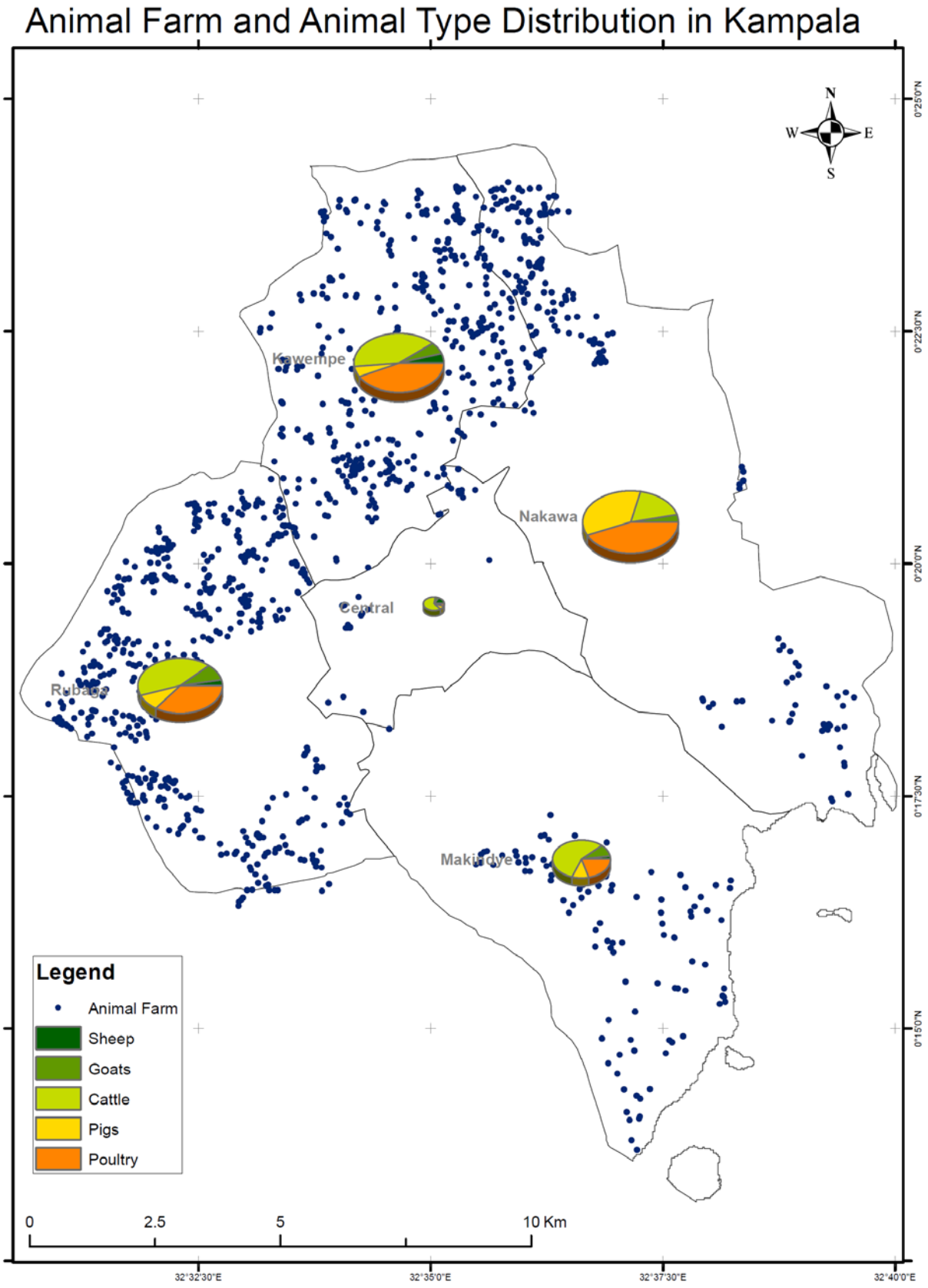
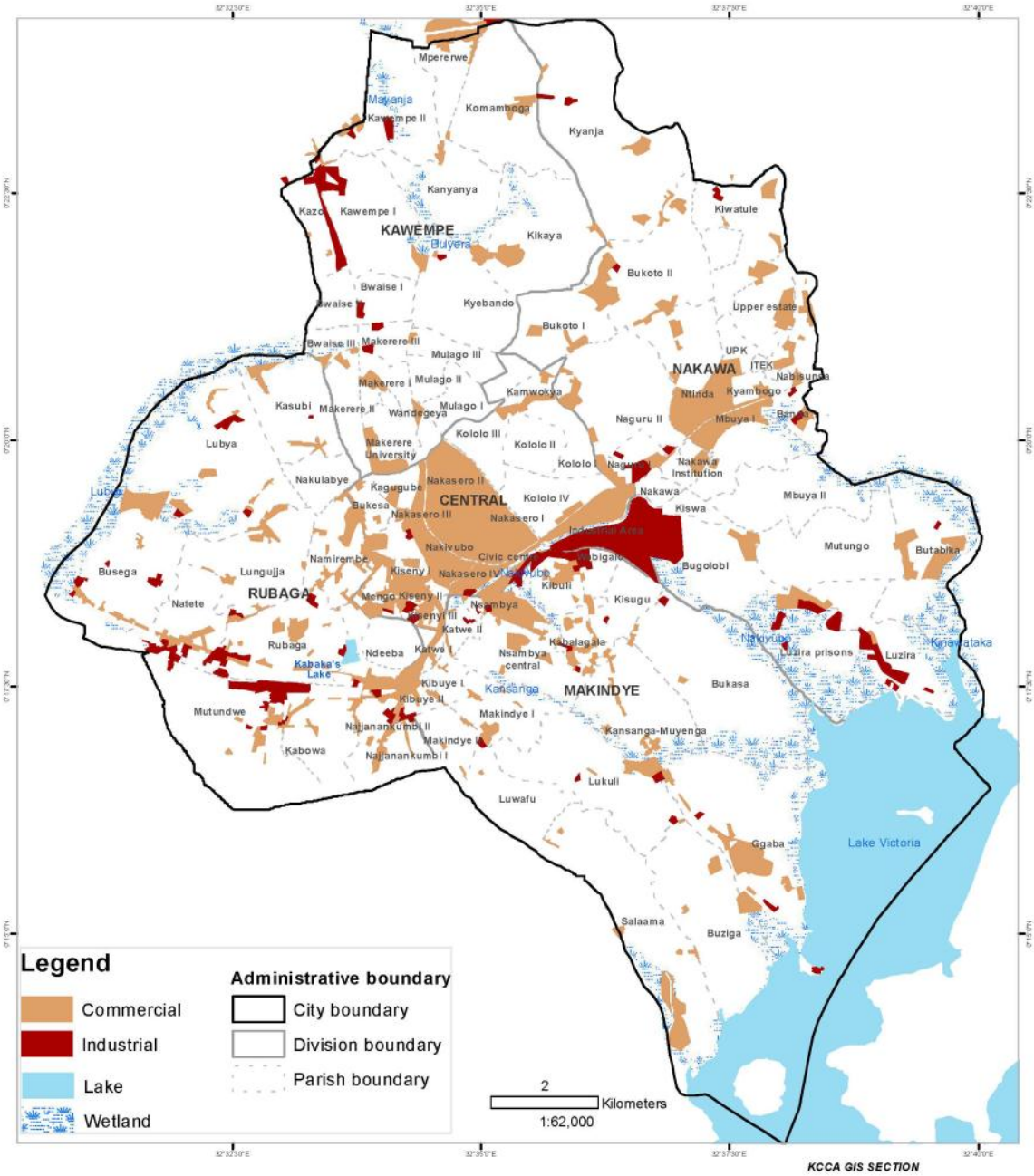


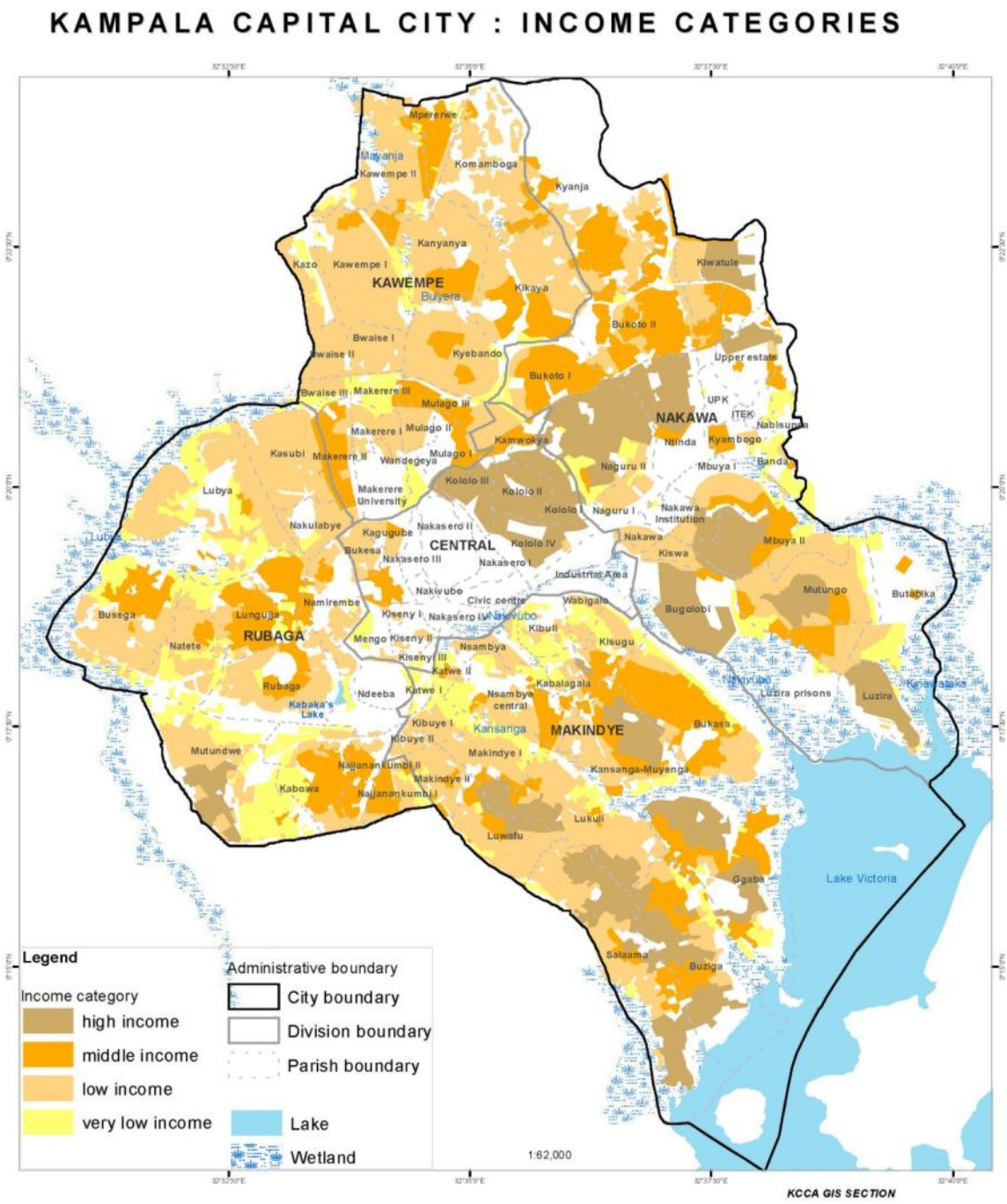
Figure 26: Animal mapping of Kampala, received from [27].

10.5 Commercial and industrial areas

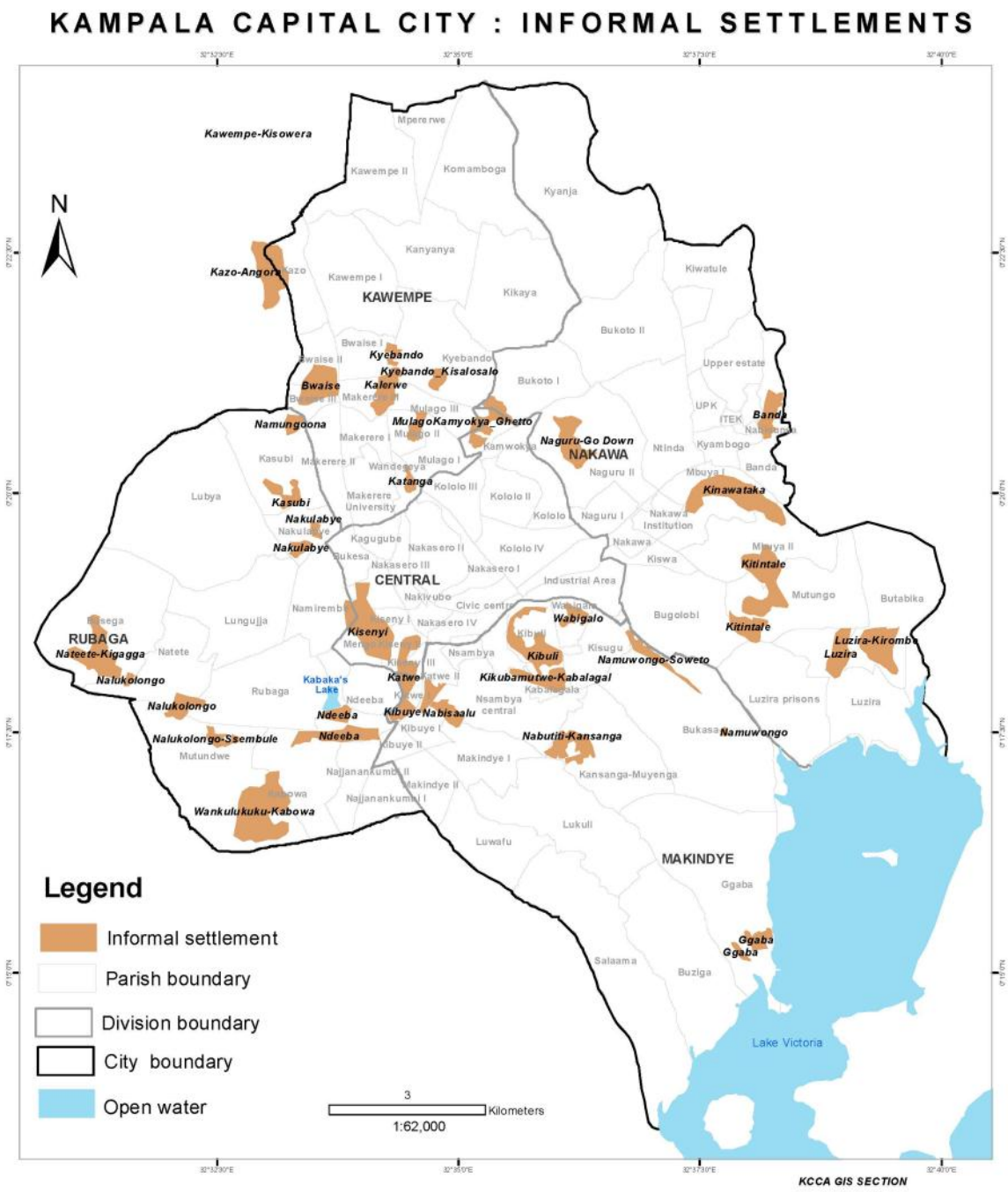
KAMPALA CAPITAL CITY: COMMERCIAL AND INDUSTRIAL AREAS



10.6 Income Categories of Kampala



10.7 Informal settlements



10.8 Pictures of Naalya WSPs

Figure 27: Naalya WSPs. November 2013. Photo credit: Lars Schoebitz

10.9 Pictures of Ntinda WSPs

Figure 28: Ntinda WSPs. November 2013. Photo credit: Lars Schoebitz

10.10 Pictures of construction works at Lubigi WWTP/FSTP, November 2013

Figure 29: Figure 26: Ntinda WSPs. November 2013. Photo credit: Lars Schoebitz

10.11 Questionnaire of the TCS

Questionnaire for the quantification of Faecel Sludge that arrives at the Bugolobi Wastewater Treatment Plant

Date:	Time:	Reg. No.:	Picture taken: Yes/No
1. What is the volume of your truck? ☐1.8 ☐2.5 ☐2.7 ☐3 ☐4 ☐4.5 ☐6.5 ☐7.2 ☐10 ☐Other, specify:			
2. Who does the truck belong to? ☐ Private Business ☐KCCA ☐ Police ☐ Army ☐ Other, specify:			
3. From which system have you collected the Sludge? ☐ Lined pit ☐ Unlined pit ☐ Septic Tank ☐Other, specify:			
4. Was the sludge only collected from one system?			
☐ Yes A. Did you completely empty the system?		☐ No. B. How many systems? C. Which other systems? ☐ Lined pit☐ Unlined p☐ Septic Tank ☐ Other, specify:	
☐ Yes	☐ No Will you return to finish? ☐ Yes ☐ No		
5. Where is the Sludge coming from? ☐ Hotel, Restaurant, Institution ☐ Household ☐ Multiple Household ☐ Public Toilet ☐ School ☐ Other, specify:			
6. Did you add any water to empty the system? ☐ Yes ☐No			
7. Is your truck completely full? ☐ Yes ☐ No. Estimate how full it is:			
8. What was the fee you charged for emptying the system?			
9. What is the distance you had to drive? (Ask if one way or there and back)			

10.12 List of agro-processing industries

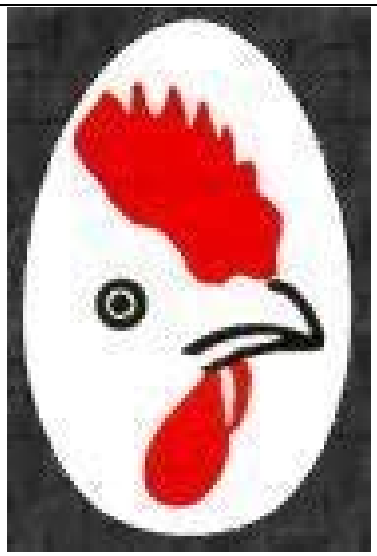
LOGO	COMPANY NAME AND BACKGROUND	CONTACT DETAILS
	Association of Vanilla Exporters (VANEX) The Association of Vanilla Exporters of Uganda (VANEX) brings together Vanilla Exporters in Uganda under one umbrella in order to promote the production of vanilla in Uganda	Plaza Building Plot 2-2b Kampala Road P.O. Box 27000 Kampala, Uganda Tel: **256 712 402 244**

	for the long term benefit of the Ugandan vanilla industry. It also seeks to promote the sale of Ugandan vanilla worldwide. It was established in 2004 and is made up of the most prominent vanilla exporting companies in Uganda.	
	Kakira Sugar Producing sugar for the Ugandan market since 1930. The most popular brand for sugar in Uganda. Flagship company of the Madhvani Group involved in sugar processing and production; tea, soap and sweets.	Head Office Plot Road P.O. Box 0 Kampala, Uganda Tel: 256 312 275 056
	Sameer Agriculture and Livestock Milk, Yoghurt, Butter, Ghee, Powdered Milk. The company is already exporting milk products to Kenya, Tanzania, Rwanda, Mauritius and Southern Sudan. COMESA is already short of milk therefore there's a huge potential in 24 countries in the COMESA region.	Head Office Plot 49-53 5th Street, Ind P.O. Box 7078 Kampala, Uganda Tel: 256 414 258 751 Tel: 256 414 258 755 Fax: 256 414 230 942
	Greenfields Uganda Uganda's first fish processing plant in the outskirts of Entebbe garden town. Strategically located on the shores of Lake Victoria, the factory is five kilometers from Uganda's fully refurbished airport, and one kilometer from the company's approved landing harbor. The company has its own potable water treatment station, effluent treatment plant, fleet of vehicles, and modern	Greenfields Uganda Head Office Plot 15-17 Entebbe Ind P.O. Box 667 Entebbe, Uganda Tel: 256 414 321 141 Tel: 256 414 320 716 Fax: 256 414 321 386

	processing plant with top of the line chilling and freezing facilities	
	Bee Natural Uganda Ltd Bee Natural Uganda Ltd started business in April 2008 after an investment buyout of the previous company Bee Natural products Ltd. Our main area of operation is the west Nile region which includes the districts of Arua, Nebbi, Yumbe, Moyo, Koboko and Adjumani. The Ediofe Mission Centre in Arua is the location of our modern processing plant. Our control of quality is achieved by working with the registered 1,200 beekeepers that are clustered into groups of 15.	Pan Africa House Plot 3 Kimathi Avenue P.O. Box 5318 Kampala, Uganda Tel: 256 414 253 844
Rwenzori Commodities	Rwenzori Commodities Ltd Rwenzori Commodities Ltd is part of Mukwano Group of Companies. It was started 15 years ago by Mr. Amirali Karmali, now Chairman of the Group. Rwenzori Commodities is a very special Company, since the family roots lay in Fort Portal, Kabarole district, the very location of the tea gardens at the foothills of the Rwenzori Mountains.	Plot 9 Old Port bell Road P.O. Box 20072 Lugogo, Uganda Tel: 256 413 490 70 Tel: 256 413 477 2
	Star Coffee Producing coffee right from the Ugandan soil, Star Café Ltd has raised the standard for the world to enjoy the best quality coffee at an affordable price and at the same time set its focus on boosting coffee farmers by partnering with the	Plot 703 P.O. Box 25604 Kampala, Uganda Tel: 256 414 253 454 Fax: 256 414 254 417

	small holder farmers directly.	
	Uganda Coffee Development The Uganda Coffee Development Authority (UCDA) was established by statutory mandate in 1991 following the liberalization of the coffee industry. Vision: 'Making Uganda a distinguished producer of high value coffee	Coffee House Plot 35 Jinja Road P.O. Box 7267 Kampala, Uganda Tel: 256 412 569 40 Tel: 256 412 233 073 Fax: 256 412 569 94
Uganda Tea Corporation Ltd	Uganda Tea Corporation Uganda Tea Corporation Limited (UTCL) has been a leading tea producer and exporter in U for over 20 years. It has three estates with its headquarters at Kasaku near Lugazi. Kasaku is about 48 Km from Kampala and 40 Km from Jinja.UTCL is also one of the leading corporations in the private sector in Uganda contributing more than 10% of Uganda's national tea production.	Head Office Kampala, Uganda
	Quality cuts Whether its tender cuts of beef, lamb, pork or chicken, Quality Cuts provides a vast Range of prepared and cold meats. On top of this, we serve a wide range of savory home-made, marinated and seasoned meats perfect for the barbecue. Quality Cuts also offers exotic cheeses and ice cream in a cool, fresh and hygienic environment. Plus, you can order online and enjoy our convenient delivery service!	Head Office Plot 1273 Gaba Road P.O. Box 12721 Kampala, Uganda Tel: 256 414 510 465 Tel: 256 392 206 65
Tilda	Tilda Uganda Ltd A British owned company in that does Farming, processing ,	P.O. Box 23019 Kampala Kibimba, Bugiri Tel: +256 (033) 555 000

	import, export , sales and distribution of rice in Uganda	Fax: +256 (033) 555 111 Mobile: +256 (077) 2255 444 E-mail: venu@tildauganda.com
	MUKWANO PERSONAL CARE PRODUCTS LTD – (MPCP).	A MEMBER OF MUKWANO GROUP Plot 339, MBUYA II, NAKAWA INDUSTRIAL AREA P.O. Box 2671, Kampala-Uganda. For Customer Care- Call Toll Free: 0800200070 Email: admin@mukwano.com, Website: www.mukwano.com
	A.K OILS & FATS (U) LTD – (KAMPALA).	A MEMBER OF MUKWANO GROUP Plot 30, Mukwano Road, P.O. Box 2671, Kampala-Uganda. For Customer Care- Call Toll Free: 0800200070
	MUKWANO INDUSTRIES (U) LTD. BEVERAGE DIVISION.	A MEMBER OF MUKWANO GROUP Beverage Division, 8th Street, P.O. Box 2671, Kampala-Uganda. For Customer Care- Call Toll Free: 0800200070 Email: admin@mukwano.com, Website: www.mukwano.com
	KAMPALA JELLLITONE SUPPLIERS LTD Kampala Jellitone Suppliers (KJS) is Uganda's first producer of briquettes made from agricultural wastes. Made mainly from sawdust, peanut husks and coffee waste, the fuel replaces wood and charcoal helping protect the rich biodiversity of the area. Schools, hospitals and factories across the country are buying 130 tonnes a month of	Plot 259, Sir Albert Cook Road, Factory Zone Nateete, Rubaga Division, Kampala District P.O. Box 30430, Kampala Uganda Tel no: +256-414-270-887, +256-414-274-976, +256-772-409-405, +256-772-491-377 Email: a.k.musisi@jellitone.com www.jellitone.com www.nguvucoffee.com

	briquettes, along with efficient stoves for heating and cooking. The business is set to double over the next two years and hoping to expand to other African markets.	
Uganda Clays Ltd	Uganda Clays Ltd Uganda Clays Ltd is Uganda's leading manufacturer of quality baked clay building products. Using Italian-made heavy clay processing machinery, the Company manufactures well over 40 items of building materials from clay excavated using surface mining techniques. The materials are baked to a characteristic Kajjansi brick-red color in two continuous Hoffman kilns using coffee husks.	PO Box 3188 Entebbe Rd Kajjansi, Kampala Tel: +256 41 420 0255 +256 41 420 0261 email: uclays@ugandaclays.co.ug
	Ugachick Poultry Breeders Ugachick Poultry Breeders is a private Ugandan, family owned and run business. Established in 1992, it has since evolved into a vertically integrated poultry producer. Located in Magigye, about 15 miles North of Kampala. Ugachick Poultry Breeders has five mutually dependent business divisions; Feed Mill, Parent Stock Farm, Hatchery, Broiler Farm and Processing Plant. The Parent Stock farm produces hatching eggs for our Hatchery, which in turn is used to produce day-old-chicks. The day-old-chicks are sold to commercial farmers and some of the boilers are reared on our farm.	Magigye Farm, Namulonge Rd, Gayaza, P.O. Box 12337 Kampala, Uganda Tel: +256 414 251957 +256 414 250341 +256 772 404491 +256 392 853492 Fax: +256 414 251958 E-mail: ugachick@infocom.co.ug, info@ugachick.co

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