RUNRES CITY- REGION CONTEXT STUDIES

Prepared by:

The RUNRES core team

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1 Introduction

1.1 Project Background

RUNRES: The rural-urban nexus: Establishing a nutrient loop to improve city region food system resilience is a four-year development project funded by the Swiss Agency for Development and Cooperation (SDC). The purpose of RUNRES is to address two critical development challenges facing rapidly urbanizing countries across Sub-Saharan Africa: the provision of dignified and sustainable basic sanitation; and the sustainable and equitable production of food. Currently, both the sanitation and agricultural sectors are dominated by linear solutions that are heavily dependent on resource intensive inputs. These approaches are obsolete and have led to radical nutrient imbalances within rural-urban interfaces across the world. In rural areas, long-term nutrient mining has created a downward trend of agricultural productivity, which harms livelihoods and exacerbates food insecurity. Simultaneously, rapidly growing urban areas suffer from an accumulation of nutrients; the insufficient collection and disposal of organic green waste, food waste, and human waste presents a critical environmental and human health risk in cities across lower income countries.

Most development approaches view these problems as disconnected. In contrast, RUNRES views the provision of processes capable of capturing, treating, and reusing food processing and urban waste streams as a viable alternative model, one capable of supporting resilient and sustainable communities. Thus, by reimagining the rural-urban relationship, RUNRES seeks to create a transformed local economy, one which supports a circular flow of resources within four city-regions across Sub-Saharan Africa: Bukavu, Democratic Republic of the Congo; Arba Minch, Ethiopia; Kamonyi, Rwanda; Msunduzi, South Africa. To achieve this goal, the RUNRES team, working within a transdisciplinary framework that prioritizes stakeholder input and participation, developed the RUNRES theory of change (TOC) (Figure 1.1), which serves as the theoretical roadmap guiding the project.

To achieve the outcomes laid out in the TOC, however, a nuanced understanding of the local conditions within each city-region is critical. Thus, the RUNRES core team conducted a context analysis in each of the four project sites during the first year of the project. This work focused on the following thematic areas:

- Socio-economic background
- Policy and Regulatory Environment
- Agricultural production systems
- The city-region food value chain
- Rural-urban waste flows

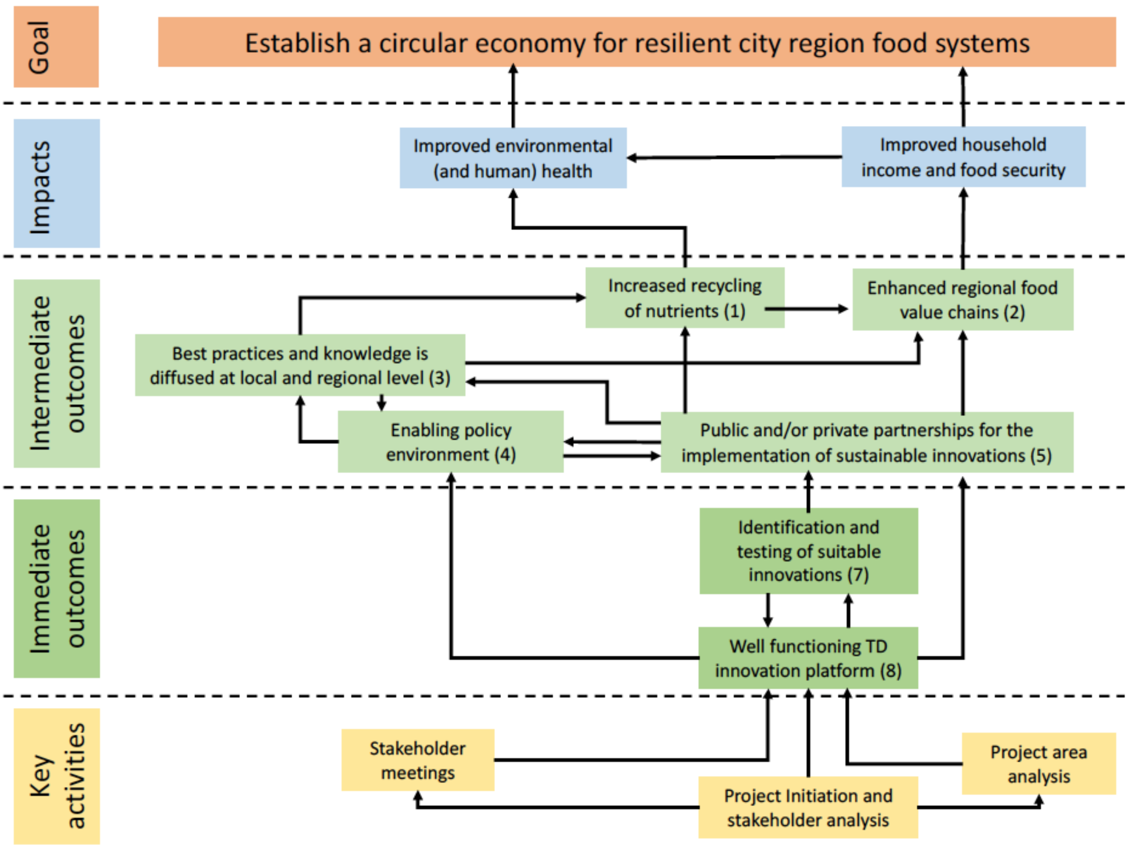

Figure 1.2: RUNRES theory of change

Together, these context studies provide the information and understanding necessary for the RUNRES core team and country stakeholders to select locally appropriate innovations capable of supporting a transition towards a circular economy predicated on nutrient recycling. The document below is the result of this effort. It is to be noted, however, that these studies are exploratory in nature and are intended to serve as a foundation upon which future reports will be based.

1.2 Report Scope & Structure

The purpose, scope, and structure of this report is to provide a preliminary understanding of the local conditions and issues that are pertinent to the identification, selection, and implementation of locally appropriate innovations within each RUNRES city-region. The selection of locally appropriate, economically viable, and technologically proven innovations is a critical project challenge. Efforts to shift the food system from a linear model towards one predicated on circular flows of resources face an array of regulatory, biophysical, technical, and socio-economic hurdles. Successfully navigating through these challenges requires a nuanced understanding of the local conditions within each project. This report is intended to provide the first step towards acquiring this knowledge.

The report is structured to provide any reader the ability to understand the socio-economic, biophysical, and regulatory landscape in each of the four city-regions. An initial introduction to each city-region is followed by an in-depth assessment of the key themes of the report. Structured around each theme, the report will allow readers an ability to quickly appreciate the large differences that exist within each city-region.

1.3 Executive summaries

1.3.1 Production systems

This context study aimed to generate an overall understanding of agroecosystems at a farm and regional level within each RUNRES city-region by: (i) characterizing the site's geographical and environmental context and (ii) understanding current agricultural practices, land tenure systems, and market dynamics. To accomplish these objectives, this work utilized existing literature, farmer focus group discussions, and semi-structured interviews with content matter specialists. Our findings indicate that three of the RUNRES city-region economies, Arba Minch, Ethiopia, Kamonyi, Rwanda, and Bukavu, DRC are heavily dependent on local agricultural production, with key commodities and supply chains easily identifiable. In contrast, small-holder farming plays a less prominent economic role in Msunduzi, South Africa. Here, large commercial growers dominate the food system, from production to market, in ways that are unique across the four city-regions. Despite this difference, smallholder subsistence production is still common in the rural areas of the city-region and efforts to organize and grow this activity to improve economic development are heavily supported by the South African government.

In addition, this study found that similar challenges are faced by farmers in each of the analyzed production systems. For example, the project researchers routinely identified that insufficient access to both organic and inorganic fertilizers is a major challenge facing smallholder production. Closely linked to this problem, both existing literature as well as interviews with content matter specialists express that poor soil fertility and health is a critical biophysical challenge facing the farmers. Interviewed farmers also frequently stated that poor postharvest processing is a key challenge that contributes to high amounts of waste and a reduction in farm profitability. Indeed, extension agents identified improved small-scale processing as an area of interest in every project site. Finally, this study identified market access as a key barrier to smallholder success. Large distances to market, insufficient transport capacity, and high spoilage rates all conspire to impede the ability of smallholder farmers in the study sites to successfully sell the commodities they produce.

However, this study also identified opportunities in the four production systems. For example, RUNRES scientists found strong state support for local agricultural production within the four city-region food systems. Extension agents, input subsidies, funding grants, and local academic institutions all provide mechanisms for local producers to receive aid. Support of this kind indicates that the importance of smallholder production is well recognized and provides opportunities to introduce the concept of a circular food system within each local context.

1.3.2 Food Value Chain

In this report we collected and analyzed data from food commodity value chains from three city-regions of the RUNRES project across three different countries, namely, cassava in Rwanda, coffee in DRC, and bananas in Ethiopia. Data from South Africa was not considered as a food commodity value chain was not yet clearly defined. We collected data from randomly selected actors along the respective food commodity value chains from all available actor segments in the respective value chains, including input sellers, farmers, middlemen, processors, wholesalers, retailers, and consumers. Data was collected electronically by project coordinators and enumerators and was analyzed descriptively by the project scientists. Data was collected from a sample of 2,721 consumer households (1,318 from Rwanda, 809 from DRC, and 594 from Ethiopia). In addition, a sizeable number of households were also interviewed from other actor segments.

Analysis of the data revealed that most of the actors in these food commodity value chains are, in general, minimally educated, with the majority of the respondents having attained only primary level education. With regards to the value chain composition, some food commodity value chains in some countries (city-regions), notably Ethiopia, are incomplete with some actors completely inexistent. For instance, input suppliers, wholesalers, and retailers are missing, while in other value chains some actors are too few in number to even warrant statistical validity of their sample. For instance, the banana value chain in Ethiopia has only one processor, while the coffee value chain in DRC has only seven input suppliers. The cassava value chain in Rwanda has only twelve wholesalers. Almost all actors make net positive returns from their business activities in all value chains, however most actors operate on a small-scale, and these net returns are very small, thus subjecting actors to consumption constraints. Along the food commodity value chains, many actors face various challenges, including poor market and communication infrastructure, and lack of access to financial or technical assistance.

Business policy regimes (regulations or laws) seem unknown and thus indirectly “unavailable” to most actors (actors largely stated that they were not guided by any policies in their businesses). In all business activities along all actor segments, men dominate, particularly business ownership and transportation services, while females mostly dominate in shop attendant activities. Exchange of information between actors and customers is dominated by the person-to-person mechanism or use of phone calls, and in some chains the internet was never used at all. Most of the clients for most actors are from the local communities, mostly in the target city-regions. Most actors sell their products (crops) as fresh harvests or with minimal processing (dry cassava pellets or dried coffee beans). Most actors keep their customers committed by ensuring proper product performance, offering good prices, and ensuring good personal relations. Many actors view the availability of relatively cheap raw materials for their activities in these value chains, and the prospectively high demand of respective food commodity products as key opportunities that can be harnessed in these value chains. Most actors minimally use inputs from formal systems other than their own sources, and when they are purchased, they mostly buy fertilizers that are inorganic. Therefore, innovations that could valorize organic waste for production of organic fertilizers could play an important role across all value chains. In some instances, some consumers experience food insecurity, at times, at a very high frequency. Therefore, interventions / innovations in these value chains that could lead to increased food productivity or market access with added value through processing, could bring about positive impacts in household incomes and food security. In all value chains, in above average proportions (over 50%), actors stated that they are aware of circular economy (CE) concepts, and are also knowledgeable about these concepts. In even bigger proportions (over 80%), actors would support such CE concepts in their communities. Moreover, a very high proportion of consumers (70% – 95%) across all food commodity value chains are willing to pay for and or consume farm products or foods grown using circular economy-based principles – for instance urine as fertilizer, fecal material as fertilizer or compost as a fertilizer. However, in all cases the preference for compost fertilizer or food products is stronger than for urine or feces, implying that some awareness to consumers on the safety of urine or feces grown foods may still be needed.

Generally, all the three food commodity value chains are dominated by low educated actors, implying that technical assistance or innovations that would enhance access to technical information could help improve the value of the products in these chains. Moreover, most actors also identified failure to access technical and financial assistance as a key challenge. In all food value chains, there is very minimal processing. Thus, most of the products are sold as fresh products with minimal value addition. Therefore, innovations that can enhance processing activities to add value to products at various actor segments would also significantly improve high value food markets' access, thus income returns to respective actors. On the other hand, most of the waste generated from activities of many actors is merely dumped and not recycled for reuse in these food systems. Yet, many actors have minimal capacity to buy farm inputs, especially fertilizers. Therefore, innovations that can enhance valorization of waste generated by actors along these chains, while following the circular economy model, can enhance closing of nutrient loops, improve soil nutrient content, and subsequently crop or animal productivity that should in the end enhance household incomes and food security.

1.3.3 Waste stream mapping

Presently, the generation of organic and inorganic waste in urban and rural areas of Sub-Saharan Africa poses a health and environmental risk. Furthermore, the waste being lost into the environment contains large amounts of mineral nutrients (NPK) and organic C. At the same time, countries in the sub-Saharan region suffer chronic nutrient mining as minerals exported from farms are transported to urban areas through agricultural produce and are lost as human excreta and food waste. Therefore, the RUNRES project was established to promote synergy between rural and urban areas with an aim to improve waste and food values chains for a circular economy.

Critical to the achievement of this goal is the quantification of the waste streams currently produced within each project site. Thus, the waste stream mapping work of RUNRES was designed to map and quantify the flows of inputs into the city, the transition of these inputs from resources into waste, and the flow of the produced waste (human excreta, organic waste) to current disposal sites. This protocol comprised three major outputs.

1.) City-region solid waste collection and management analysis
2.) Shit flow Diagram
3.) Nutrient flow analyses

Within each city-region, the RUNRES team identified that large amounts of organic urban green waste and food waste are produced. On average, of the total amount of waste generated, 60-80% is biodegradable and could be used to support nutrient recycling innovations. Furthermore, the RUNRES team found that some form of public-private cooperation forms the basis of solid waste management efforts in each of the four city-regions.

With regards to human waste, the sanitation landscape differs markedly across city-regions, with South Africa once again being quite unique amongst the four. In Msunduzi, the urban core benefits from a very well-developed municipal sewage system. However, in the peri-urban and rural areas of the city region, pit latrines are the primary sanitation solution. Similarly, the primary sanitation solution utilized in the other three city-regions is the pit latrine. Given the volumes of human waste produced, and the fact that municipalities are searching for solutions to this development challenge, innovations capable of capturing, and effectively processing, human waste into soil inputs have potential to supply large amounts of locally produced soil nutrients that could support sustainable city-region food systems.

1.3.4 Socio-economic context

In this context study, we looked at the socio-economic situation in the four RUNRES countries. For this, we took the five different conceptual lenses: *acceptance, social capital, cultural theory*, and *taboos*. In addition to a quantitative approach, this study also entailed a qualitative approach, where we used *grounded theory* to uncover remaining issues around the re-circulation of organic waste in RUNRES, also with a perspective on how the different respondents see development in a context of recycling waste. This study is based on data collected among key-informants, relying on relatively small sub-samples of 20 to 30 respondents per country. The results of this study may therefore not fully represent what the entire set of actors affected by RUNRES might think about the different aspects that we aim to observe. However, this study is, nevertheless, very complementary to the other studies and will be complemented by data collected through the monitoring surveys.

In the different RUNRES countries, we found high levels of acceptance towards the use of organic waste for agricultural production among the respondents, as well as for their related concepts appraisal and support, with slightly lower levels regarding the re-use of human waste. Through cultural theory, we observed that grid-response is relatively low for the respondents (i.e., stronger individualism or egalitarianism), except for the respondents in Rwanda (i.e., a stronger hierarchy). In addition, respondents from DRC and Rwanda are relatively high on group-response (i.e., tending to egalitarianism), while those from Ethiopia is relatively lower (i.e., more individualism). The lenses of social capital could not provide data that are easily comparable between the different RUNRES countries, but we could still observe relatively low levels of general trust among the respondents for the DRC, and moderate levels for Rwanda. The respondents did not report specific taboos, although dealing with human waste may be seen as belonging to lower social positions, and disgust may play a role in the acceptance of the use of human waste. Finally, the collected qualitative data also showed that many respondents view the lack of acceptance of re-using human waste as a result of a lack of knowledge, and they therefore suggest that demonstrations and education measures can help in increasing acceptance.

1.3.5 Policy and regulatory environment

In this context study we present an evaluation of the legal viability of the different RUNRES activities to re-circulate nutrients. We cover the RUNRES activities through three main fields: farming, trading, and consumption, which we split in the three main re-circulation loops as defined by RUNRES: organic waste, human waste, and small-scale processing. Nevertheless, we also focus in this study on the most contentious issue related to recycling waste: the use of human waste for agricultural production. In all RUNRES countries, the legal frames state that people and the environment must be preserved from the effects of hazardous waste. However, the way this protection is defined varies between the different countries.

In Rwanda, it is not forbidden to use human waste for agricultural production, but it must be treated before being applied. In addition, food grown for export must be compliant with the rules of the countries where the crops are exported to, potentially presenting a major barrier to the use of treated human-waste as a fertilizer. *In South Africa*, it is allowed to use human waste such as treated sewage sludge for agricultural production, and the country is the only one in RUNRES to have legally stated pathogen thresholds for human waste. In addition, depending on the proposed recycling activities and the potential hazard caused by the waste in question, actors have to apply for a waste management licence permit. *In DRC*, there is no explicit law regulating the use of human waste for agricultural production. However, from a sanitation perspective, toilets have to be built according to local regulations and have to be approved by the local authorities. *In Ethiopia*: the current legal scheme does not explicitly state that using human waste for agricultural production is forbidden. However, this statement requires a cross-check with legal specialists as a subsequent step to assure that RUNRES activities may not be compromised.

Overall, the treatment, storage, and use of human waste for agriculture production is not clearly regulated, except for South Africa. We can therefore assume that using human waste in the way envisioned by the current innovation can be safe for the first phase of RUNRES, which remains experimental. However, a more thorough evaluation will have to be carried out when RUNRES will reach the stage where the different innovations will be upscaled.

2 City-Region Introductions

2.1 Bukavu, Democratic Republic of the Congo

The city of Bukavu (Figure 2.1) comprises an area of 60 km^2 and extends between 2 ° 26 'to 2 ° 33' South latitude from 28 ° 49 'to 28 ° 53' longitude East. It is located within the highlands of South Kivu province at an altitude between 1,460 m (lake level) and 1,900 m (Kadutu summit). Both the province and the country itself remain at the very bottom of the Human Development Index (HDI), positioning it at 176 out of 189 countries in 2017 (United Nations, 2018) and at the bottom of the Gross Domestic Product per capita ranking (rank 179) (World Bank, 2018). Currently, 77% of the population lives below the international poverty line of 1.9 \$ d^{-1}capita^{-1} (World bank, 2018). The country's economy is predominantly agrarian and remains, together with the mining sector, the driving force of economic activity.

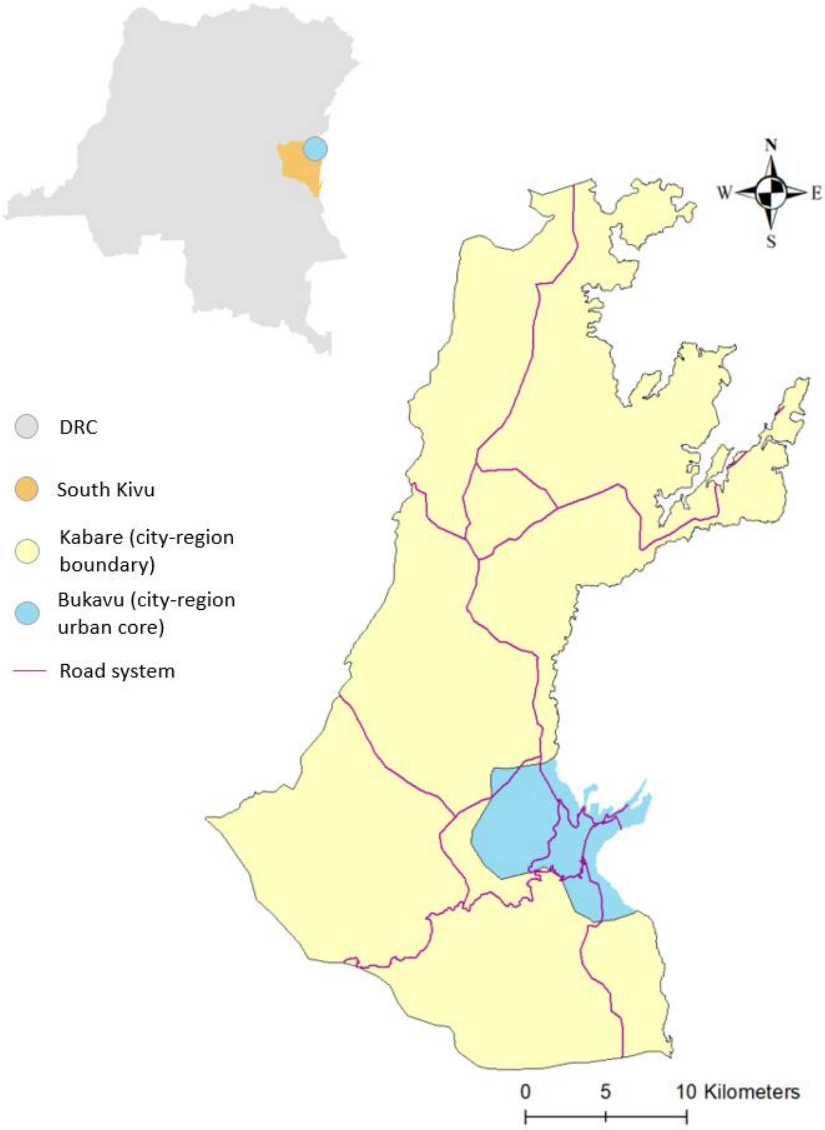

Figure 2.1: Bukavu city-region (GIS data obtained from municipality of Bukavu, 2020).

Administratively, the city is made up of three municipalities, namely Ibanda, Kadutu and Bagira. The city infrastructure, most of which was constructed during the colonial period, was designed to accommodate 50,000 inhabitants. However, approximately 1,184,913 inhabitants reside in the city currently. This increase in the population residing in Bukavu is due not only to the natural growth linked to high national birth rates but also to the rural exodus caused by livelihood challenges that exist in rural areas of the country. As with many cities in lower income countries, the municipality struggles to provide sufficient levels of solid waste management, basic sanitation, food security, and employment.

2.2 Arba Minch, Ethiopia

Located roughly 500 kilometers south of the Ethiopian capital Addis Ababa, Arba Minch is a municipality in the Gamo Gofa Zone of the Southern Nations, Nationalities, and Peoples Region (Figure 2.2). The population within the city-region is approximately 221,677 residents. According to Jenberu & Admasu, (2019), Arba Minch is one of the fastest growing urban areas in the region. This rapid rate of urbanization has placed enormous strain on existing resources, with the municipality struggling to provide sufficient basic sanitation, housing, and employment opportunities to meet this growing population. Data collected by Jenberu & Admasu, (2019), indicates that a major driver of this rapid population growth is due to the influx of new residents not only from outlying rural areas within the zone and region, but across the country.

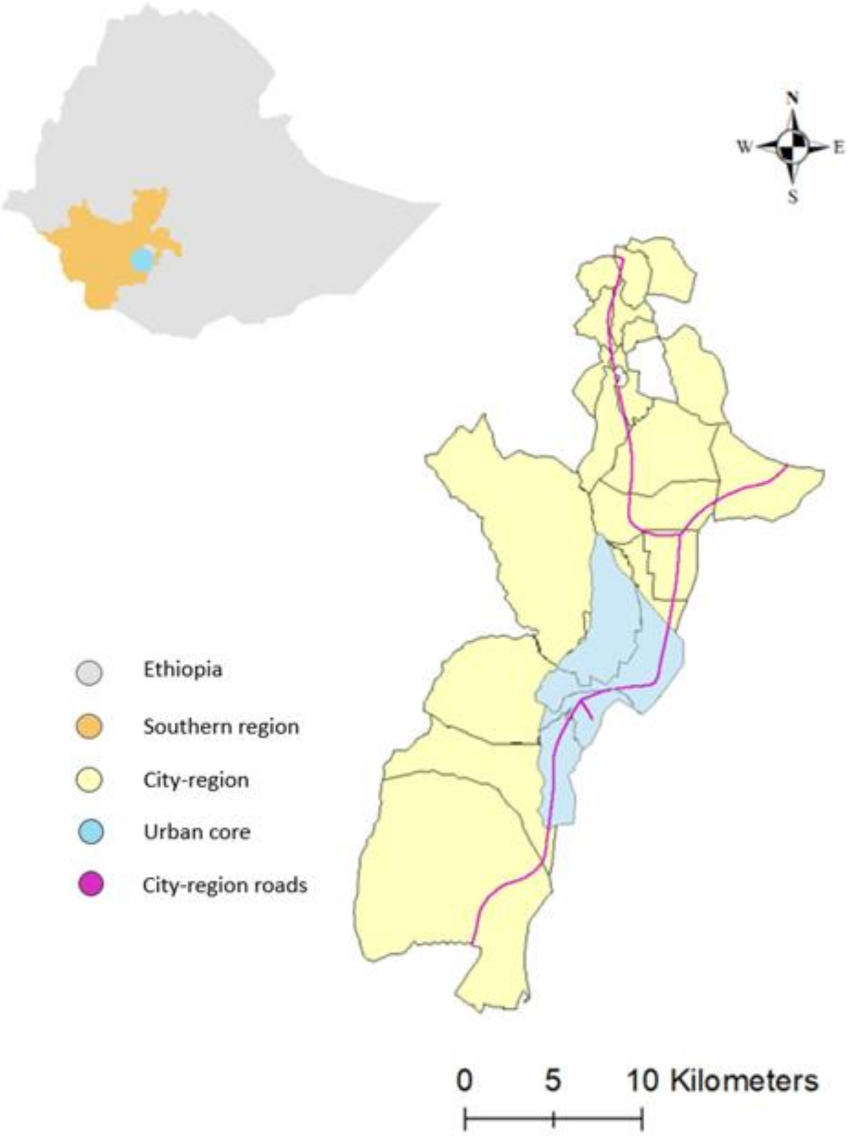

Figure 2.2: Arba Minch, Ethiopia city- region (GIS data obtained from Arba Minch municipality).

As with much of the economy of Ethiopia, agricultural production plays a critical role for the economy of Arba Minch. Farmers in the rural areas of the city-region grow cash crops such as banana, papaya, mango, and apple. This produce is sold in local markets within the local food system and exported to foreign markets (GGZ ARDO, 2015).

2.3 Msunduzi, South Africa

Msunduzi municipality is the city-region boundary in which RUNRES is operating in South Africa (Figure 2.3). The Municipal Demarcations Board (MDB) classified Msunduzi as a category B (local municipality) of the uMgungundlovu district municipality (category C). Msunduzi is the largest local municipality within the uMgungundlovu District Municipality, and the second largest in KwaZulu-Natal with a population of 679,039 (Statistics South Africa, 2016). Pietermaritzburg, located within Msunduzi, is the capital of KwaZulu-Natal. It is comprised of four Area based Management (ABM) zones; Vulindlela, Greater Edendale and Imbali, Northern Areas, and Ashburton and Eastern Areas. The RUNRES pilot studies will focus primarily in Vulindlela, a rural area in the west of Msunduzi, and Sobantu, a peri-urban community in the eastern portion of the city-region.

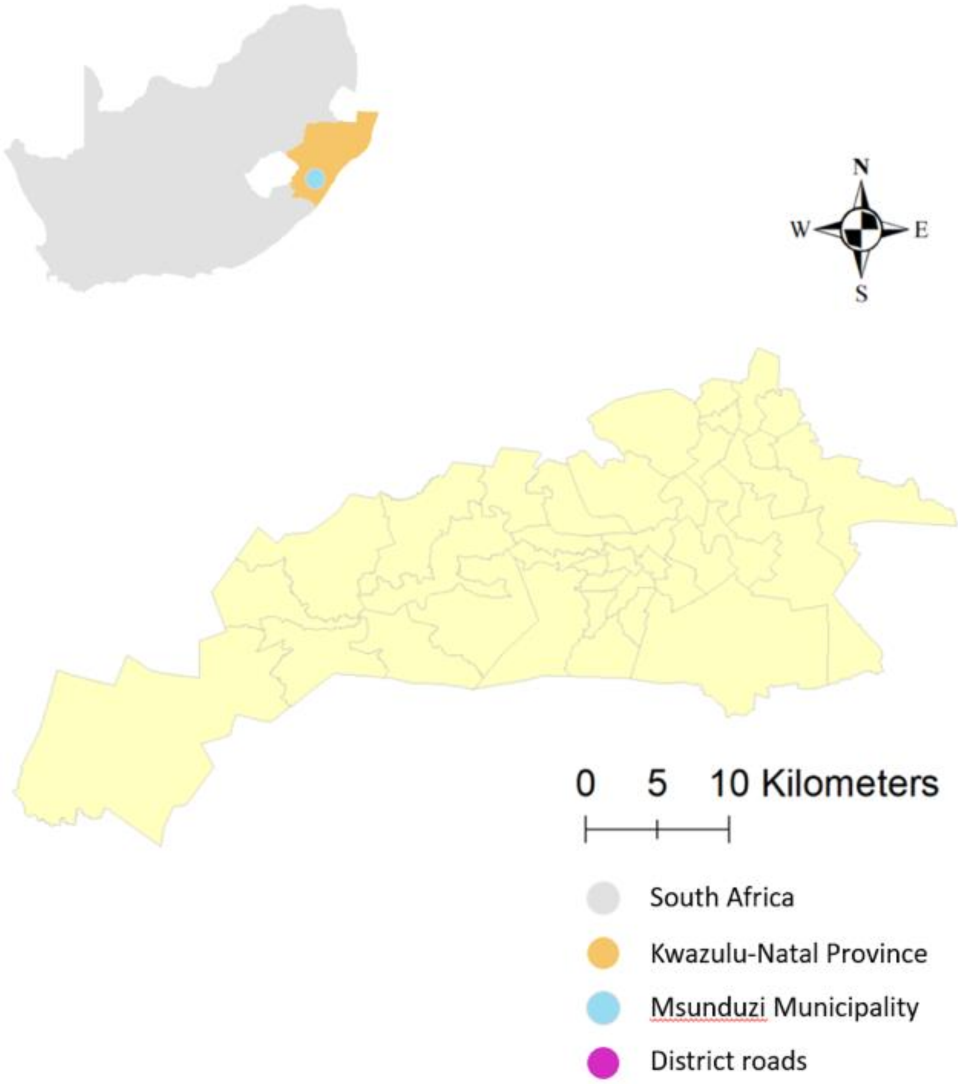

Figure 2.3: The city-region boundary for RUNRES Msunduzi, showing the location of the other surrounding municipalities within the province (Msunduzi municipality, 2020).

The city-region lies within the Msunduzi river basin with altitudes ranging from 495 – 795 meters above sea level. The area slopes down from west to east, which influences the climatic conditions of the region. Average annual temperatures vary from 16°C to 18°C, with cool dry winters and hot wet summers characteristic of the seasons. Average rainfall varies between 748 and 1017 mm year^{-1}.

Demographic dynamics indicate an increasing population within the Msunduzi municipal boundary. This has impacts on poverty, food security and service provision. In addition, the municipality struggles with high youth unemployment, low education levels, and poor income generation opportunities (Crush, 2012). Furthermore, in the rural areas of the city-region there is no solid waste collection service and basic sanitation is a challenge. Simultaneously, the urban core of the municipality, because of high rates of urban migration, is struggling to maintain current levels of solid waste and human waste management.

2.4 Kamonyi, Rwanda

Kamonyi city-region is a district located within the southern province of Rwanda. The district is divided into twelve sectors: Gacurabwenge, Karama, Kayenzi, Kayumbu, Mugina, Musambira, Ngamba, Nyamiyaga, Nyarubaka, Rugalika, Rukoma, and Runa that comprise a total area of 655 km^2 (Figure 2.4).

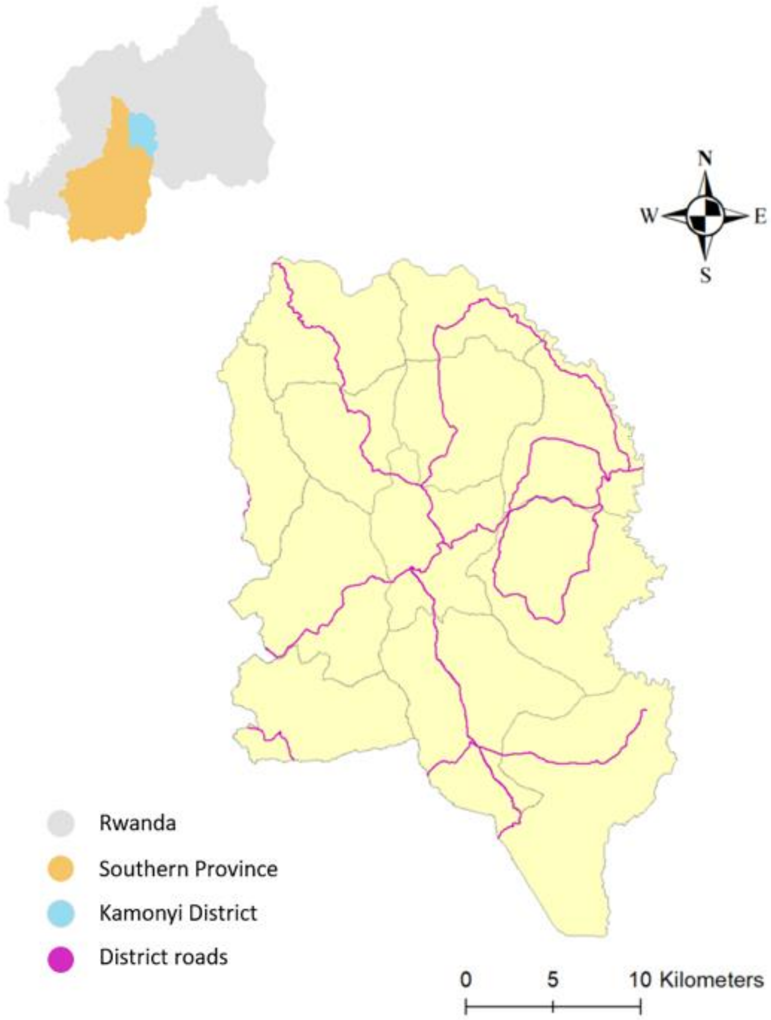

Figure 2.4: Kamonyi city-region (Kamonyi GIS data, 2020).

As of the 2012 census, the population within the city-region is approximately 340,501. According to the World Bank (2017), Rwanda has experienced rapid rates of urbanization over the past decade, with the proportion of the nation's population in urban areas increasing from 16 to 27 percent between 2002 and 2015. Although a complex phenomenon shaped by a variety of "push" and "pull" factors (Tacoli, 2003), migration into urban centers in Rwanda is largely driven by two factors: better economic opportunities in the cities, and a lack of access to land in rural areas (World Bank, 2017).

3 Agricultural Production Systems

Acronyms and Abbreviations

CARG	Agricultural and Rural Management
CSIR	Council for Scientific and Industrial Research
COCOF	Conseil Consultatif des Femmes
DAFF	Department of Agriculture, Forestry and Fisheries
DALRRD	Department of Agriculture, Land Reform and Rural Dev.
DAP	Diammonium phosphate
DRDLR	Department of rural Development and Land Reform
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
KZN	Kwazulu- Natal
LCCS	Land Cover Classification System
MINAGRI	Democratic Republic of the Congo Ministry of Agriculture
PTO	Permission to Occupy
RAB	Rwanda Agriculture Board
RASET	Radical Agrarian Socio-Economic Transformation
RDO	Rwanda Development Organization
RWARRI	Rwanda Rural Rehabilitation Initiative
SARA	Sludge application rate advisor
UNEP	United Nations Environmental Program

3.1 Bukavu, Democratic Republic of the Congo

Introduction

Democratic Republic of the Congo's economy is still predominantly agrarian and remains, together with the mining sector, the driving force of economic development. Thus, the county's prosperity relies heavily on ecosystem goods and services, in particular on fertile and productive soils. Beside the importance of the export of agrarian goods (coffee, rubber) guaranteeing employment and income, agriculture is of uttermost importance to provide food security for smallholder farmers, not only in the target city-region, but also in other parts of the country. The agricultural sector is governed by the Democratic Republic of the Congo Ministry of Agriculture (MINAGRI). Further, the country has set up Agricultural and Rural Management Councils (CARGs), which are platforms for discussion, information sharing, and formulation of local agricultural strategies on territory and province level.

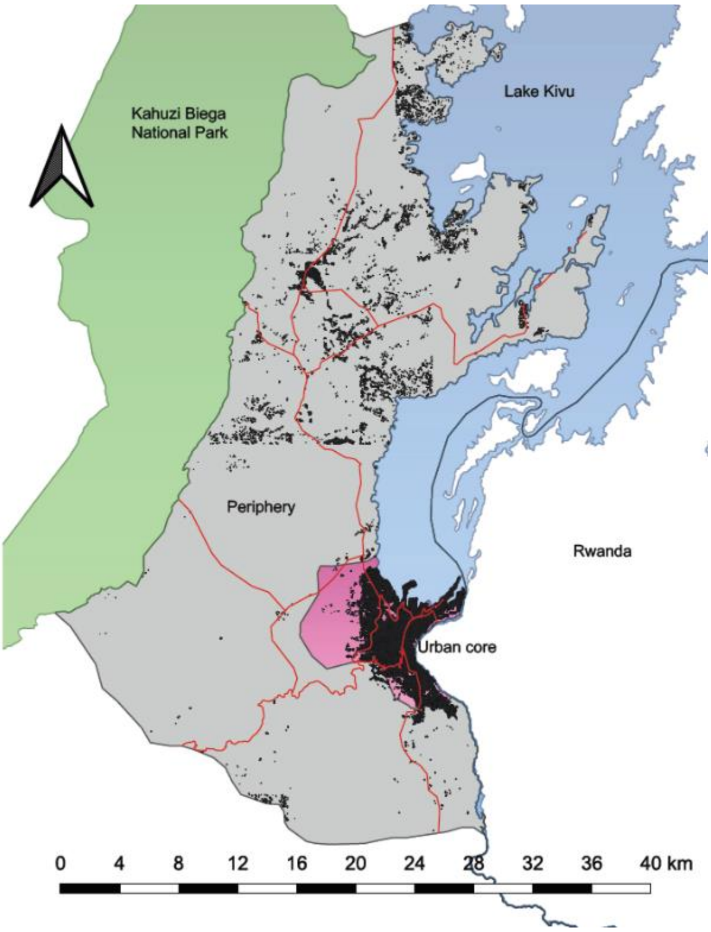

Figure 3.1: The city-region with urban core (black), peri-urban (pink), and rural (grey) highlighted.

Characterization of the study area

We can divide the study area into three layers according to their characterization and function for the city region. The urban core is characterized by a high population density, urban structures and a second and third sector economy (Figure 3.1). The secondary layer is the peripheral territory around the urban core. Most agricultural products for the urban core are produced here. It is, thus, the agricultural territory of Kabare where both staple and cash crops are grown. As Bukavu is close to the Rwandan and Burundian borders, the tertiary layer should not be neglected. Together with other territories of South Kivu, these two neighboring countries play a crucial role for the trade of agricultural and non-agricultural products in the city region. The following paragraphs will describe each layer in more detail.

In this case study, the urban center of the city region Bukavu is the provincial capital of South Kivu in the DRC. The city itself consists of three communes, namely: Ibanda, Kadutu and Bagira (Figure 3.2). The city stretches from 2°28'S to 2°34'S in latitude and from 28°50'E to 28°53'E in longitude covering 58km^2. The altitude of the lake Kivu is 1460 m.a.s.l. while the highest point of the city is the summit of Kadutu in 1900m.a.s.l (Paul, 2019). By 2014, the population in Bukavu counted 857'000 (CTA, 2017) (13% of the total population in South Kivu). Two other studies confirm these findings with estimates between ~700,000 (Karume, 2017) and ~1,200,000 (Kayeye, 2013) persons living in ~155,000 households. Their estimations vary depending on the method of counting and the year of assessment. Further, 2'800 farming households exist within the core region - all in Bagira (CTA, 2017).

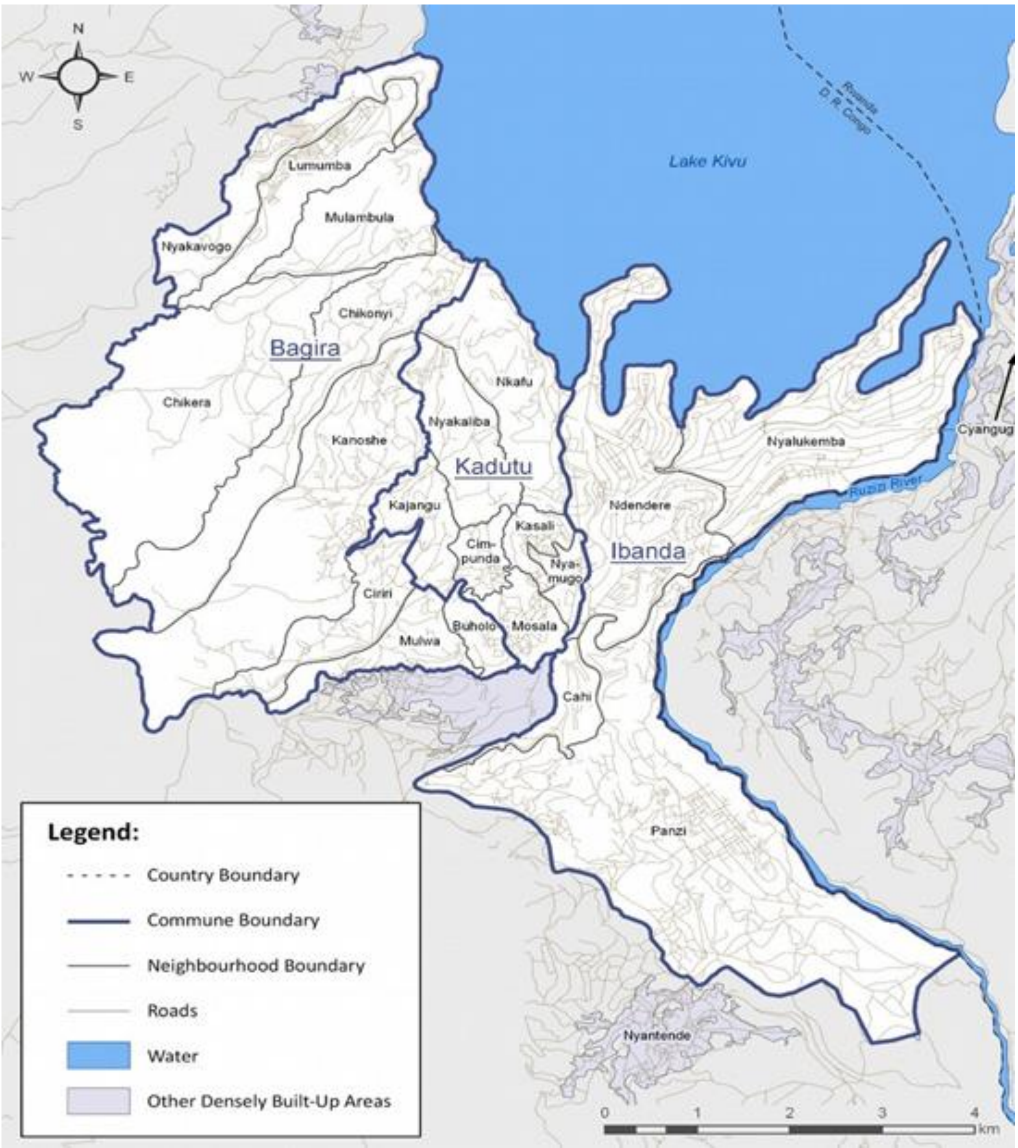

Figure 3.2: Organization of the Bukavu city-region

The peripheral region (Kabare) has a surface of 1,960km^2. In the year 2014, a census estimates 680,000 people and 61,000 farming households (=5.7% of all farming households in South Kivu) inhabiting Kabare (CTA, 2017). Over one third of the surface is protected and part of the Kahuzi Biega National Park. Thus, the peripheral region that is relevant for agricultural and other economic activities is 1,200km^2. The most common food crops which are produced in the area are: starchy tubers (cassava, sweet potatoes, potatoes, taro, yam), legumes (groundnuts, beans, peas, soybeans), cereals (maize, rice, sorghum, finger millet) and fruits (banana, pineapples) and vegetables (tomatoes, onions, leafy vegetables). Most agricultural products are meant for family consumption due to weak trade in agricultural food products in South-Kivu. Trade, commercialization, and market integration is constrained by low production, food insecurity, poor roads, and a lack of access to information (Vwima, 2014). In addition to the plant-based diet, food security in the city region also relies heavily on the fishery in Lake Kivu (i.e., sambaza, haplochromis) and livestock husbandry (goats, chicken, and cattle) for protein provision.

Coffee, sunflower, tea, oil palm, tobacco, cotton, sugar cane and cinchona are the main industrial crops produced and exported for further processing. The land tenure structure is diverse, and most farmers can be classified as smallholder producers. However, there are also large-scale farmers that are relevant for their higher yields and thus also for the food security of the region. The tertiary layer includes neighboring territories (Uvira, Kalehe) and provinces (North Kivu) within DRC but also Rwanda and Burundi as neighboring countries. Rwanda is particularly important for the city region because a lot of imported products are currently cheaper than local products. Due to a lack of adequate infrastructure, small input supply systems and rudimentary processing, local products sometimes pass through Rwanda first before being sold back to DRC. This phenomenon is particularly true for Bukavu. On average, the population of Bukavu consume about 1,030 kcal person^{-1} day^{-1}, of which 590 kcal, 90 kcal and 340 kcal are provided by products from Rwanda, North Kivu, and from within South Kivu, respectively. Thus, the city region imports most of its food from Rwanda, even for products for which the region holds some comparative advantage, which further aggravates deficiencies in the local production system.

Climate

The climate of the city region is determined not only by its geographical position (28°E 2°S), but also by its location to other influencing geographical traits (i.e., altitude, topography, water bodies, vegetation). Practically, the climate of the region is diverse and is influenced by wind speed regimes, rainfall patterns, altitude, water (Lake Kivu) and protected areas (Kahuzi Biega National park). The climate of the study area can be classified as tropical but moderated by its altitude. The study area is characterized by a bimodal pattern of two rainy seasons, occurring from March-May and September-December, followed by two short dry seasons in June-August and January-February (Figure 3.3). Annual rainfall is between 800mm (Ruzizi plain) and 2650mm (mountain zones). The maximum intensity during a rainfall is between 5 and 10 mm per minute (Carel, & Tondeur, 1986). The average monthly temperature is about 20°C. High variability in climatic factors is evident in recent years. This variability is registered in terms of date of onset of rainfall period (the date of rainfall start), the number of days of rainfall, and in terms of the frequency of semi-dry months during the rainy seasons (Munyuli, 2017).

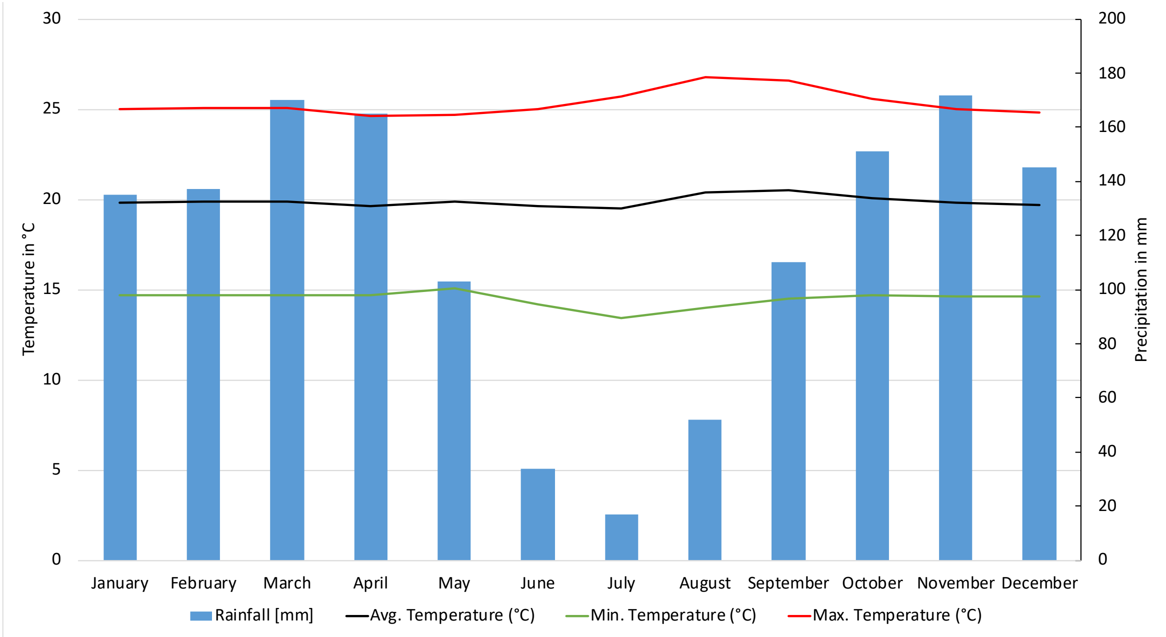

Figure 3.3: The climate in Bukavu (created with data from https://en.climate-data.org/africa/congo-kinshasa/sud-kivu/bukavu-4604/ retrieved on the 06.01.2020.

Vegetation

The vegetation within the city region boundary is remarkably diverse. In the study area we find the following categories of naturally abundant vegetation: primary and secondary equatorial mountain, forest, high altitude bamboo forest and steppes. However, due to high population density and a pronounced agrarian sector the vegetation is highly shaped by human activities. Most of the surface is either arable land, planted forest, or even buildup semipermanent or permanent. The land cover types, and its classes have been identified using the FAO/UNEP international standard LCCS classification system (Table 3.1). Most of the natural (tree and shrub dominated) vegetation can be found on the border with the Kahuzi Biega National Park, on steep slopes or on the shores of Lake Kivu.

Table 3.1: Land cover types

Major land cover type	Abbreviation	Description
Cultivated terrestrial vegetation	SR13H47V	Shrub crop, small field, clustered, 1 additional crop, herbaceous crops, rainfed, permanent, orchard and/or other type of plantation
	SR23H47V	Shrub crop, small field, isolated, 1 additional crop, herbaceous crops, rainfed, permanent, orchard and/or other type of plantation
	SR3H47V	Shrub crop, small field, 1 additional crop, herbaceous crops, rainfed, permanent, orchard and/or other type of plantation
	SR47V	Shrub crop, small field, rainfed, permanent, orchard and/or other type of plantation
	HR3S47	Herbaceous crop, small field, 1 additional crop, schrub crop, rainfed, permanent
Natural and seminatural terrestrial vegetation	2SPJ67	Shrubs, open general 65-15%, sub general height for shrubs (5-0.5m) and herb. (3-0.3m), herbaceous 2-3 layer, trees 2-3 layer
	2TCI217	Trees, closed, high, broad leaved deciduous, broad leaved evergreen, trees 2-3 layer

	2TPM86	Trees, open general 65-15%, medium height, shrub 2-3 layer, herbaceous 2-3 layer
Artificial surfaces	5U	Urban area
Inland water	8WP	Water bodies, perennial

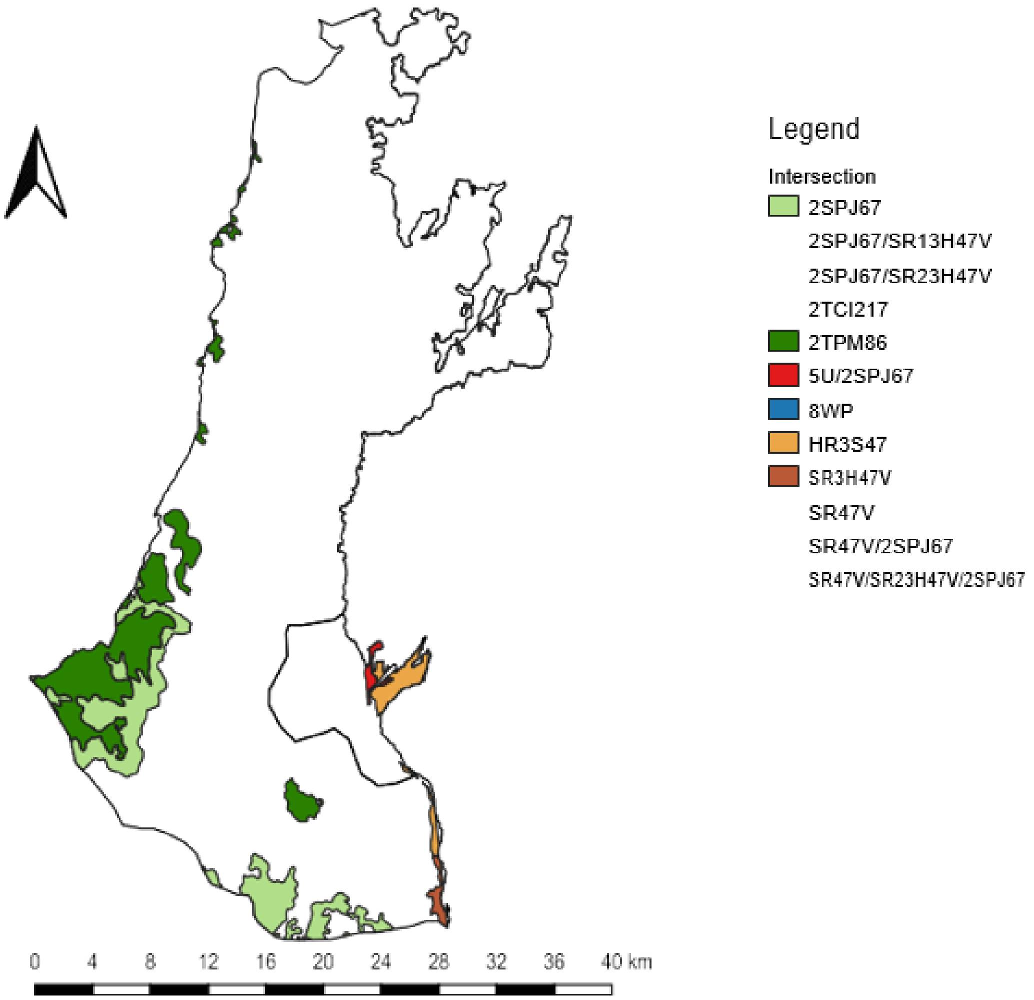

Figure 3.4: Dominant vegetation in the city-region (vegetation codes located in appendix).

Geology and soil classification

Agricultural activities are influenced by the given soils and their properties, which are themselves strongly influenced by the local geology. The western branch of the Rift Valley borders Uganda, Rwanda, Burundi, Tanzania, and Zambia. Thus, the bottom of this graben is occupied by the eastern lakes in the DRC, notably Lake Kivu. The graben is intersected by many extinct or active volcanoes (i.e., Nyragongo, Kahuzi, Biega), especially south and north of Lake Kivu. The city region itself is located on high plateaus. The geology classification is done based on Lepersonnne (1974) and the Global and National Soils and Terrain Digital Databases (SOTER) (Lepersonne, 1977). Most of the study area is covered by recent, basic lavas covering the Burundian Precambrian formations. Further, we subclassify in three different lithology types. Most of the area relevant for agricultural production consists of basic igneous rock (IB). In the western part, acidic metamorphic (MA) rock is the dominant parental material. Further, the third category is basic igneous basalt rock (IB2) which is found in a few areas where the Ruzizi river flows out of Lake Kivu.

Due to the predominant geology, there are young, fertile volcanic soils in the region. In general, most soils of the region are classified as Ferralsols. The alluvial plains around Lake Kivu have deep soil with good structure in contrast to the soils of the surrounding hills, which are more shale and clayey. The soils of South Kivu can be divided into four groups: soils recently formed from volcanic substrates, soils formed on old volcanic substrates that are predominantly basaltic, soils formed on old sedimentary and metamorphic rocks, and finally alluvial soils and fluvial deposits in the Ruzizi plain.

The abundant soil types in the specific city region are mainly (1) Haplic Acrisols (ACha), (2) Umbric Ferralsols (FRum). This classification is according to the African Soil Atlas (p.111) and the World Reference Base (WRB_96) as the international standard to classify soils (FAO, 2014). The map above (Figure 3.4) and the table in the appendix (Table 9.1) give a georeferenced description of the abundance and characteristics of the soil types which can be found the city region of Bukavu. However, we can conclude that most soils are rather fertile because of recent rejuvenation by volcanic ashes or mudflow deposits and that these soils have high organic matter content (2-7%), favorable pH (5-6) and larger nutrient reserves (0.2% N, 18mgkg^{-1} P, 0.8cmolkg^{-1}) (Ntamwira, 2014).

Topography

The topography within the city region consists of steep slopes and is hilly shaped. This influences not only soil erosion and farm management practices, but also market and road access and water availability. The flattest areas are found around Kabare in the north-eastern part of the study area. However, steep slopes are a serious threat for the city of Bukavu, causing significant soil erosion and landslides, the risks of which are exacerbated by the informal and unregulated way of constructing houses. The topography correlates with vegetation cover and thus the flattest areas are the most intensively used agricultural lands while steep slopes are either grazed by small ruminants or covered with forest and shrubs.

Historical context and land tenure

One can broadly say that the city region represents the traditional Bashi lands of the Shi tribes. Aside from their language, Bashi identify strongly with certain types of food production: as summed up by several informants in the study of Cox et al. (2012): “being Bashi means cows, bananas, and hoe farming”. The same authors further outline the historical context by saying that in the 1950s, Bashi, still bearing its natural cover of tall grass, already supported 15–25persons/km^2 (Cox, 2012). Utilizing cattle manure as a source of organic fertilizer, farmers also planted unfertilized outfields on a shifting basis. The outfields on less desirable lands (marshland, steep slopes etc.) allowed for greater diversification of crops under varied conditions, an important mechanism of resilience (van Acker, 2005). This farming system was also reflected in traditional forms of land tenure. From the 19th century, local rulers, Bami, owned both land and livestock. Access was handed down through a social hierarchy, regulated by kinship and clientship. Rents had to be paid in labor and or produced agricultural goods. A long-term, patrilineally inheritable contract known as ‘kalinzi’ safeguarded rights to use land and tied tenants to their chiefdom. Meanwhilem, for short-term cultivation in outfields (lasting for one season to a year), landlords granted an alternative contract called ‘bwasa’. While ‘kalinzi’ offered a source of secure land for establishing permanent farming, ‘bwasa’ provided extra land for shifting agriculture areas.

Between 1900 and 1960, Bashi became a center for plantation crops such as cinchona, chrysanthemums, coffee, and tea. By the start of the 1930s, 20,000 hectares of prime land had been given for plantations which were managed by Europeans. Most of these plantations were in the city region and most often along the roads to Bukavu. In 1985, plantations occupied 65% of the best land in Kabare (Schoepf and Schoepf, 1988, p. 112). The cultivation of these plantations depended on, and created, cheap labor in the city region. However, of 10,000 ha of surveyed plantations in Kabare in 1984, only 8,000 were used for commercial cropping (van Acker, 2005). The remaining, often unproductive, land was rather acquired as a strategy to monopolize access and to nurture cheap labor (Fairhead, 1990). Meanwhile, the population in Kabare had boomed from 15–25 persons per square kilometer to 230 persons in 1981: one of the densest spots in the country.

Current agricultural system and consumption pattern

Nowadays, the economy in the city region and of all South Kivu is still based on the primary sector of agriculture, livestock, fishing, forestry, and mining, which involves about 80% of the population and contributes about 50% to the provincial GDP. Subsistence farming is the main pillar for food security in the region and constitutes more than 70% of all farming livelihoods. Subsistence production is based on maize (*Zea mays*), Phaseolus beans (*Phaseolus vulgaris*), bananas (*Musa spp.*) and cassava (*Manihot esculenta*). About 50–80% is produced for household consumption, with only a few crops exclusively aimed for sale (Brigitte, 2010). Meanwhile, the plantations remain conspicuous on the geography of the region today; all but inoperative since 1998, they provide little wage labor opportunities in return for their occupation of valuable land (Vlassenroot, 2007). As a measure of stability returns, however, the resumption of agro-industrial activities seems likely, as in the quinquina fields owned by 'PHARMAKINA', a Belgo-German initiative. This is in line with observations from other enterprises like Nespresso, who are investing in an initiative for the revival of single origin coffee from both Kivus (Nespresso, 2020).

In addition to crop production, livestock is an integral part of the mixed farming systems in the city region, despite their presently low numbers per household (Maass, 2012). The small numbers of cattle is due to land use pressure and because the livestock sector suffered heavily from insecurity in the region (De Failly, 2000). Cattle theft reached its highest level during the conflict 1993, which discouraged many farmers. However, small livestock including goats, poultry, cavies, and rabbits, which are promoted by local and international NGOs, gradually replaced cattle in the region. The other animal protein consumed in the city region is fish from Lake Kivu (i.e., sambaza, haplochromis) and from Lake Tanganyika. The amount sent to Bukavu city is low, however, due to high perishability, a lack of storage and drying racks, and poor transport for fishery products. Fishermen therefore usually end up selling fish locally for a low price.

Table 3.2 shows the basic food products that provide the population of Bukavu population with 1,027 kcal per person and day. The calories consumed in Bukavu city derive mainly from plant matter. Foods with the greatest calorie contributions include maize, cassava, and beans. These crops, providing more than 80% of consumed calories, play a strategic role given their importance in Bukavu diets. In an urban economy where all food products are purchased, the elimination of bottlenecks from production to marketing can improve calorie intake. Animal protein deficits are often observed in South Kivu's population. The consumption of animal-sourced food is not common due to the chronic poverty of the population and limited availability. In particular, children suffer from the lack of animal protein, reflected in the very high stunting prevalence in children under 5 years old (Kandala, 2011).

Table 3.2: Calorific input of staple food by principal source of supply in Bukavu

Products	Total food supply (t)	Supply ($gday^{-1} cap^{-1}$)	Kcal per 100g	Total calories ($kcalday^{-1}cap^{-1}$)	Sources of supply ($kcalday^{-1}cap^{-1}$)		
					Rwanda	North Kivu	South Kivu
Maize	10,015	155.13	363	563.1	372.8	175.9	14.5
Cassava	2,293	35.52	338	120	27.9	38.1	54.1
Beans	3,164	49.01	341	167.1	51.3	114.4	1.4
Potato	1,419	21.98	67	14.7	12.1	2.7	0
Sorghum	911	14.11	361	50.9	37.1	7.0	6.6
Groundnut	1,045	16.19	567	91.8	63.4	6.8	21.6
Sweet potato	97	1.50	101	1.5	1.5	0	0
Rice	20	0.31	360	1.1	0.8	0	0.3
Plantain	24	0.37	75	0.3	0.1	0	0.2
Beef	619	9.59	150	14.4	12.2	0	2.2
Pork	55	0.85	220	1.9	1.7	0	0.2
Total	19,662			1,027	593.5	338.9	92.4

A lot of the consumed calories originate from Rwanda (593kcal), and North Kivu (339kcal), while the city region and South Kivu province only provide very few (92kcal). The reason for the high reliability on imports is because of the inadequate and dilapidated transport infrastructure within the core and periphery of the city region, which makes the movement of people and goods difficult. Further, the persistence of political conflict, especially in rural areas, has added to this challenge, resulting in decreased crop and livestock production all over South Kivu. Thus, this decreased availability for locally produced goods is the reason why expenditures for food for non-agricultural households per month in Bukavu are rather high (260 USD). Table 3.3 shows these food expenditures for an average household and month in the urban core in the year 2014. Half of the total expenditure is spent on cereals, roots, and tubers. 30% is spent on animal products, with an almost equal amount spent on fish as on meat.

Table 3.3: Monthly food expenditure of consumer households in Bukavu.

Groups	Amount (US$)	Percent (%)
Cereals	59.15	23
Rice	23.72	9.2
Maize and maize flour	25.46	9.9
Wheat and derived products	5.64	2.2
Sorghum and sorghum flour	4.33	1.7
Roots and tubers and other staples	61.71	24
Banana plantain	5.64	2.3
Cassava and cassava flour	15.64	6.1
Potato	9.05	3.5
Yam	0.03	0
Sweet potato	4.87	1.9
Peas	0.04	0
Beans	24.74	9.6
Groundnuts	1.39	0.5
Legumes	10.52	4.1
Animal products	79.99	31.1
Fish	33.72	13.1

Meat	39.15	15.2
Milk products, eggs, honey	7.12	2.8
Oils and nuts	11.73	4.6
Condiments and spices	6.03	2.3
Fruits	4.62	1.8
Sugar and sugar products	2.92	1.1
Beverage, soft drink, juice, bottled water	21.65	8.4
Total	258.33	100

Crop production in the city region

The bimodal rainfall allows crop cultivation during two subsequent seasons. One season starts mid-September and ends mid-January, while the other season lasts from mid-February to mid-June, followed by a short dry period, when farmers still cultivate in valleys and drained marshlands.

The best fields are primarily stocked with beans, a staple protein source. The beans are often intercropped with maize or sorghum, otherwise with cassava or grown under bananas. Less fertilize fields are allocated to sweet potatoes; some farmers do a crop rotation after a year or two. More often, however, sweet potatoes are just 'the crop that will grow where nothing else will' (Cox, 2012). The same applies for cassava, which grows even on poor and exhausted soil and requires little water. In addition to this ability, cassava can be harvested at any time between 8 to 24 months after planting and it can be left in the ground as a buffer for unforeseen food shortages.

To boost the competitiveness of local agricultural value chains, appropriate policies are required to protect small local industries. For example, imported products are currently cheaper than local products. Due to a lack of adequate infrastructure, input supply systems and cheap means of processing, local products sometimes even pass through Rwanda before being sold in the city region. Another challenge facing subsistence farming is plant diseases (development of banana wilt, persistence of cassava mosaic virus) that significantly reduce production and cause price volatility in the markets.

Table 3.4: Crop production (t) in South Kivu, 2014.

Crop	Production (t)
Food	7,383,063
Vegetables	113,015
Fruits	51,338
Industrial	199,324
Total	7,746,740

Coffee production

With the support of IITA, we conducted Focus Group Discussions (FGD) with cooperatively organized coffee producers and cooperative managers particularly to gain insights into the coffee farming in the city region. We found that in Kabare most coffee growers are smallholder farmers with coffee fields <1ha practicing mixed multi-tier intercropping. The upper tier is occupied with trees providing different agroecosystem goods and services (mainly shade for coffee trees, organic material for soil improvement, fruits and wood). The second tier is occupied by coffee trees and banana stems while vegetables, legumes or tuber crops are planted in the lowest tier close to the ground. During these discussions, we learned that coffee is often not the primary source of income, but that the annual and directly monetized coffee yield contributes significantly to very specific expenditures, e.g., paying school fees, renovating houses, or making purchases and investments. The fact that coffee is often not the primary source of income makes it partially understandable why currently neither soil amendments nor fertilizers are applied to coffee trees in the smallholder context. Nevertheless, it must be considered that in term of Kabares' total coffee production (coffee cherry yield), the few large-scale producers (either members of cooperative or individuals like e.g., Kivu Coffee with 100ha) contribute in a large part. The three most important coffee cooperatives of Kabare are RAEK~2100, TCC~1500 and CPCK~2200. In addition ~ 20% of producers in the region do not belong to any cooperative. Taken together there are roughly 7000 farmers engaged in coffee farming within the city region. The average yield in the region is 600-700 $kgha^{-1}$, whereby a farmer planting 1500 coffee trees on one hectare resulting in 1.5-2.5kg of coffee cherry per tree.

The coffee harvest occurs around February every year and is the most labor-intensive time within the production cycle. The red and ripe cherries are handpicked and carried to the cooperative washing stations where they sort, wash, and husk the best quality cherries. The green coffee beans are then dried in the sun on dry racks. The limited number of coffee drying racks (550USD for one rack 8mx5m) was mentioned to be one of the bottlenecks for not being able to process more of the harvested coffee. Once dry the beans are brought to Goma for hulling, where the endocarp is separated from the dry parchment coffee in threshing machines to obtain green coffee, which is then ready for export via Mombasa. The poorer quality of coffee cherries rejected by the washing stations is sun dried and then often informally exported by pirogue to Rwanda.

Input costs for agricultural production

Most farmers have no access to improved varieties and are very limited in their possibilities to improve soil fertility. Manure is only available very locally and in limited quantities and synthetic fertilizer is practically absent. The cost for synthetic fertilizer purchase within the city region by a local stockist in Bukavu is estimated 75USD for a 50kg bag (Pypers, 2011). However, pressure on land is very high due to high population density in the territories near Bukavu and justifies agricultural intensification and investment in soil productivity (Pypers, 2011). Pypers et al. (2011) valued hired agricultural labor at a wage of 0.76USD (1500FRC) for a 6h working day.

Livestock production in the city region

Livestock is an integral part of the mixed farming systems in the region of South Kivu province, despite their presently low numbers per household. The city region only has small numbers of cattle because of the pressures on land (Table 3.5). It should be noted that the relationship between farmers and herders in South Kivu has never been good, with disagreements sometimes ending up in court. Additionally, and according to De Failly (2000), the livestock sector in South Kivu has paid a very heavy price given the insecurity that has prevailed in the region since 1993. Cattle theft reached its highest level during this period, which discouraged many farmers to engage in livestock farming. However, goats, poultry, cavies, and rabbits, which were promoted by local and international NGOs, gradually replaced cattle in the region. This livestock is often kept as an asset and for cash income generation and household reserves and not too much for consumption. In a study by Maass et al. (2012), interviewees consumed only about 20–40% of their livestock production. Pigs and goats were mostly sold, while cavies and fowl were about half for consumption and half for sale.

The need for cash dictates strongly the timing of sale, especially, to pay school fees at the beginning of the school year in September. Most of the largest cattle owners live in Bukavu and use cattle as an investment for income from other business activities such as mining or transport. They keep scores of animals on dedicated ranches or communal pastures far from the urban core. They seldom sell cattle unless forced to, and usually leave milk and manure to the employed herders. Livestock prices have recovered in South Kivu in recent years, and cows are now valued generally at around USD 250 in the village and USD 300 in Bukavu.

Table 3.5: Livestock in South Kivu, 2014 (source: IPAPEL, 2014).

Livestock	Count
Cattle	448,116
Fowl	567,710
Goats	470,669
Cavies	362,689
Rabbits	109,777
Pig	91,631
Sheep	77,404
Total	

Culturally livestock has a high importance within the city region. Bashi custom dictates the use of cattle for two significant exchanges: bride wealth and buying land. Some land deals are still made with cattle. Cash is accepted as well, but few farmers accumulate sufficient quantities; cattle are used as a primary source of capital. The symbolic weight of cows as bride wealth is, however, much greater. According to Cox (2012), at a minimum, the groom's parents can give a single cow or even a calf to the bride's family while this is often supplemented with four to six goats. Thus, goats have taken to some extent the place of cattle in every arena but marriage, and even here many families now offer a few goats alongside a single requisite cow. Pigs, however, are culturally seen as a dirty animal, so its meat is less expensive compared to beef and goat (Klapwijk, 2020).

Major issues of animal husbandry are related to epizootic diseases and lack of feed resources, particularly in the two dry seasons (Katunga, 2014). Lack of feed or forages is unrelated to a particular livestock species. The potential introduction of improved forage is challenged by their dry-season tolerance, compatibility with cropping on smallholder farms, and people's acceptability to cultivate forages. Animal husbandry in the city region and everywhere else in the province is gradually moving towards stall feeding, due to demographic pressure and scarcity of collectable forages (Bacigale, 2014). While the contribution of nutrients from one or a few cows may not be enormous, given the poverty of the soil and few alternatives, cattle manure is becoming one of the most valuable resources in rural Kivu and Cox (2012) even compare it with other valuable resources as coltan and gold. Since cattle manure is in limited supply, farmers who have it use it first and foremost to bolster yields on their better fields and any cash crops they may be growing. However, it is not too often utilized for coffee plants.

3.2 Arba Minch, Ethiopia

Characterization of the Study Area

Mean annual rainfall in the city-region is 930 mm. The rainfall season is from May to October and has two peaks (May and August) (Figure 3.5). Mean temperature is 19.9 °C, with monthly values ranging between 17.7 °C in July and 22.1 °C in February and March. According to King, (1975) and Zebire et al (2019), "The geology and geomorphology of the Rift Valley occurred from Miocene to Pleistocene deposits. The basin being part of the rift valley was formed by volcanic activities in the Rift Valley during the period of Pliocene and Holocene. Accordingly, it is believed that ancient basement rocks lie under the whole Rift Valley. The parent materials of catchment are alluvium along river and lacustrine along lake which are derived from the rocks (King and Birchall 1975; GME 1975). The pattern of topography of the catchment is composed of flat plain in the west around Lake Chamo and the Rift Valley escarpment hills in the west and north." For further details on the geomorphologoly and soil characteristics of the Arba Minch area, please refer to Verner & Mergessa (2018).

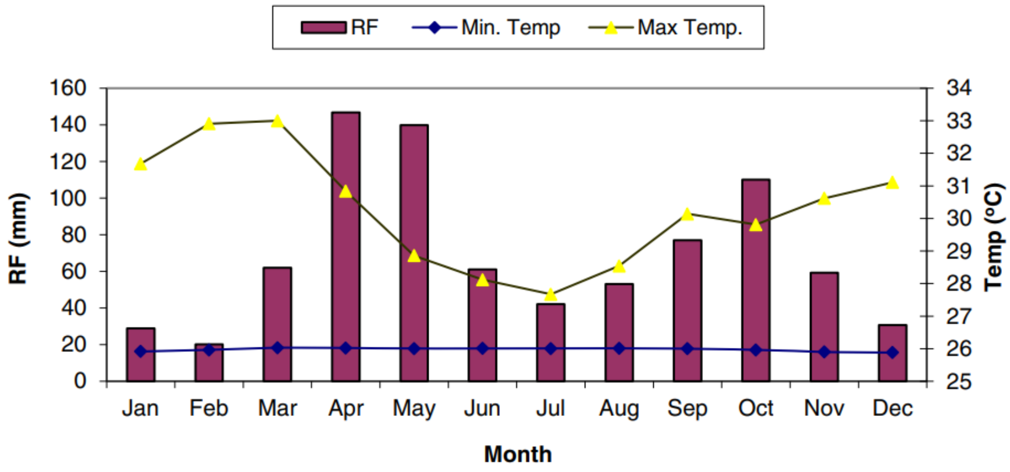

Figure 3.5: rainfall and temperature patterns in Arba Minch, Ethiopia

Apportionment of land for crops and cropping systems

This production systems study focuses on lowland agricultural areas within the city region boundary (Figure 3.6). Farming within the lowland agricultural zones of the city region has evolved rapidly in recent years, with many farmers switching from annual to perennial crops. Perennial plants that are commonly grown in the area include banana (*Musa sapientum*), mango (*Mangifera indica*), and coffee (*Coffea arabica*). Commonly grown annuals include maize (*Zea mays*), teff (*Eragrostis tef*) and cotton (*Gossypium hirsutum*). Findings from qualitative interviews conducted for this report, in combination with several reports conducted by students during a field course conducted in 2017, identified that most farmers in the area cultivate an area between 0.73- 1.5 ha. The almost universal shift towards perennial crops such as banana and mango is largely due to an increased focus on high value cash crops, of which banana and mango are of the fruits of these plants. Ten years ago, there was no banana or mango production. All interviewed farmer has banana today, and half of them has also mango. However, there is a still farmers produce crop for their own subsistence, besides cash cropping. These crops are mainly maize and teff, which are produced during *meher* (main cropping season) and *belg* (the second cropping season). Nowadays the main focus is clearly on cash crops which are financially more beneficial for the farmers. The most important crops in Lante and Ganta Kanchama are banana, mango, maize, beans and teff. This transfer is dependent on the irrigation canal, ensuring a higher and more reliable water supply which results in better yields.

Cropping System refers to the crops, crop sequences and management techniques used on a particular agricultural field over a period of years. It also includes all spatial and temporal aspects of managing an agricultural system. It is designed to maximize yield production. Mono-cropping, intercropping and mixed cropping are the most common cropping system used in Arba Minch City region RUNRES intervention area. Mono-cropping system is the agricultural practice of growing a single crop year after year on the same land, in the absence of rotation through other crops or growing multiple crops on the same land (polyculture). Maize, teff, cassava and mango are the most common crops grown using mono-cropping techniques in the intervention Kebeles. An intercropping system is the cultivation of two or more crops simultaneously on the same field. Mango and banana, cassava and banana or maize and haricot bean are the most common combination of crops grown using this technique. A mixed cropping system is a system of sowing (growing) two or more crops together on the same land, one being the main crop and the others the subsidiaries. Mango, banana, coffee, papaya, moringa, avocado, cassava, maize etc. are common crops grown using this techniques.

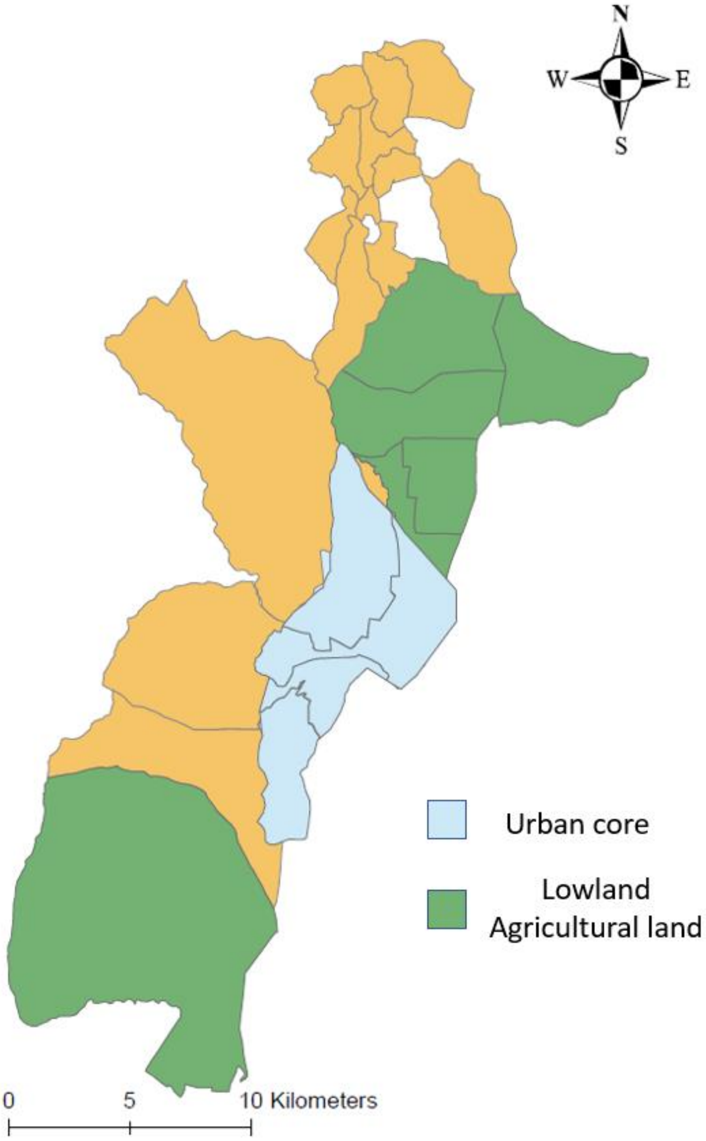

Figure 3.6: Arba Minch city region low land agricultural zones.

Cropping System refers to the crops, crop sequences and management techniques used on a particular agricultural field over a period of years. It also includes all spatial and temporal aspects of managing an agricultural system. It is designed to maximize yield production. Mono-cropping, intercropping and mixed cropping are the most common cropping system used in Arba Minch City region RUNRES intervention area (Table 3.6). Mono-cropping system is the agricultural practice of growing a single crop year after year on the same land, in the absence of rotation through other crops or growing multiple crops on the same land (polyculture). Maize, teff, cassava and mango are the most common crops grown using mono-cropping techniques in the intervention Kebeles. An intercropping system is the cultivation of two or more crops simultaneously on the same field. Mango and banana, cassava and banana or maize and haricot bean are the most common combination of crops grown using this technique. A mixed cropping system is a system of sowing (growing) two or more crops together on the same land, one being the main crop and the others the subsidiaries. Mango, banana, coffee, papaya, moringa, avocado, cassava, maize etc. are common crops grown using this techniques.

Table 3.6: Harvest periods and average household yields for key crops in lowland agricultural zones

Crop	Harvest Period	Average yield kg household^{-1} year^{-1}
Banana	Upon ripening (year round)	3222
Mango	May and December	/
Maize	May and December	392
Teff	June and December	64
Coffee	November	/
Papaya	Every 2 months	100
Avocado	June	/
Lemon	November- January	/

The agricultural yields are an important outcome of the cropping strategies and the allocation of inputs and land for specific crops. based on farmers estimation average yields of banana is 5405 kg/ha/year, mango 2642 kg/ha/year, maize 3467 kg/ha/year, teff 500 kg/ha/year, haricot/common bean 1285 kg/ha/year. The yields are based on the farmer’s estimations of their land size and harvest and might thus be very rough approximations. to check whether farmers estimation is correct or not triangulation with national average yield considering varietal issues is very important, but due to time shortage we failed to do so.

Farm power used in within the city-region system

Large ruminant animals such as oxen are mainly used to plow agricultural fields. Transportation of equipment and harvested and they consider them as tractor and also equines like donkeys are used for transportation. Mostly male donkey are used to pull carts and they help to transport fresh harvest from farm land to home and home to market places too, while female donkeys are used for biological reproduction and to transport small quantities for household consumables like water from different sources, flour from mill houses and etc. Not all, but some farmers with small number of households may encounter labor problems because as user for irrigation for their farming, farm activities are year-round activities in these areas and may weeding, inter-cultivation and harvesting calls labor simultaneously.

Common Agricultural practice and access to rural institutional service

Agricultural activity is year-round job in these areas because most farmers are cultivating both perennial crops and annual crops. Perennial crops are crops developed to reduce inputs the need to replant crops from year to year. Perennial cropping in these kebeles can reduce topsoil losses due to erosion. The following crops in these kebeles can be classified under perennial crops: mango, banana, avocado, papaya, coffee and lemon are perennial crops.

Annual crops are plants with a life cycle that lasts only one year. They grow from seed, produce seeds, and die in one growing season. Then, they need to be replanted each spring. The following crops can be classified under annual crops of RUNRES interventions Kebeles: maize, teff, haricot bean and elephant grass are annual crops. All crop cultivation activities from land preparation to harvesting is done manually in the intervention Kebeles.

There is an extension program in RUNRES intervention rural Kebeles, of which the office is located next to the Kebele Administration office with the same gate. The program is led by development agents who have trained animal science, plant science, and natural resource management either in diploma or degree and working as experts. They give different trainings, which are related with agricultural activities to the farmers. Most of the farmers participate in extension program. The extension worker may visit the farmer weekly, every two weeks, monthly or yearly. Each Kebeles has plots called 'farmer training centers' or "FTC" when they abbreviate its name, on which extension workers demonstrate techniques to the farmers during *Belg* and *Mher* seasons. This could be considered as a transforming structure from the public sector and creates opportunities for farmers to gain practical knowledge from Development agents practically.

Omo Microfinance is the nationalized institution present in the kebeles office where people usually save money and ask for credits because there is no other bank institution. The condition for credits is to have saved more than ten percent of the whole amount of the credit and to have an ID card. Another important rural service provider institution is the cooperative. It helps people to access the market of the big cities to sell their cash crops. Both Lante and Genta Kanchama Kebele have cooperatives, works only with fruits like mango and banana. Each member of cooperative are basically obliged to sell all their production to the cooperative but are assured of constant prices.

Access and control over agricultural land

In Ethiopia land is belongs to the government, but the farmers in RUNRES intervention Kebeles received official certificates which gives them authority to use, rent and inherit to their off-springs/next generation, they cannot sell even their certified farm land to third body. The average land size of the sampled households is 0.73 ha. On the escarpments there is still communal land used for grazing and forests. This communal grazing land is meant to be really large in area so no apparent overgrazing has happened so far.

The big issues local households are struggling with there is building strong social capital. An important part of social capital is their network of friends and neighbors, people with whom they have social relations and who can help them when they are in need. Interview participants stated that people in RURNRES intervention rural Kebeles are always helping each other by contributing in kind and/or cash and time to realize comment development goals of community. Besides their social relations, membership of social and/or economic groups is also an important aspect of the people's social capital. A first important group in the community is formed by the members of the cooperative. Members have better access to markets for their produce and they get a share of the profits.

The male/husband in male headed household is usually carrying out most field agricultural production related works and tasks. Female/spouses job is limited to reproductive (biological like child bearing and management) and household non-remunerative job like kitchen, cleaning, collecting fire wood, fetching water,etc not income bringing activities).

Livestock production

There are three main agricultural strategies which can be used alongside each other in the households. They are subsistence farming, cash cropping and livestock. On average number of livestock ownership ranges from no livestock ownership to four livestock. Animals are mainly used for manure and ploughing farm land, transportation and as a food resource. Using animals as a food resource is a risk reducing strategy when (cash) cropping yields are insecure, especially for during the dry season. The two main livestock management system observed were zero grazing and grazing on communal lands. In zero grazing (cut and carry) system, animals kept at home and get fed with crop residue or tree leaves. When animals get ill, veterinary services and medicines are commonly purchased. However, animal disease was still often mentioned as important problem, especially when households have no resources to buy medicine. Most farmers rear local cattle breeds due to resistance to hardship like drought and disease.

Challenges to small holder production

Most common agricultural production related problems and farmers coping mechanisms are discussed below:

Soil salinity: The irrigation water does not only provide water to the crops, it also deposits solutes. Because the study area is located in an alluvial plane, the soils in the area are influenced by the presence of fluvic material. Soil samples taken by KULEUVEN, Arba Minch and ETH Zurich for field course, analysis shows that all samples have pH values between 7.27 and 7.88 in the topsoil. This pH is an indication of a high base saturation. The highest pH values were found on sites close to the lake. Over irrigation leaches out the solutes present in the soil and in the irrigation water itself. The higher base saturation in the drained soils close to the lake can be explained by a net upwards movement of water in these soils due to capillary rise. This is possible because the water table is close to the surface, at about 50 cm depth. When the water evaporates on the surface, it leaves behind the solutes.

Pest and diseases are also important for farmers because two third of them are facing these problems. For banana and mango, some farmers are facing diseases without any use of pesticides because they don't have the information about where this disease comes from and how to deal with it. One farmer told us that he burns infected plants. On the other hand, for maize, every farmer facing pest problems is using the pesticides proposed by the government even though they were not very efficient for the farmers.

Another agricultural production problem is *soil erosion*. Farmers in Lante use Baso river, while Farmers in Genta Kanchama use Sile river for irrigation. When rain is abundant, the river must transport more water to the lake. This bigger flow can cause flooding. Sometimes both Rivers may broke river banks and change its course to that of an irrigation canal, leading to a major flood. Flooding is one of the major concerns for the agricultural production in the kebeles. to cope these problem most of the farmers using stone bund or just like terracing and check dams to prevent soil erosion when they face heavy rain, leading to soil erosion. Putting stones or terracing reduces both the amount and velocity of water moving across the soil surface, which greatly reduces soil erosion.

Fluctuations of the input and output market: Most farmers buy their agricultural inputs, such as fertilizers and seeds, from the government through Omo Micro Finance. Fertilizers are very important in the cultivation of teff and maize. However, over the past years the prices of these inputs have increased a lot and many farmers no longer have the capacity to buy the inputs.

Furthermore, there are also price fluctuations on the output market. This is especially important for the cash crops cultivated in Lante, namely banana and mango. Farmers are dependent on the prices of the market in Addis Ababa and price insecurity can lead to suboptimal production levels.

As copping mechanism, some of the farmers mentioned that one of the reasons for their shift from seasonal crop production to perennial was the increase in the price of fertilizer (Dap, Urea), which needs to be used when cultivating seasonal crop production like maize and teff. Also to cope output market fluctuation most farmers joining primary cooperatives and they reported that being cooperative membership increased bargaining power when they supply their output to market.

Rainfall Fluctuation: experienced farmers said that the area rainfall is decreasing from year to for the last ten years. This decrease is one of the main constraints for productivity. It has the greatest effects on farmers without irrigation but still impacts those who do have access to it. Following this there is a clear difference of value between irrigated and non irrigated fields. Farmers shifted to irrigation utilization to cope this problem. Irrigation can be seen as a transforming structure, allowing people to cultivate crops that need more water

3.3 Kamonyi, Rwanda

Biophysical Characterization

Topography

The elevation in Rwanda is variable, ranging from 500 to >2,000m above sea level (Figure 3.7). However, in Kamonyi district the elevation is between 1,100 and 1,700 m above sea level. The eastern and northern parts of Kamonyi are occupied by the valley of Nyaborongo, which peaks in Ijuru rya Kamonyi and "Cubi na Marenga", and the lowest points are found in Kona ka Mashyuza and Mukunguri (Kamonyi District Municipality, 2013). Elevation affects spatial temperature variations and rainfall patterns, with cooler temperatures being experienced in higher elevations, and orographic rainfall occurs in mountainous areas where moist air is forced to rise high up the mountain and condense. Therefore, crops such as Irish potatoes, tea and coffee can successfully be grown in cooler areas while crops such as banana and cassava thrive well in lower elevations, where temperatures are relatively higher.

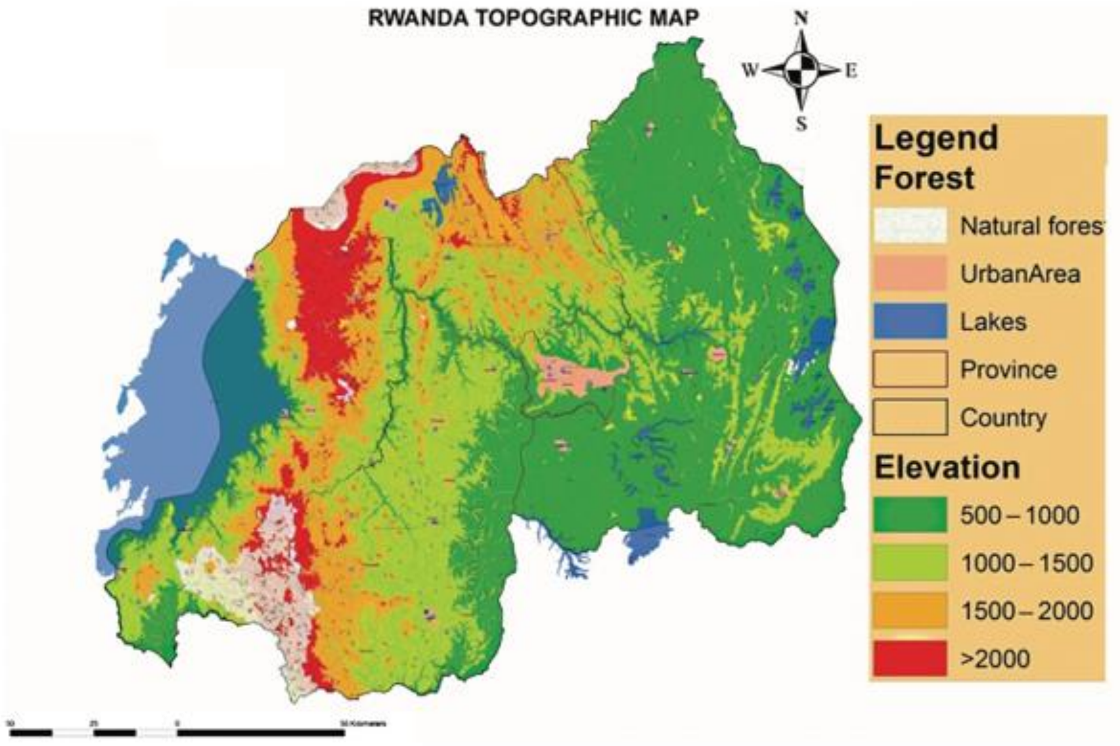

Figure 3.7: Topographic map of Rwanda (Ngarukiyimana et al., 2018).

Soil classification

The Rwandan soils classification map reported (Figure 3.8), shows that the country is characterized by a by wide range of soils formed from differences in parent materials, anthropogenic activities, climatic conditions, topography and vegetation cover (Food and Agriculture Organisation, 2001). However, Kamonyi district has four common soils, which are acrisols, ferrasols, lixisols and cambisols (Iiyama et al., 2018). These are described in the following sections according to the Food and Agriculture Organisation (2001):

Acrisols

These are soil profiles that have been modified by climate and are dominant in tropical monsoon, sub-tropical and warm temperate climates. The soils are generally acidic with low base saturation, originating from acid weathered clay soils, and they are also undergoing further degradation. They are found on old land surface with undulating and hilly terrains, and light vegetations.

Ferrasols

These are generally red and yellow soils due to high percentage of sesquioxides (aluminium and iron minerals), exclusively formed in humid tropics. They originate from strongly weathered material on old stable geomorphic surfaces. These have good physical properties but are chemically poor, hence they need constant liming and fertiliser application for sustainable agriculture. The soils are generally poor due to high P sorption and Al toxicity; therefore, they favor acid tolerant crops such as rubber.

Lixisols

It is a group of soils which are generally strongly weathered, in which the clays have been washed and accumulated to a certain soil depth. The soils are found in tropical, subtropical and warm temperate climates dominated by dry season and on old erosional surfaces. These soils have a better moisture holding capacity compared to acricols and ferrasols. Their major advantage is low Al toxicity due to higher pH but since they highly weathered, they are low in nutrients, hence extensive fertilizers are required when growing crops in such soils.

Cambisols

These are widely distributed in all climates. Their beginning horizon differentiation is characterized by changes in color, structure and carbonate content. The minerology consists of medium and fined textured materials derived from a wide range of rocks such as alluvial, colluvial or aeolian deposits. They have a neutral to weak acidity, slight fertility and active microbial activity.

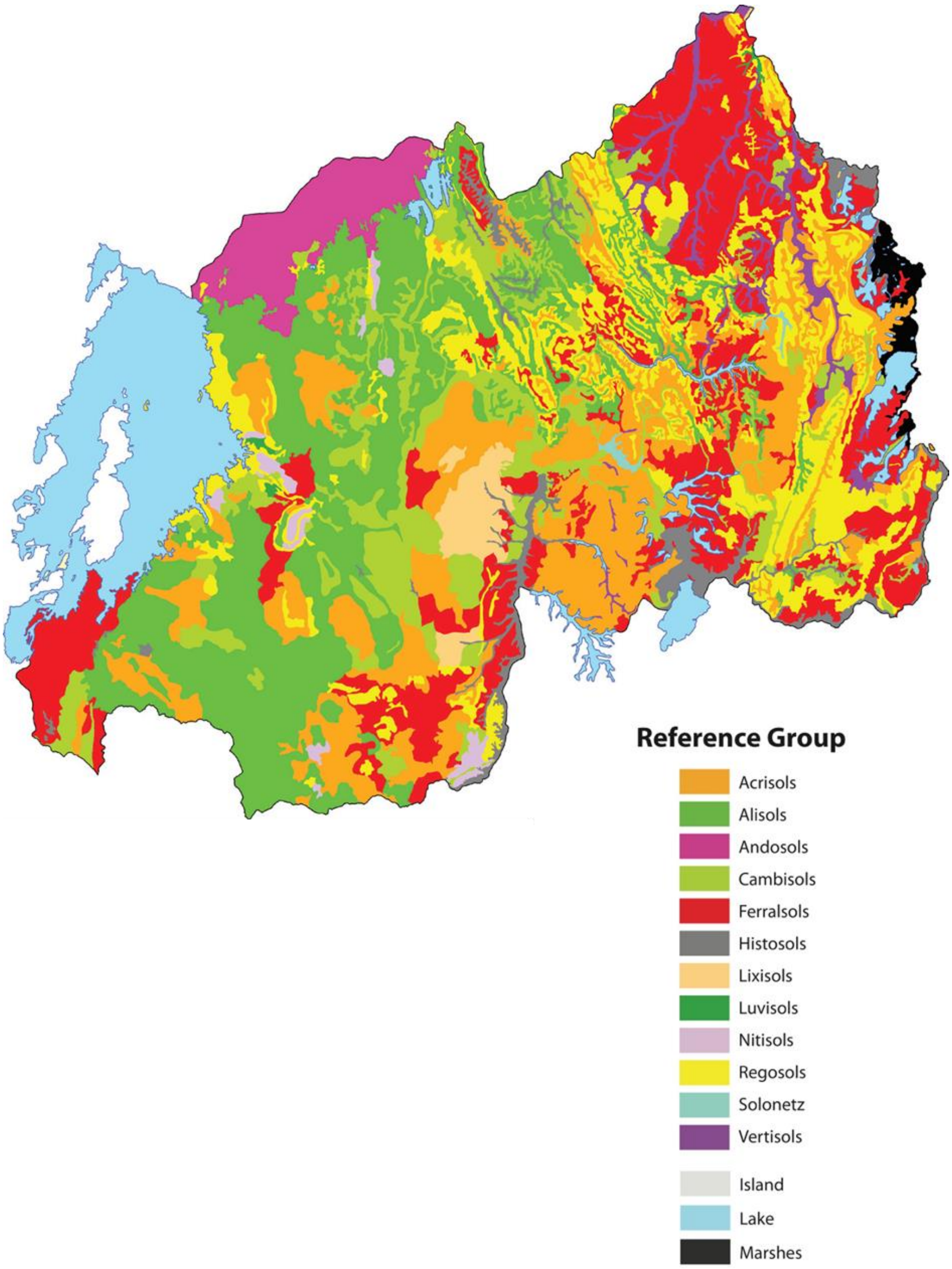

Figure 3.8: Soil classification map for Rwanda showing different soils across the country. Map adapted from Jones et al. (2013).

Slope

Land slope is one of the factors, together with rainfall intensity, soil properties (soil texture, drainage and hydraulic conductivity) and agricultural management practices that contribute to soil erosion. Soil erosion facilitates the loss of nutrients (especially particulate P), which pollutes nearby surface water resources. Rwanda is a soil erosion prone country, characterized by large areas with a slope of >10% (Figure 3.9) and this this has been confirmed in district reports (Kamonyi District Municipality, 2013, 2019). Therefore, in such areas, sustainable erosion control practices such as terracing, mulching and production of trees are recommended (Nambajimana et al., 2019).

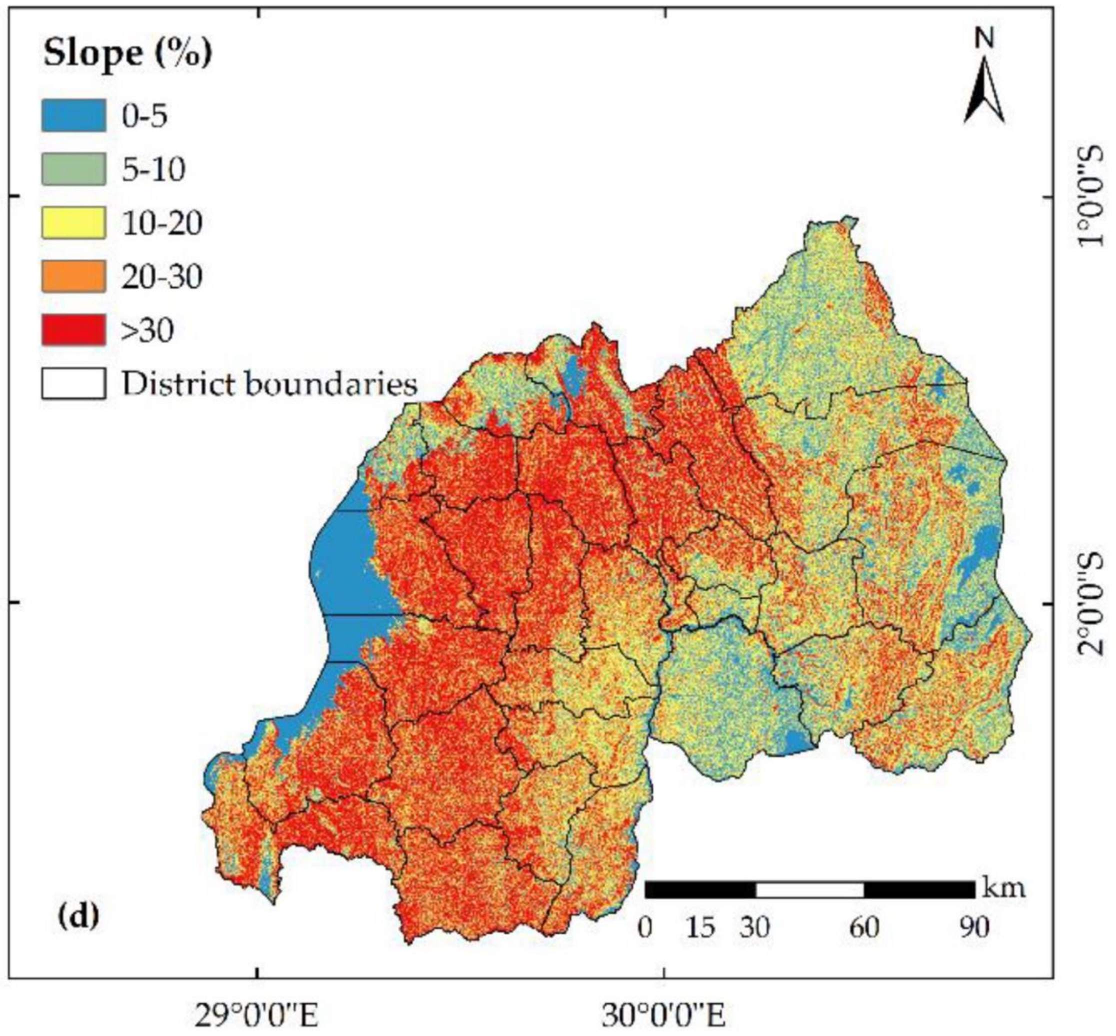

Figure 3.9: The variations in slopes (%) across different districts of Rwanda. Adapted from Nambajimana et al. (2019).

Soil texture

The reported variations in soil textural classes across Rwanda shows that the largest proportion of the country (54.43%) is dominated by clay soils with >38% clay (Figure 3.10). Kamonyi district is one of the 13.57% areas dominated by sand clay loam soils, which are deemed most fertile due to a combination of clay properties (good water and nutrient retention capacity) and sand properties (good aeration, drainage and unimpeded root growth). Plants grown in such soils have enough moisture and nutrients available for plant growth and good drainage promotes good root growth and allows adequate distribution of water and nutrients in the soil. Therefore, a wide range of plants can be grown in sandy loam soils, and these include root crops, tubers, vegetables and even fruit trees.

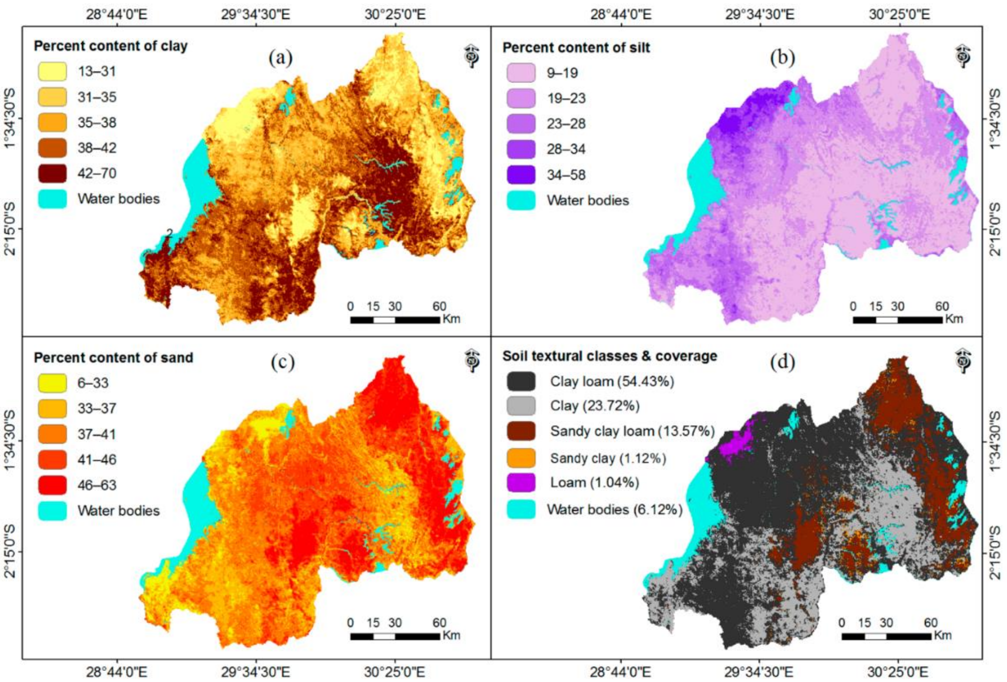

Figure 3.10: Map of percent content of (a) clay, (b) silt, (c) sand and (d) soil textural classes of Rwanda (Karamage et al., 2017)

Geology

Rwandan geology is mainly characterized by the Precambrian metasedimentary rocks which are mostly sandstones, quartzite and shales intruded by granites (Figure 3.10). The schists, micaschists and quazites are partly found in Kamonyi District, while the granite-gneisses rocks dominate the area. Due to the nature of such rocks, fractured and semi permeable aquifers are commonly found in Kamonyi.

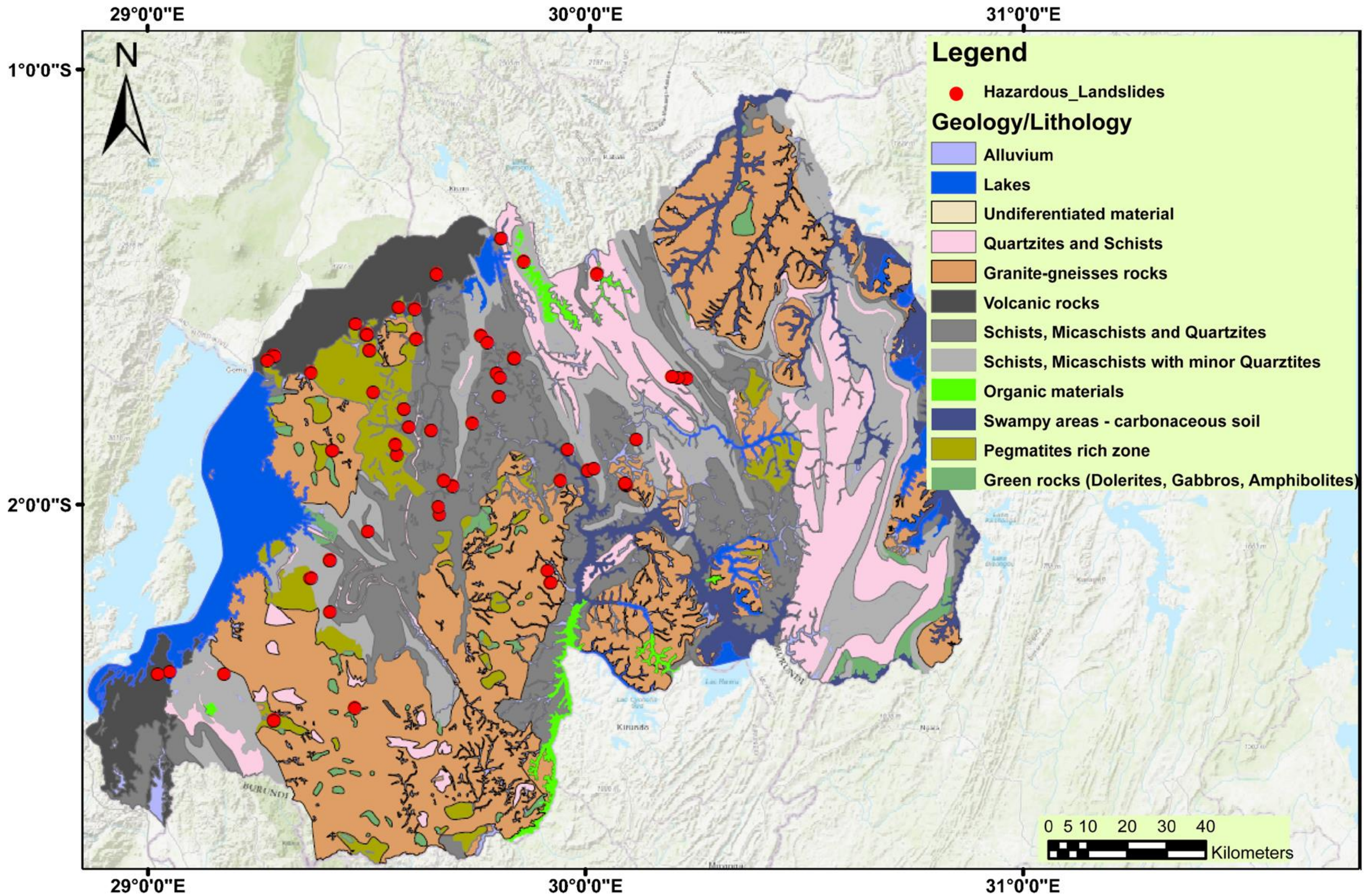

Figure 3.11: The geological map for Rwanda (Petricec, Lavreau, & Waleffe, 1981).

Kamonyi climate

The climate of Kamonyi, reported in Figure 3.12, shows minimum variations in temperatures across the year with a range between 15-30 ºC. These temperatures allow production of various subtropical and tropical crops due to predominantly frost-free days. In addition, the rainfall is very high from September to May, the highest being experienced in April. Low rainfall periods are June – August; considering such rainfall regimes, irrigation requirements are generally low. A total annual rainfall of 1,099 mm makes the city-region suitable for the production of even crops with high-water requirements such as banana.

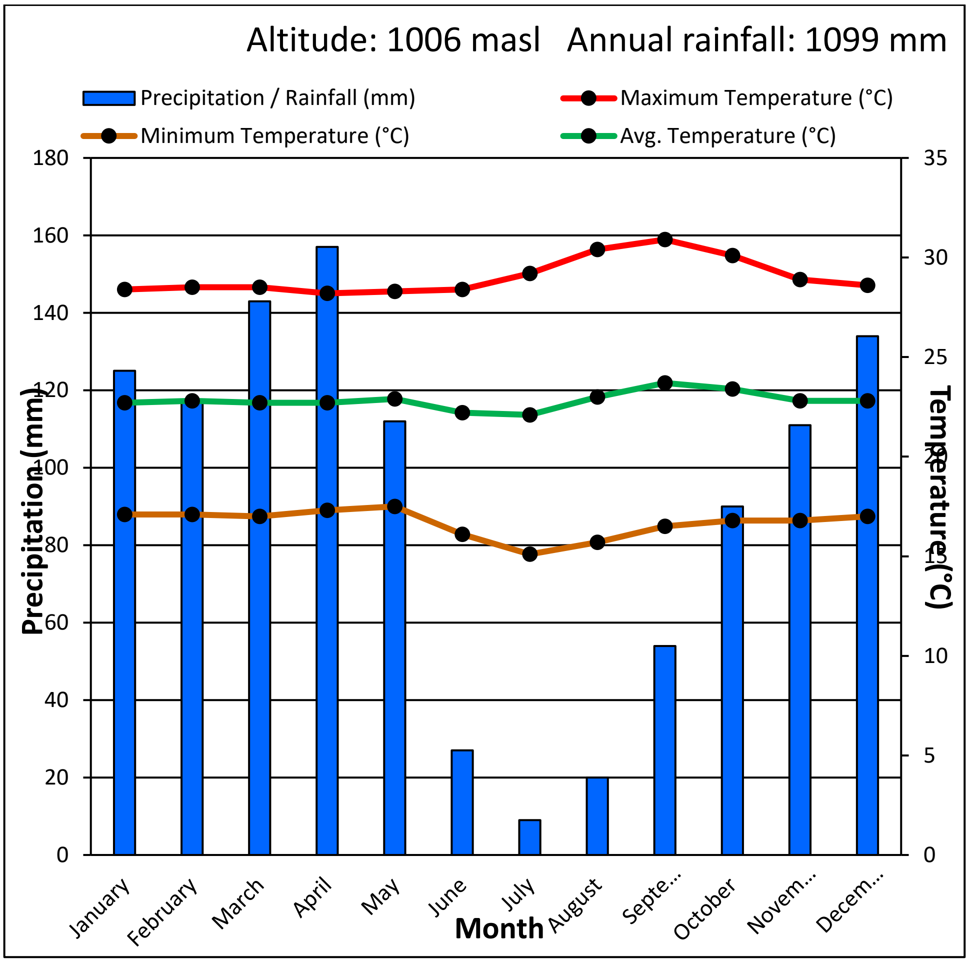

Figure 3.12: Rainfall and temperature Kamonyi district Rwanda (Climate-Data.org, 2019)

Spatial distribution of vegetation

There is variability in the spatial distribution of vegetation biomes across Rwanda. The natural vegetation cover ranges from savanna (east) to tropical mountain forest and Afro-alpine moorland. According to Ndayisaba et al. (2017), Kamonyi is dominated by 50-70 % mosaic vegetation and 20-50% grassland or shrubland or forest (Figure 3.13), which is characterized by natural and planted forestry, and agroforestry crops including grevillea robusta, coffee, avocado, erythrina and pinus (Kamonyi District Municipality, 2013). Historically, Kamonyi vegetation was a shrub savanna, however this has been eliminated by population increases, which have resulted in replacement of natural forests with agricultural activities.

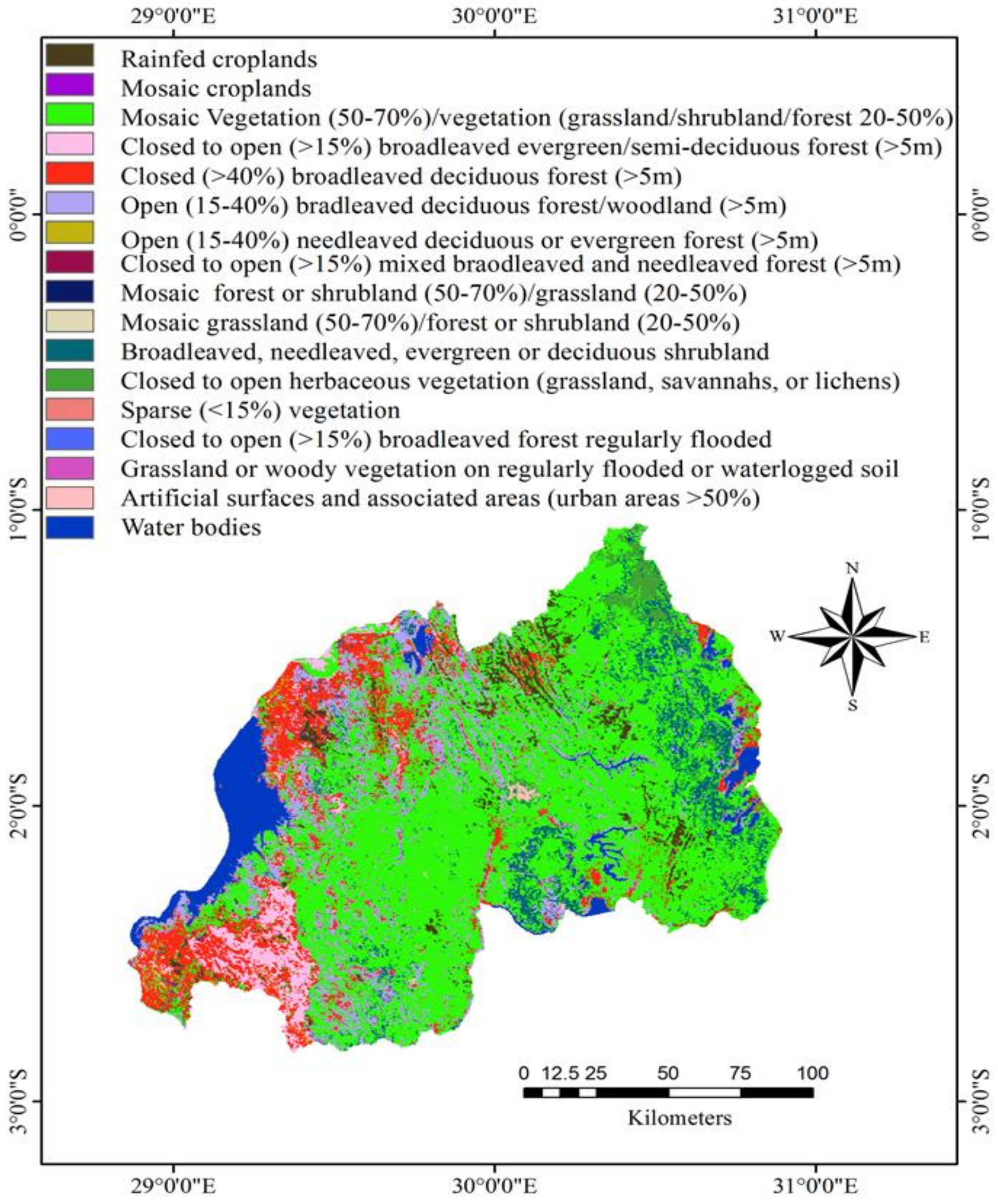

Figure 3.13: Spatial distribution in vegetation biomes of Rwanda. Adapted from Ndayisaba et al. (2017).

Rwanda agroecological zones

An agroecological zone is defined as a land resource mapping unit that is based on landform, soils, and land cover (FAO, 1996). The agroecological zoning provides a specific range of potentials and constraints for certain land use. Rwanda comprises six agroecological zones: Buberuka Highland, Eastern Plateau, Eastern Savanna, Congo Nile Crest, Plateau and Collines and Volcanic Highlands (Figure 3.14). Kamonyi is in the Central Plateau (Plateau and Collines), which is characterized by annual rainfalls of between 1,000 and 1,500 mm (Iiyama et al., 2018).

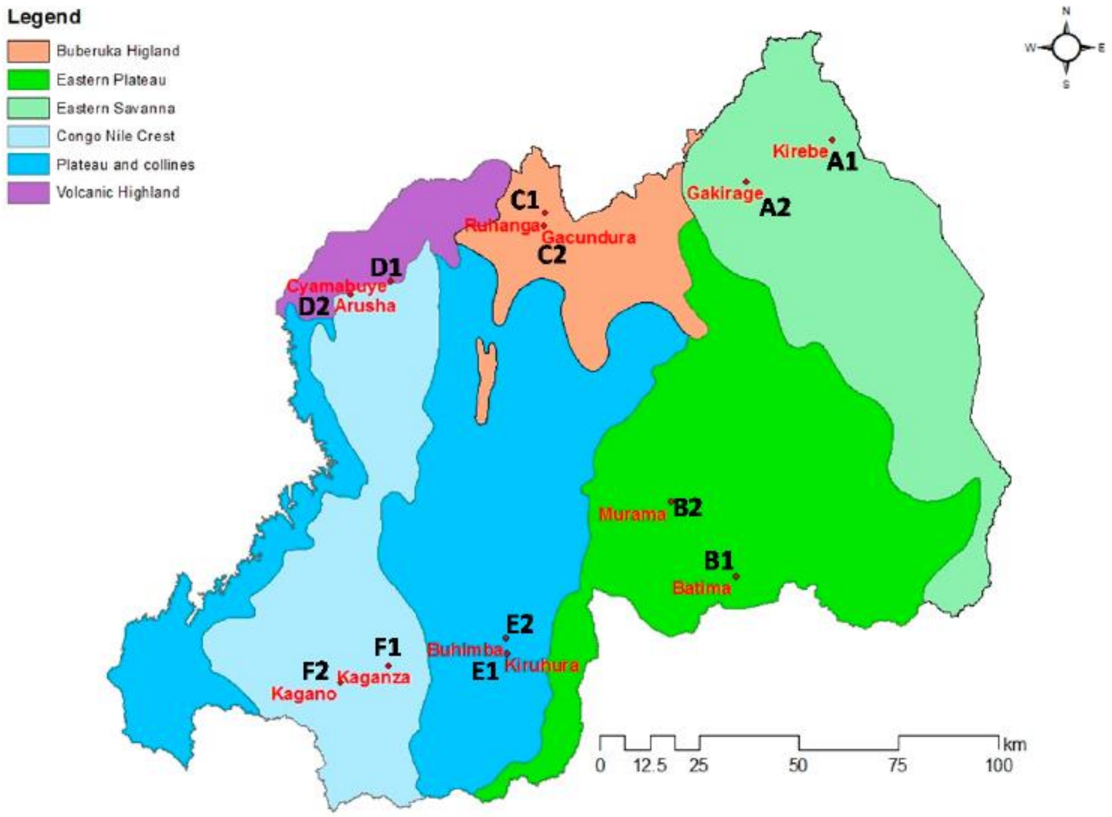

Figure 3.14: Six agroecological zones of Rwanda, adapted from Iiyama et al. (2018).

Crop production systems

The common agricultural activities include production of cassava (*Manihot esculenta*), banana (*Musa parasidiaca*), coffee (*Coffee arabica*), bush beans (*Phaseolus vulgaris*) and rice (*Oryza sativa*). Local livestock production activities include grazing of cattle, pig and goat.

Cassava is a valuable, drought tolerant food security crop grown mainly for its starch, although the leaves can be used as vegetables. Cassava can be processed into flour, which can be used for various purposes such as bread production or cassava meal. In addition, cassava is an industrial crop that can be processed into starch, and subsequently used for pharmaceuticals or textiles. Despite good climate, soils and available techniques to improve crop yields, cassava production is mostly affected by short postharvest life, hence it should be processed as soon as possible (Nduwumuremyi, et al., 2016).

Banana is a subtropical crop, which requires high temperatures, frost free days and adequate water to grow well. It is susceptible to various diseases including root rot, which is caused by poor drainage, hence the sandy loam soils of Kamonyi support its production. The crop has a long growing season, ranging from 12-18 months, being faster in tropical than subtropical climates. However, during the growing period farmers have options to intercrop it with other crops such beans, maize and vegetables. The banana contains high starch content when not ripe and this can be cooked and there are options to dry and pound them into flour.

Table 3.7: Summarise biophysical and farming characteristics of six agroecological regions of Rwanda and common crops grown in such areas. Adapted and modified from Iiyama et al. (2018)

	Biophysical characteristics				Farming characteristics	
Agroecological zone	**Elevation (m)**	**Annual rainfall (mm)**	**Temperature (^{o}C)**	**Soils (FAO classification)**	**Principal crops**	**Animals**
A (Eastern savanna)	1 200-1 400	800-1 000	>21	Ferrasols, Regosols, Vertisols, Acrisols, Histosols	Banana, cassava, maize, bush bean, rice	Free grazing cattle ranching
B (Eastern plateau)	1 200-1 500	800-1 000	20-21	Ferrasols	Banana, cassava, maize, bush beans	Cattle and goats
C (Buberuka Highland)	1 900-2 000	1 200-1 300	15-18	Allisols, Ferrasols, Luvisols, Histisols, Regosols, Cambisols	Wheat, maize, climbing beans, tea, Irish potato	Zero grazing cattle, sheep and goat
D (Volcanic Highland)	2 200-2 400	1 300-1 500	<15	Andosols	Irish potato, wheat, climbing beans, maize, pyrethrum	Free and zero grazing cattle ranching, sheep and goat
E (Central Plateau)	1 100-1 700	1 000-1 500	18-20	Ferrasols, Acrisols Lixisols, Cambisols	Cassava, banana, coffee, bush beans, rice	Zero grazing of cattle, goats and pigs
F (Congo Nile Crest0	1 900-2 500	1 300-2 000	<15-18	Luvisols, Acrisols	Tea, coffee, Irish potato, wheat	Cattle free grazing and zero grazing sheep, and goat, pig

Agricultural Production Characterization

RUNRES scientists conducted focus group discussions to understand the food production systems in Kamonyi district. Three agricultural cooperatives participated, including Comaleka cooperative, KOPABOKI cooperative, and KABIYAKI cooperative. KOPABOKI in full is "Koperative y'Abahinzi Borozi ba Kigusa", and operates in Kamonyi district, Nyarubaka sector. It has 107 members including 87 women and 20 men (Figure 3.15). The COAMALEKA cooperative comes from Karama sector of Kamonyi and it has 14 participants (6 women and 8 men). The KABIYAKI: Koperative y'Abahinzi Bahinga Ibigori n'Imboga Mu gishanga cya Yanza na Kibuza works in Kamonyi district, Gacurabwenge sector.

Figure 3.15: Members of the KOPABOKI cooperative who participated in the production systems focus group discussion.

Land tenure

Land tenure refers to control over resources and how people hold on to exclusive rights of that land or natural resource. This has implications on the investments done in that area, which if not taken into consideration can affect the resilience of food systems. The focus group discussions showed that farmers from the hillsides of Kamonyi own their farmlands and they have title deeds. They rent extra land from wetlands and other farmers who are not using theirs. The rented lands from the wetland belongs to the government and a contractual agreement between the farmer and the district council is done, and an annual fee must be paid. Farmers from farmlands can decide on crops to grow since they a full control of the area. However, those in wetlands should consult with the district on which crops to grow.

The farmers' lands are often fragmented; it was reported that farmers typically own 3-5 plots which are generally small (~0.1 ha per plot), totaling around 0.5 - 0.6 ha per farmer. Some farmers, especially women, reported that they have fragmented land since they inherit some other portions while staying in their matrimonial homes. One of the challenges is that the farmlands are not within the homesteads, hence they must walk from 10 minutes to 2 hours in some areas to cultivate their land.

Apportionment of land

During the focus group discussion with various cooperatives, it was found out that there is a diversity of crops grown by various cooperative across Kamonyi district. The crops commonly grown are summarized in Table 3.8.

Table 3.8: Crops grown by various cooperatives in Kamonyi district.

Comaleka cooperative	KOPABOKI cooperative	Kabiyaki cooperative
Common bean, Maize, Sorghum, Cassava, Irish potato, Sweet potato, Soybean, Groundnuts Garden peas, Banana, Tomatoes, Banana	Maize, Soybean, Cassava, Sweet potato, Banana, Beans, Ground nut, Coffee, Irish Potatoes, Pineapple	Cassava, Sweet potato, Beans, Maize, Irish potato, Ground nuts, Banana, Vegetables, Spices

The farmers from three cooperatives practice both monoculture and polyculture agriculture. Monoculture refers to the production of one crop species at a time while polyculture (e.g. intercropping) is the production of two or more species on the same land at the same time. Monoculture and polyculture systems can be rotated when crop rotation is being done.

Participating farmers shared that intercropping agricultural production systems are practices on the hillsides, whereas the crops in swamps are monocropped. The mostly intercropped crops are cassava with beans, sweet potato, Irish potato, groundnuts, soybean or garden peas. According to KOPABOKI farmers, crops grown in monocrop systems include coffee that is grown for three years, cassava (farmers with large land) and vegetables. The farmers prefer different systems for various reasons. Monocropping systems allow them to easily implement the correct fertilizer management programs, since they can quantify specific amounts of fertilizer for a specific crop. In addition, they find pest and diseases management easier in monocropped systems. They pointed out that crop yields in monocropping system are often higher, which is expected because of less competition between different plant species.

Intercropping allows them to grow a diverse range of crops at the same time, to maximize and efficiently utilize land available, which is beneficial in land limited areas. Some farmers grow crops in intercrops because of traditional norms to continuously grow their common crops such as groundnuts, sorghum, sweet potato and garden peas. However, the major challenge is that yields are relatively lower because different crop species compete for resources such as water, nutrients and even sunlight. Therefore, farmers in land limited areas would benefit from RUNRES innovations dealing with nutrient rich fertilizers by growing as much crops as possible over a small area with adequate resources to sustain soil fertility.

Some farmers practice crop rotation, whereby annual crops such as beans are followed by maize or sorghum or cassava or Irish potato. This is a principle tenet of sustainable agriculture, which helps control pests and diseases because different plant species are attacked by different pests and diseases. However, this was not the case with other farmers who pointed that vegetables such as tomatoes are rotated with eggplants, which are plants within the same family. Some farmers reported growing crops such as coffee and rotating it with cassava after three years.

Institutions

The interviewed farmers reported that the farming system in Kamonyi is well institutionalized. The members are affiliated with various cooperatives, which are KOPABOKI, COAMALEKA and KABIYAKI. Within the cooperatives, farmers are responsible for crop production and supply of inputs. The farmers benefit from cooperatives and various institutions in various ways:

- Training on modern farming methods and technologies (capacity building)
    - For example, institutes such as COCOF and IMPUYABO provide farmers with quality seed and agricultural training.
    - RDO assists in training on sustainable post-harvest handling and storage.
- Improved access to markets and collective marketing of produce.
    - SEAD is responsible for exchange visits with farmers, good agricultural practices and market access.
- Health insurance for cooperative members.
- Advocacy with donors and collaborators from outside the community.
    - SACCO and ICCOTRIFINA are responsible for providing loans and creation of group savings for investments and development.
    - PASP helps in collaboration with BDF to avail the funds for small scale processing.

Access and control of farmland activities from procurement, cultural practices, harvesting, and marketing is usually controlled by cooperatives. However, farmers reported having control of all operations they do on their farmlands, but they have no control of operations on wetlands. Decisions on cropping systems or crops to be grown on wetlands comes from the district.

Farm power

Agricultural production systems in Kamonyi is rarely mechanized. The farmers do not own or rent machinery for agriculture, and the government does not provide this service. Therefore, most operations such as ploughing, weeding, planting, and harvesting are done manually using implements such as hand hoes. A principle challenge faced by farmers is labor, especially during critical periods such as land preparation, planting and harvesting. Some farmers do not have enough money to pay for labor. Labor shortages affect crop productivity, since sometimes planting operations are delayed, resulting in crop failure and relatively lower yields. Some farmers may not plant at all because of these constraints.

Agricultural cultural practices

Land preparation is done by any adult household member (male and female) when they are free. In some instances, labor may be hired. Land is prepared in July and August (1 to 3 months after crop harvest) for the first season and January (second season). Sowing on the hillside is done manually by women.

The use of locally sourced fertilizers to improve crop yields from nutrient depleted soils is one of the RUNRES aims. Currently, the farmers in Kamonyi use various types of organic and inorganic fertilizers for crop production. Organic fertilizers used include both livestock manure and toilet manure (decomposed waste from pit latrines). The use of decomposed pit latrine manure shows that there is an element of human excreta recycling currently being done in Kamonyi. The farmers have learned how to use toilet manure from the training conducted by prisoners from Muhanga prison. However, the inorganic fertilizers used include diammonium phosphate (DAP), urea, and NPK compound fertilizer (17:17:17), which according to the farmers, were recommended by extension officers and various organizations (RAB, Ingabo, CEFOPEC, ICCO, SEAD, RDO and RWARRI). Well decomposed organic fertilizers are applied before planting at a rate of 10 tons per hectare. Early application allows organic fertilizers to mineralize and provides the crops with required nutrients at the right time. Inorganic compound fertilizers (DAP and NPK) are banded in rows at planting. Overapplication of organic and inorganic fertilizers can cause pollution, especially in runoff prone fields of

Kamonyi. Therefore, fertilizer advisory services provided by various extension officers, NGOs, and cooperatives makes agricultural production in Kamonyi environmentally sustainable.

Irrigation is more prominent in wetlands areas while the farmers on hillsides produce dryland crops. Vegetables are irrigated in farms near the wetlands and on the hillsides, while maize is only irrigated on the wetlands. One focus group discussion with farmers reported that water is acquired from the rivers but most of it come from wetlands and the longest distance to the water source is about 45 minutes and this is supplied through canals. The rivers found in Kamonyi are perennial, therefore water supply for irrigation is available all year round. On the other hand, sewage wastewater is not being used for irrigation, but some women highlighted that they use greywater (from washing and households) to irrigate their gardens. There are different methods used for irrigating crops, these include watering cans and basins. The use of watering cans poses health risks if sewage wastewater is used to irrigate crops that are consumed raw. However, farmers have confirmed that the water used for irrigation is coming from clean sources such as wetlands and rivers. This implies that if RUNRES innovations producing blackwater are to be implemented, intensive farmer education on health and safe methods for irrigation with wastewater are required. Farmers do not use any herbicides to control weeds, but they do regular weeding using hand hoes. During the later stages when crops are bigger hand pulling can be done.

Improved hybrid varieties give higher yields compared to recycled planting materials. Farmers in Kamonyi have access to hybrids seeds, and some are using them in their fields. The availability of improved planting materials is supported by various institutions such as COCOF. There are few farmers using recycled unimproved seeds, which they favor for certain characteristics, such as adaptability and resistance to diseases.

Yields and outputs

The estimated yields obtained by farmers for various crops are described in Table 3.9. Yield for crops such as maize (4 tons per hectare) is which is within the range of 1.2 – 5.5 tons ha^{-1} reported for smallholder farmers by Bucagu et al. (2020). This implies that yields are generally good, although the farmers pointed out some issues which might negatively impact crop productivity. These are shortages of organic manure, late planting resulting from labor shortages during land preparation, insufficient fertilizers in intercrops, climate change, poor quality of seed, and low soil fertility.

Table 3.9: Estimated crop yields from three different cooperatives.

Crop	Comaleka cooperative (yield in tons/ha)	Kopaboki cooperative (yield in tons/ha)	Kabiyaki cooperative (yield in tons/ha)
Maize	4	4	4
Soybean	1.2	1.2	0.5
Cassava	7	20	50
Sweet potato	10	10	12
Vegetables	7.5	20	13
Banana	-	20	6-7
Fresh coffee	-	19	-
Climbing beans	-	2	-
Bush beans	0.8	1	0.8
Ground nuts	-	0.5	0.3
Sorghum	-	-	2

Livestock production

Most of the farmers keep animals such as bees, rabbits, dairy cows, beef cows, chicken, pigs, sheep, and goats. Livestock production is semi subsistence; they produce for household consumption and the surplus is sold. The animals are cross bred between local and imported species, while others are local landraces. The veterinary services are offered by the sector veterinarian assigned by the district and private veterinary service providers. The farmers buy feed for chicken and pigs from established agroshops. However, goats and cattle are free range animals and sometimes fed with grass fetched by farmers. The animals are paddocked. Some farmers in Comaleka do not keep free range animals and some farmers grow fodder crops for stock feed.

Problems and coping strategies

The RUNRES project seeks to increase food systems resilience in low-income communities. It is therefore crucial for the project to understand the challenges being faced by small scale farmers and how they can be improved based on their existing knowledge. Therefore, various issues that might affect agricultural productivity and subsequently impacting food security include soil fertility, pests and diseases, market dynamics, availability of water (quantity and quality) and costs of inputs.

Irrigation water is readily available and Kamonyi receives >1 000 mm of annual rainfall. The farmers have confirmed that they have perennial rivers that supply water the whole year. In addition, there wetlands around, which allow continuous production across seasons.

Soil fertility does not only refer to the nutritional status of the soil but quality in terms of physical properties such as aggregate stability, cation exchange capacity and moisture retention capacity, and biological properties such as microbial biomass. Microorganisms play a major role in facilitating nutrient bioavailability through decomposition of complex organic compounds into inorganic compounds. The application of organic fertilizers such as pit latrine and cattle manure being done by Kamonyi farmers increases soil organic carbon, which increases biological activity and improve soil properties (Levy, et al., 2014). The farmers reported that the organic fertilizers utilized are not adequate, therefore, they must purchase from other suppliers using money from group savings. This implies that RUNRES innovations dealing with composting have a potential market, farmers being the primary target as well as other small enterprises.

Organic fertilizers are slow releasing, meaning that the nutrients applied are not bioavailable. Application rates and timing affect the amounts of nutrients to be contributed by the respective fertilizer. The farmers reported that fertilizers are applied based on rates recommended by extension officers, which is 10 tons of organic fertilizer per hectare per year and, they apply before planting, which gives the organic fertilizer enough time to mineralize. This is the same recommended rate for sewage sludge in South Africa and most parts of the world (Ogbazghi, Tesfamariam, & Annandale, 2016). According to studies by Ogbazghi et al. (2016) the mineralization of nitrogen in organic fertilizers vary with agroecological regions due to differences in edaphic factors and climate. The authors have reported high N mineralization in sludge applied in clay soils especially in super humid agroecological region of South Africa (Ogbazghi et al., 2016). As a result, recently, the Sludge Application Rate Advisor (SARA) model has been developed to give site specific application rate for sludge, and this can be adopted for any organic fertilizer being considered in all RUNRES innovations. Therefore, to maximize the benefits of organic fertilizers produced from innovations such as composting and co-composting, it is crucial to analyze the products for their respective nutrient composition, use biophysical information to run the SARA model, and provide application rates for farmers in different agroecological regions of Rwanda. The project can work with relevant institutions such as Impuyabo, extension services and various cooperatives in teaching them new agricultural technologies.

The advantages of using inorganic fertilizers is that the nutrients are bioavailable, however, in irrigated systems this might also cause non-point pollution. However, the ability of the soil to retain nutrients in the rooting zone may increase nutrient uptake by crops and minimize subsequent losses through leaching. Soil nutrient retention ability depends on physical properties such as cation exchange capacity and moisture retention capacity, which are also increased by organic carbon. Therefore, use of organic manure in such agricultural systems increases fertilizer use efficiency through reduced nutrient losses into the environment. Furthermore, farmers can manage pollution through existing interventions such as terracing and production of trees in the field periphery.

Local farmers purchase inorganic fertilizers from agro-dealers, which might be potentially expensive. Therefore, there is a potential to substitute or supplement inorganic fertilizer with human excreta based fertilizers such as urine. According to Jönsson, Stintzing, Vinnerås, and Salomon (2004) urine is able to suffice 400 m^2 (N) and 600 m^2 (P) per person per year if all is collected, thereby eliminating the need to apply extra fertilisers. In addition, human beings do not consume heavy metals and these are not found in urine (Etter, Udert, & Gounden, 2015). There are certain technologies to concentrate urine into less bulky and non-odorous products, other than the highly expensively and technical nitrification and concentration, recent evidence shows that urine can be treated with lime (wood ash) (Senecal & Vinnerås, 2017). The introduction of innovations that can allow urine collection from urine diversion toilets and its treatment using wood ash from pyrolysis of agricultural residues

Market dynamics such as availability, price volatility and logistics are important to farmers. Choice of market depends on market dynamics e.g. volumes of produces, location of buyers and different prices. However, Kamonyi farmers survive such dynamics by contracting with buyers. Most of the vegetable markets are in Kigali, which is a distance away from farmers, therefore its logistically unsustainable for farmers to transport their produce. As a result, farmers organize themselves and sell their products as a group to the market. Cooperatives work with institutions such as SEAD, which provide them with information on access to best available markets and examples of available markets for KOPABAKI farmers are Musumba, Muhanga and Musambira markets. Sometimes market prices may be prohibitive to farmers, therefore production during on-season may be unprofitable such that farmers resort to off-season production in wetlands, allowing them to maximise sales returns when the product is scarce. Alternatively, some farmers may keep the product and sell it when the prices are higher. Some farmers add value to their products by sorting and grading so that they can be sold at higher prices. With these available options, small scale processing may help to minimise post-harvest losses emanating from market dynamics, and RUNRES may collaborate with organization such as RDO in coming up with low cost, sustainable and simple small scale processing technologies.

Livestock production is a component of the food value chain as noted in Section 0. The farmers purchase feed from agro-dealers, others produce fodder crops, and some keep free-range animals. In return, the animals produce manure, which is extensively used in crop production and the meat being consumed by farmers, and excess is sold to generate income. The sustenance of a livestock production component is crucial in the food chain as well to the resilience of current agroecosystems. Just like crops, livestock production is also affected by pests and diseases. However, the cooperatives in Kamonyi are well prepared to cope with these challenges. During the focus group discussions, the farmers have reported that they protect their animals in various ways. They regularly visit veterinary services for vaccinations and hygienic practices are done to keep animals disease-free. There is an opportunity for RUNRES to explore around fodder production using various fertilisers and soil amendments from selected innovations. In addition, small scale processing waste can be used as livestock feed.

3.4 Msunduzi, South Africa

Introduction

South Africa has a dual agricultural economy, with both well-developed commercial farming and smaller-scale communal farming (located in the former homeland areas) prevalent. Although agriculture contributes a relatively small share of the total South African GDP (Greyling, 2012), it is important in providing employment and earning foreign currency. The agricultural sector is governed by the Department of Agriculture, Land Reform and Rural Development (DALRRD), which was established in June 2019, by the merger of the departments of Agriculture, Forestry and Fisheries (DAFF) and rural Development and Land Reform (DRDLR).

In the predominantly white-owned commercial sector, applied research and improved farm management have nearly doubled agricultural production during the past 30 years (Liebenberg, 2013). However, production in the rural small scale and communal sector remains low. This is of particular importance to KwaZulu Natal (KZN) province, where rural areas account for 57% of the total provincial population, making it one of the most rural provinces in the country.

This context study aims to understand agricultural production systems in South Africa, with particular interest in Msunduzi (RUNRES city region). Agricultural activities depend on the climatic and geographical characteristics; therefore, this study describes national climatic zones, provincial (KZN) vegetation, and outlines soil, geology and climatic data for Msunduzi. In addition to grey literature, RUNRES scientists utilized qualitative data collection methods, in this case focus group discussions and key informant interviews, to understand the current conditions of smallholder farmers in the project area.

To assess smallholder production in a rural area of the city region, a focus group discussion was held at the Madlala community hall in Vulindlela. To understand the dynamics of peri-urban smallholder production in the city-region, RUNRES scientists conducted a virtual focus group discussion with farmers from the Sobantu community; due to the COVID 19 regulations in place at the time of the data collection, in person methods were prohibited. In addition, a key informant interview was carried out with the Department of Advisory and Extension services. In conclusion, the study reports on the agricultural production systems in Msunduzi with emphasis on Vulindlela and Sobantu areas.

Characterization of the study area

Climatic zones

The South African climate is determined by the country's position between 22° and 35° South and its location between the Atlantic and Indian oceans. It has a wide range of climates compared to other countries in Sub Saharan Africa, ranging from Mediterranean to desert (Charles-Dominique et.al, 2015). These climatic zones are delineated by their seasonal rainfall patterns and temperatures. There are many different approaches for bioclimatic, empirical climate classification. However, the Köppen-Geiger is still the most used climate classification method worldwide (Rubel and Kottek, 2010). The five vegetation groups of the Köppen classification distinguish between plants of the equatorial zone (A), the arid zone (B), the warm temperate zone (C), the snow zone (D) and the polar zone (E). A second letter in the classification indicates mean precipitation and a third letter mean air temperature. The Council for Scientific and Industrial Research (CSIR) developed a Köppen-Geiger map to classify the current climatic conditions in South Africa using 20 years of precipitation and temperature data based on a 1 km x 1 km grid. According to the developed Köppen-Geiger map (Figure 3.16) 70.89% of the country can be characterized as arid while 28.9% is warm temperate and 0.2% is equatorial.

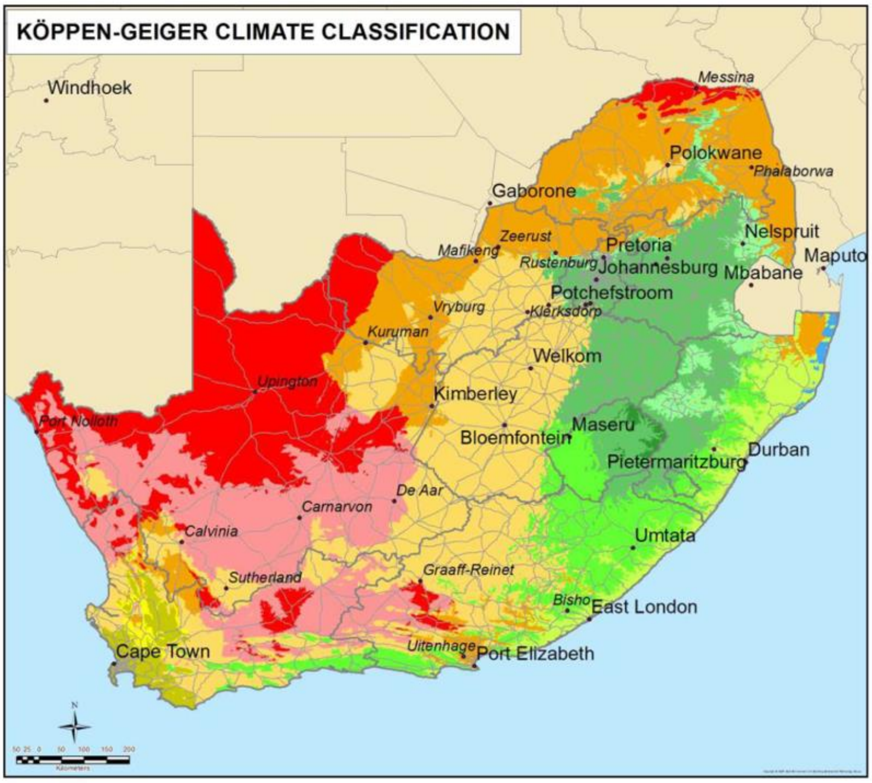

Figure 3.16: South African Köppen-Geiger map showing climatic zones (CSIR). Corresponding table can be found in the appendix.

The arid climate areas comprise the steppe and desert regions. The steppe hot (Bsh) region is characterized by a dryness threshold of 5mm and an annual mean temperature greater than 18 ◦C. This region lies in the North West province and some parts of the Limpopo province and covers an area of 192,269 km^2. The steppe cold (Bsk) region has an annual mean temperature less than 18 ◦C. It is located in the Free State and some parts of Eastern Cape and stretches over an area of 275,927 km^2. The desert areas are characterized by a dryness threshold less than 5mm, with the hot desert (Bwh) covering most parts of the Northern Cape and some parts of the Limpopo (188,784 km^2). The cold desert (Bwk) is located in the lower parts of Northern Cape and upper parts of the Eastern Cape and covers an area of 164,629km^2. Warm temperate areas are categorized into the fully humid hot summer regions (Cfa), fully humid warm summer (Cfb), fully humid cool summer (Cfc), dry hot summer (Csa), dry warm summer (Csb), dry winter hot summer (Cwa), dry winter warm summer (Cwb) and dry winter cool summer. The characteristics of the aforementioned regions are explained in Table 1, located in the appendix. The only equatorial climate of South Africa is located within Northern KZN and covers an area of 2,296 km^2.

Geology and soil classification

Soil properties are influenced by an area's geology; the chemical properties and fertility of a soil are directly impacted by their geological parent material, which ultimately influences agricultural activities. The underlying geology of Msunduzi consists of a sequence of claustic or fragmented sedimentary rock strata, which is primarily composed of sandy and clayey shales, sandstones and tillites, overlaying a bedrock composed of granite and gneiss. Significant areas of intruded dolerite are found throughout the region. Figure 3.17 below illustrates the geology of Msunduzi with its subsequent soil types as described in table 1 (appendix). The sandy and clayey shales, which form part of the Pietermaritzburg Formation (Ecca Groups) and Volksrust formation, underlie about 80% of the region. While they are easily weathered when exposed, their low porosity and permeability often causes high surface water runoff, especially in areas having a shallow depth of soil cover. Soils derived from the process of weathering have accumulated at the base of escarpments within the region to form the talus geological formation. Extensive areas of talus are found in the Town Bush Stream Valley and the northern portion of Northdale (Ab118 and Ac218), within the Borough of Pietermaritzburg (Ab119, Ab120, Ac221, Bd32), the Sinathingi River Valley within Edendale, portions of Vulindlela, particularly the Mpumuza (Ac227 and Ac228), and in the vicinity of Otto's Bluff. These areas are generally unstable and subject to slumping.

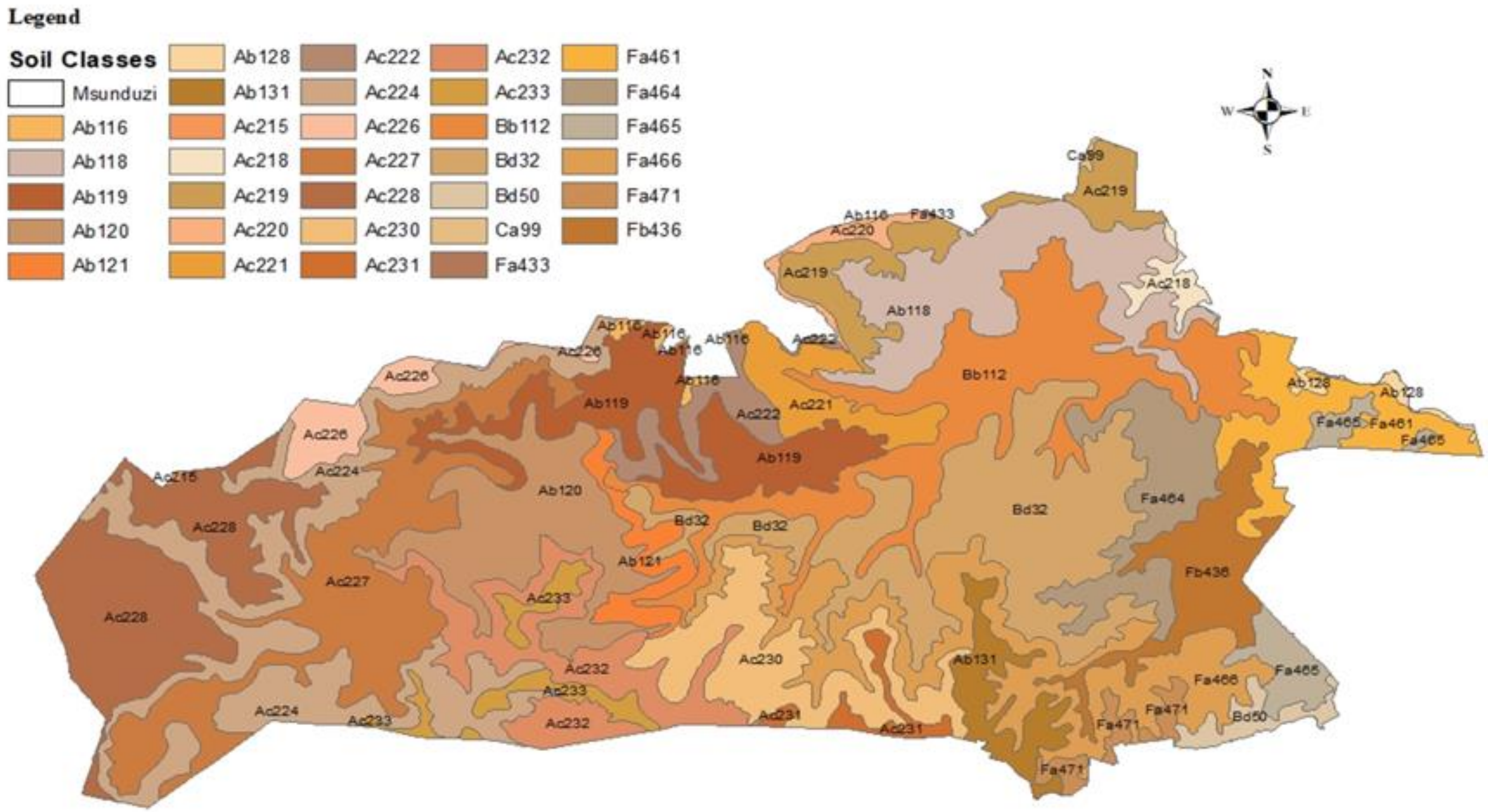

Figure 3.17: soil map of Msunduzi. Soil classification table located in appendix.

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Topography

Approximately 30% of the municipal area consists of topography having a gradient steeper than 1 meter in 3 meters (1:3). More than half of this steep topography is located in the western quadrant of the municipal area, particularly within the boundaries of the Greater Edendale-Imbali ABM and the Vulindlela ABM (Figure 3.18). Flat topography having a gradient flatter than 1 meter in 3 meters (1:3) constitutes approximately 70% of the municipal area. At least 60% of this topography is concentrated in the former Pietermaritzburg Borough and its surrounds.

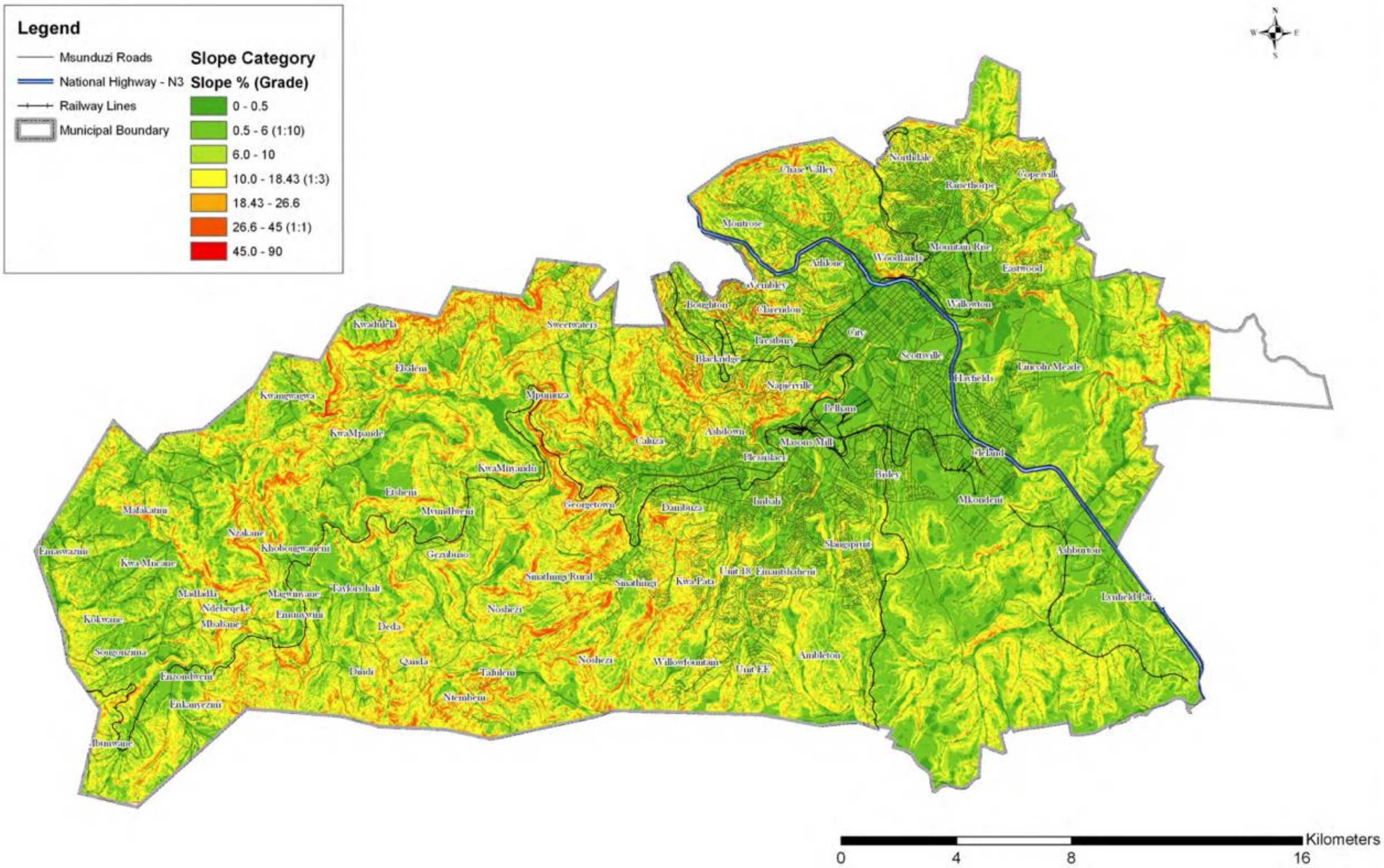

Figure 3.18: Slope analysis within Msunduzi municipality

Agricultural production systems

The afore mentioned bioclimatic and geomorphological properties have a direct impact on agricultural production systems. This section outlines agricultural activities carried out in Vulindlela and Sobantu areas from land preparation to harvest. Challenges faced during production, as well as typical mitigation strategies employed are also outlined.

Agricultural potential

Commercial agriculture is the main employer in most municipalities of KwaZulu Natal. However, agricultural output in Msunduzi is limited, with agriculture contributing only 3% to the Gross Value Added to the municipality (Zimu, 2014). This is attributed to the limited agricultural land in the municipality. The challenge is magnified by the rapid urbanization occurring in area. Although the land located in the Edendale valley area is zoned for agriculture, in reality much of that land has been occupied for housing, either by informal settlements and land invaders, or earmarked for low-cost housing. However, agriculture remains an important sector in the area, as Msunduzi is a major service center of the sector. The current focus of the municipality is to protect available and high potential agricultural land (Figure 3.19) and improve the linkages between commercial and subsistence farming to facilitate the intensification of agricultural production (Davies et al., 2017). Vulindlela has most of the agricultural land in the municipality, most of which is cultivated by smallholder farming.

Vulindlela is situated in the mist belt, at an altitude of 1100 m and lies 50 km west of Pietermaritzburg. The area receives an average of 929 mm rain annually. The dominant soil type is an Avalon form with an orthic A horizon. The B horizon is a yellow brown apedal on top of a soft plintite, the latter limiting root growth mainly to the top 600 mm. The climate is favorable for a wide range of adapted crops and the area has a year-round growing season. Smallholder farmers often lack supplementary irrigation unless they are beneficiaries of smallholder irrigation schemes of the former homelands (Aliber et al., 2006). As a result, some farming activities are not very active during the dry season but only gain momentum during the rainy season.

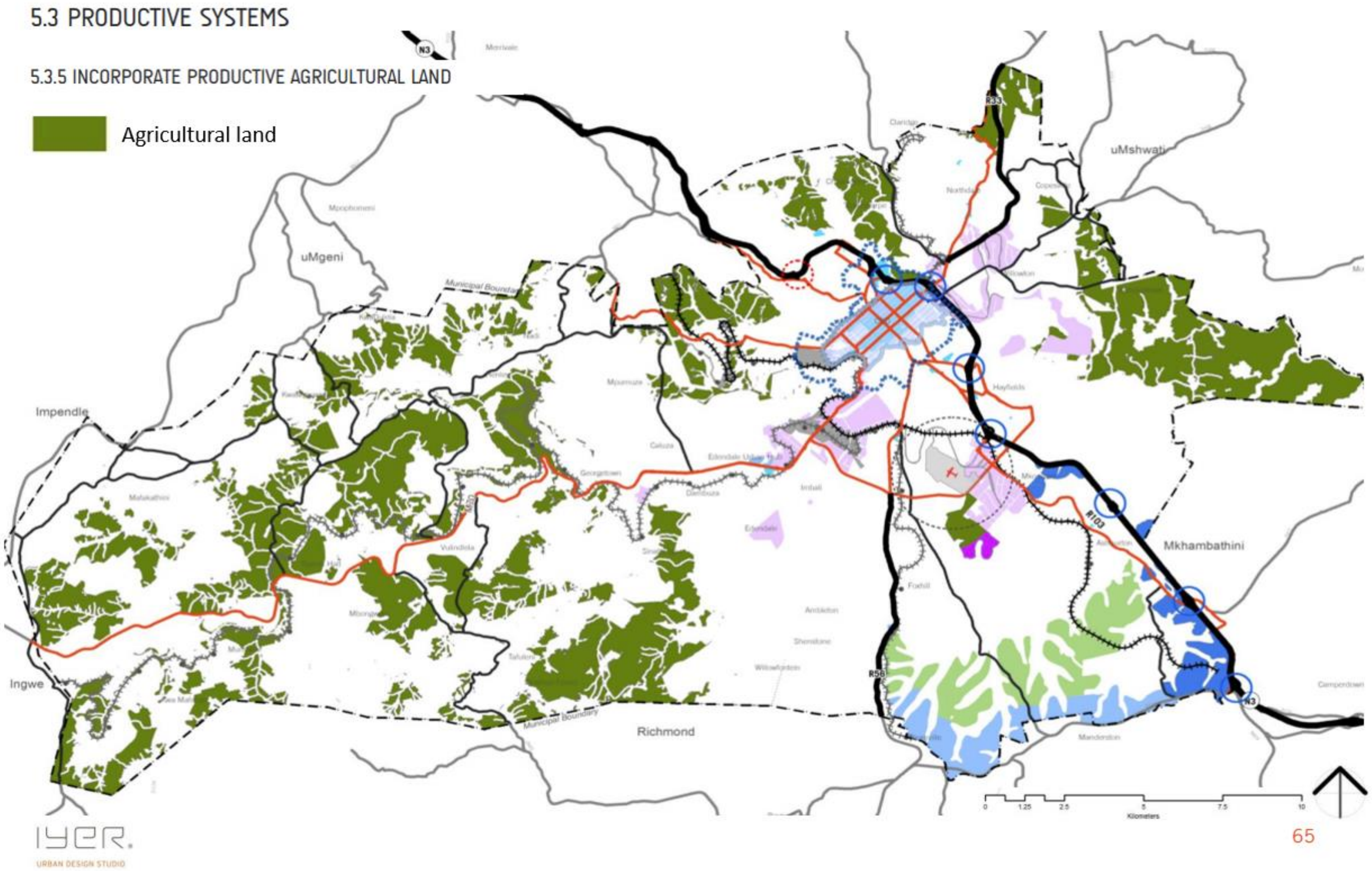

Figure 3.19: Areas of land within the municipality targeted for agricultural production.

Land tenure

In South Africa, land ownership remains a complex and contentious political issue that is linked to the country's colonial history. Several land reform policies (land distribution, land restitution and land reform) have been implemented in an effort to correct the injustices of the apartheid government (Kepe and Hall, 2016). Land redistribution was targeted at citizens intending to buy land under the willing buyer willing seller policy. The government supported individuals interested in buying land through financial grants. However, the policy is regarded as unsuccessful because only 7% of the land was redistributed to the poor.

The restitution policy endorsed the need to give back or compensate South Africans who had been deceitfully disposed of their land under the Land Act of 1913 (Alan-Dodson, 2013; Beinart and Delius, 2014). The policy's main objective is to effectively deal with the administration of land in the communal parts of the past homelands and colored reserves (Gumede, 2014). Regardless of the aforementioned reform policies, inequalities within land ownership are still very high. A land audit conducted in 2017 revealed that white South Africans own 72% of the total agricultural land, while colored South Africans own 15% and black South Africans 5% (Land Audit Report, 2017). The South African Joint Constitutional Review Committee adopted a recommendation that proposed to amend the Constitution to allow the government to expropriate land without compensation (LEWC, 2018). The National Council of Provinces approved this legislation in December 2018. The uncertainties surrounding LEWC have resulted in illegal land grabs and in severe cases the killing of white farmers. Afriforum, a civil rights organization, reported that 57 white farmers were killed in 2019, with most cases taking place in Gauteng and Freestate provinces (Head, 2020).

Vulindlela is located within a region of the former KwaZulu homeland that was characterized by traditional forms of land tenure and subsistence agriculture. Thus, land in Vulindlela is owned by the traditional leadership through the Ingonyama Trust. The trust was established in 1994 to hold all government land in KwaZulu Natal for the benefit, material welfare and social wellbeing of the members of the tribes and communities living on the land. The sole trustee to land under Ingonyama Trust is King Zwelithini Bhekuzulu, who owns approximately 2,883 million hectares of land. However, the *amakhosi* (Chiefs) are responsible for the distribution and management of land in their assigned areas. An *Induna* (headman) appointed by the chief performs specific tasks as agreed to by the chief. In Vulindlela, each family is allocated a one-hectare plot, which the chief has the right to take back if the land is not used. This is consistent with studies carried out in other rural communities of KZN, where average smallholder farm sizes of 1.8 and 1.1 hectares were reported respectively (Matungul et al. 2001). The occupants are issued with an official permission to occupy, which allows the person given land the right to use the plot of land. This does not confer ownership. In most cases, the PTO is issued to the male members of the family. The allotment of larger pieces of land is possible (up to 30 ha) when residents organize into farming cooperatives. In contrast, land in urban areas is owned and controlled by Msunduzi municipality. Farmers in the Sobantu community target unutilized land in the area; however, they must obtain consent from the councilor's office for agricultural use. Sobantu farmers are organized into a cooperative (Sakhubuntu) to share ideas and to get assistance from the government.

Farming cooperatives are common in South Africa. Members of cooperatives are expected to generate more income than individual farmers unless the latter have enough capital, skills and labor to sustain their farming activities (Moloi, 2008). An analysis performed by the Department of Agriculture Forestry and Fisheries (DAFF) in 2014 identified 1,443 cooperatives with a total of 35,799 smallholder members across KZN. Most of the profiled cooperatives are involved in vegetable production. In an effort to promote profitable and market-oriented cooperatives with quality business development and management DAFF collaborated with AgriSETA for development and training through an initiative called Farm together Cooperative Training Program. (Nchabeleng, 2016).

Land use

Land use in the rural areas of the city region is predominantly agricultural in nature and can be characterized primarily by small-scale subsistence farming, timber plantations, and some pockets of indigenous forest. Maize (*Zea mays*) and dry beans (*Phaseolus vulgaris*) are the major crops produced in Vulindlela during the rainy season through the relay intercropping system. Relay intercropping is the most common cropping system, with maize and beans grown simultaneously. Maize yields in Vulindlela average 1 ton ha^{-1} while beans produce on average 200kg ha^{-1} (Magwaza, 2019). This is much lower than local commercial growers, who routinely produce around 4 tons ha^{-1} and 3 tons ha^{-1} respectively.

In addition to maize and beans, important vegetables that are produced in Vulindlela include cabbage, green beans, sweet potatoes, tomatoes, taro (amadumbe), onions, lettuce, and butternut. These crops are produced in household gardens as well as by farmer groups. There is no major variation between crops grown in home gardens and in farmer's groups except the quantities, which are higher when produced by a farmer group. A few farmers also produce other crops such as brinjals and green pepper, though in very small quantities.

Land preparation

Cultivation tractors are provided by the government to the farmers at the beginning of every farming season (November). Msunduzi local municipality also provides tractors to farming cooperatives. However, most farmers prepare the land manually using digging hoes in their community and backyard gardens.

Inputs

The planting material used in Vulindlela depends on the crop type. For example, maize and bean seeds are purchased from Agro dealer shops or in some cases remnant seeds from the previous season is used. The government, through the department of agriculture and rural development, provides chemical fertilizers (2:3:2) for farmers in Vulindlela. In addition, cow dung and chicken manure are also used as fertilizers, particularly in backyard gardens. Agricultural extension officers are available to advise on the fertilizer application rates and methods. Government support is minimal among Sobantu farmers. Farmers buy inputs from Agro-dealer shops, of which TWK was the most reported source of inputs (Table 3.10) for input prices). Moreover, farmers rely on TWK product advisors for management practices such as fertilizer application rates and methods. The Radical Agrarian Socio-Economic Transformation (RASET) is another initiative recently introduced by the government to the Msunduzi municipality. The program aims to provide inputs and open markets for black small scale and subsistence farmers. Msunduzi municipality emphasized prioritizing the youth in the RASET program. The target is to set up 80 youth led agri-enterprises, each with a minimum of 5 hectares. The program focuses primarily on rural farmers.

Table 3.10: Msunduzi farmer inputs and prices.

Input	Quantity	Price	Retailer shop	Location
Maize seeds	10 kg	R 520	TWK-Agri	Pietermaritzburg CBD
Dry bean seeds	5kg	R260	TWK-Agri	Pietermaritzburg CBD
Fertilizer Compound D (2:3:2) (N:P:K)	50 kg	R396.70	TWK-Agri	Pietermaritzburg CBD
Urea	50kg	R458.85	TWK-Agri	Pietermaritzburg CBD
Single superphosphate	50 kg	R419.75	TWK-Agri	Pietermaritzburg CBD
Muriate of potash	50 kg	R410.10	TWK-Agri	Pietermaritzburg CBD
Potato seeds	10 kg	R 150	TWK-Agri	Pietermaritzburg CBD
Swiss chard seedlings		R1/seedling	SunShine seedlings stalls	Pietermaritzburg CBD
Cabbage seedlings		R1/seedling	SunShine seedlings stalls	Pietermaritzburg CBD
Tractor hire		R3500/ha		
Broiler day old chicks	300	R7.40/ chick	TWK Agri Stoneor Farm	Pietermaritzburg CBD
Rhode Island red	100	R10/chick	CSP poultry	Newcastle
Potchefstroom Koekoek	100	R10/chick	Private breeder	Durban
Broiler starter and finisher	50kg 40 kg	R300 R240	Meadows Epol	Pietermaritzburg CBD

In both project areas weeds are controlled manually through hand plucking or use of hoes. The use of herbicides was not reported in Vulindlela; this is attributed to their high prices. In the event of a disease or pest outbreak the government provides the required chemicals for control. Moreover, agricultural extension officers are deployed to offer training and advisory services in the affected areas.

The primary source of irrigation water in Vulindlela is the Msunduzi river, which is a tributary of the Umgeni river. The use of sprinkler irrigation is a common type of irrigation during the dry season in Vulindlela. The sprinkler irrigation is powered by generators and connected to the Msunduzi river through hydrant valves. However, most farmers rely on rainfall for irrigation, with some farmers using grey water for their backyard gardens. In Sobantu municipal water is used for irrigation.

Livestock production

Livestock production is practiced in both Vulindlela and Sobantu. In rural Vulindlela cattle, goats, sheep, pigs and chickens are the most common animals reared in the area. Goats and cattle are kept mainly for ritual purposes or for selling to sangomas (traditional healers). Pigs and chicken are slaughtered for meat and in some cases sold to the local butchers. Livestock production is also important for providing manure, milk, and eggs. Goats and cattle are kept at the homestead at night and are grazed on communal land during the day. Thus, any manure produced during the day is not available for crop production. Grazing is conducted on communal lands, usually the steeper, less agriculturally productive land. While communally owned land is used for grazing, very few community-based livestock management systems are currently in place and overgrazing is a prevalent phenomenon (Adey et al.,2004). Landraces are common breeds for cattle, sheep and goats, however commercial breeds are preferred for chicken and pigs. Vaccination and plunge dipping services are provided by the veterinary services to control lice, mites and ticks, which are carriers of *Theileria parva* (east coast fever). Cattle are sent for plunge dipping once a week (every Thursday). Dipping services are subsidized by the government through the Department of Veterinary services through the construction of dipping structures (*Figure 3.20*) and the provision of the required parasiticides. Emulsifiable concentrates or wettable powders containing parasiticidal active ingredients with contact effect are the most common parasiticides for plunge dipping Vaccination and dipping services are provided by the veterinary services.

Figure 3.20: Plunge dipping structure in Vulundlela community (source: Melanie Surchat).

Poultry production is the most dominant livestock practice in Sobantu community. However, very few farmers involved in poultry production, practice it on a larger scale. Indigenous and commercial breeds (broilers) are both produced in Sobantu communities. The most common poultry indigenous breeds in Sobantu are Rhodes Island red and Potchefstroom Koekoek (Figure 3.21).

Figure 3.21: Indigenous chicken breeds feeding on vegetable garden waste in Sobantu community (Source: Melanie Surchat).

Commercial chicken feeds are fed to the commercial breeds (broilers) and the proximity of the community to the industrial area makes it easier to acquire the feeds. Meadows feeds was reported as the most common source of chicken feeds due to its cheap prices and staff that is willing to offer advisory management services. In comparison, free range chickens are fed with leftover food and discarded vegetables from backyard garden.

Extension services

Extension services are imposed on farmers through the transfer of technology extension approaches. This suggests that the knowledge and skills held within the agricultural extension system should be assessed and updated on a regular basis to ensure extension services stay relevant to the ever-changing agricultural landscape. Williams et al. (2008) reported that access to quality extension and advisory services depends on the ratio of extension to farmers. The distribution of extension and advisory services is relatively low among emerging farmers who arguably have the greatest need for extension. This poor distribution contributes to the fact that most small-scale farmers depend entirely on public extension services. In Vulindlela, one extension officer is responsible for 5 wards, each ward is visited once a month. The farmers reported bias of extension officers over certain farmer cooperatives, where extension services are offered to certain groups on a regular basis at the expense of other farmers. Similar sentiments were shared by farmers from Impendle and Swayimani, who reported that extension officers visited households roughly once a year (Ortmann and King, 2010).

Challenges to small scale production

Post-harvest losses

Post-harvest losses are a major problem faced by farmers in Vulindlela, particularly those involved in vegetable production. Harvested fresh vegetables are living, characterized by high moisture content, active metabolism, and tender texture. These characteristics result in substantial losses through senescence, desiccation, physiological disorders, mechanical injuries and microbial spoilage that occur at any point from harvest through the food value chain (Chun-Ta, 2010). In Vulindlela, storage, packaging, and handling techniques for perishable crops are practically non-existent, causing significant production losses. Improper harvesting and postharvest practices result in losses due to spoiling of the product before reaching the market, as well as quality losses such as deterioration in appearance, taste and nutritional value (Buyukbay et al., 2011) However, little has been done to identify the main postharvest handling practices by smallholder farmers, documenting the quantities they lose and the associated income losses. Minimizing postharvest losses of fresh produce is a very effective way of reducing the area required for production and increasing food availability (Kader, 2005). There is lack of an effective and far-reaching educational extension program on these aspects, which has a negative impact on smallholder farmers in the region.

Poor soil fertility

Poor soils low in nutrient and organic content are common in Vulindlela. Soil nutrients are constantly mined from soils through crop harvesting. Application of commercial fertilizers and animal manure are some measures taken to address poor soils. However, application is rarely done at the recommended rates. More so, plant residues are fed to livestock thus there is not enough plant residue to plough back into the fields.

Markets and prices

The major challenge faced by farmers in Vulindlela is access to formal vegetable markets. Most retail shops have signed long term contracts (50 years) with commercial farmers that makes it difficult for smallholder farmers to penetrate the market (Rylance,2018). The retail shops prefer commercial farmers because they provide large quantities and comply with stringent quality and safety standards. Smallholder farmers are marginalized because of their limited production capacity, limited access to financial capital, limited access to production equipment, and poor post-harvest infrastructure. Due to this, farmers in Vulindlela are now looking for alternative, niche markets such as local schools for the feeding scheme program, prisons, and clinics. A less popular alternative is the use of farmer markets (Figure 3.22). The reluctance to explore this market option is due to the fact that farmers must pay 5% commission of their sales to the municipality for the provided facilities and 7.5% is paid to the agents. Most farmer groups engage in group marketing as well as credit provision for their members, therefore it is expected that household membership with associations would have a positive impact on market participation (Martey et al., 2012).

Figure 3.22: Sobantu cooperative market in Pietermaritzbug, Msunduzi. (Source: Melanie Surchat, 2020).

Stray animals

Stray cattle have been reported to ruin smallholder crops in Sobantu, especially community gardens. Several farmers confirmed the total loss of crops to stray cattle. In some cases, they become violent, charging at anyone in their range. Fencing is a possible solution for the problem of stray animals. However, the land tenure system in Sobantu makes it difficult to develop the land in anyway.

Summary conclusion, recommendations

This study revealed that commercial agriculture is not dominant in Msunduzi city region due to limited agricultural land. Rapid urbanization has led to the preference of housing over agriculture on the available land. Currently agricultural activities are more in the rural than the urban areas of Msunduzi, where small holder farmers mainly produce maize, beans, and sweet potatoes for their own consumption. Vegetables are grown primarily for the purpose of reselling, which is typically done by cooperative farmers, however, backyard gardens are popular to produce vegetables for their own consumption. In comparison, agricultural production is mainly for self-consumption in the urban Msunduzi region, with few farmers exploring the option of reselling. It is also clear that rural farmers receive more government support in terms of agricultural inputs to boost productivity and enhance their livelihoods.

4 The Food value chain

Acronyms and Abbreviations

CE:	Circular Economy
DRC:	Democratic Republic of Congo
FVC:	Food Value Chain
IITA:	International Institute of Tropical Agriculture
NGO:	Non-Government Organization
ODK:	Open Data Kit
SMS:	Short Message Service
TV:	Television
USD:	United States Dollar
VCA:	Value chain analysis
WFP:	World Food Program

Introduction

According to Kaplinsky & Morris (2002), Kaplinsky (2004), DFID (2008), USAID (2009), WFP (2010), and ILO (2015), a food value chain is defined as the full range of activities that are necessary to deliver a food product from the producers/farmers through all the intermediary actors (middlemen, input suppliers, processors, wholesalers or retailers) to the final consumer. Therefore, a food value chain analysis must help understand a specific food commodity value chain by unearthing actors in this chain, what they do, how they do it, their locations, relationships, and how they are governed/sustain their operations, (WFP, 2010). WFP adds that such an analysis should as well identify opportunities along such chains and how these should be harnessed, while as well unearthing challenges along these chains and appropriate interventions necessary to overcome these challenges. Finally, WFP advises that alongside a comprehensive food commodity value chain analysis, an assessment of the consumers' incomes and expenditures must also be done to predict consumers' food security status (via available food purchasing power), and optimal food commodity pricing that could help redistribute benefits among chain actors.

According to the World Food Program (WFP), a food value chain analysis (VCA) is built on a market system (a supply chain), detailing both structural and dynamic factors that affect contributions of each actor in the chain. These factors are deemed very important and must all be covered in detail in order to have a proper understanding of the food commodity value chain. ***Structural factors*** of the VCA include: **1)** The characteristics of a food commodity – for instance; prices, quality, quantity (determined by end markets like buyers). **2)** The enabling environment – for instance; laws, regulations, policies, norms, infrastructure etc., that is, factors facilitating or hindering the functioning of markets. **3)** Relationships (i.e. formal and informal linkages and information flows) between actors at different level of the food value chain. These relationships – particularly gender- is also critical in moving food commodities to end users, thus in these relations we can know who controls what, where, and how. For instance, a food value chain would show where the women participate, and or are all women dominated products and markets included? **4)** Supporting markets along the value chain (for example financial services, technical support, telecommunications, irrigation, inputs delivery etc.). ***Dynamic factors*** (what keeps these actors together, what information is shared, how is their relationship evolving, where are their locations)– these would characterize how actors in the market system respond to opportunities and constraints (limitations).

Therefore, according to WFP, a simplified food commodity value chain would involve the following actors: input suppliers, farmers, middlemen (agents, assemblers/collectors, transporters), processors, wholesalers (importers/exporters), retailers, and final consumers. Therefore, in RUNRES we envisioned the following generic food commodity value chain under a circular economy model – where consumers in urban centers after accumulating organic waste from their consumption activities, this waste is recycled and reused as an input in farm production in rural and peri-urban areas, (Figure 4.1).

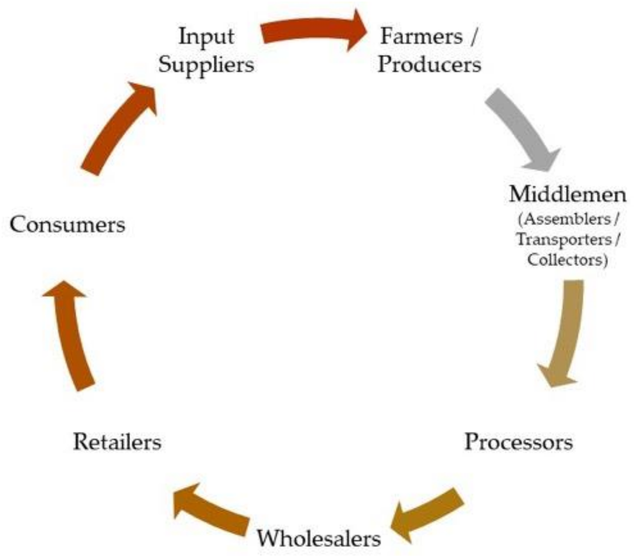

Figure 4.1: A generic food value chain envisioned to operate under a circular economy model.

General Methodology

This FVC context study sought to analyze three food commodity value chains in three different countries where the project is promoting circular economy-based innovations aimed at closing nutrient loops through recycling and reusing organic waste, thereby creating resilient rural-urban food systems. The three food commodity value chains analyzed included cassava in Rwanda (Kamonyi), coffee in DRC (Bukavu), and bananas in Ethiopia (Arba Minch).

As a sampling methodology, strategic city-regions in the respective countries where the targeted food commodities are prevalent were purposively selected. Mapping of actors was then done to understand which actors were available in the respective value chains, and in which parts of the city-region these were located. From within the respective city regions districts/sectors were randomly identified where the intensity of the respective actors was substantive. Then, villages from these sectors were finally randomly selected in an exercise conducted between project scientists and coordinators. Following guidelines of WFP (2010), on statistically valid sample sizes (targeting a minimum of 30 actors), or those that would be representative of the target populations (minimum 400 actor households), we set these as our targets for sample sizes. However, from field explorations by project coordinators and consultations with local administrators and other stakeholders in these food commodity value chains, we found that some actor segments in certain city-regions were either non-existent or had fewer actors than those recommended by WFP for either a statistically valid or population representative sample size.

From the field exploration exercises, an inventory of available actors (numbers of households) per segment was obtained from local administrators. For actor segments where the numbers were sufficient, we again did a random selection of needed participants from the general pool. The random selection was done by writing names of the subjects on papers, that would be put in a draw from which actors for interviews were randomly selected. A list of randomly selected participants was compiled and handed to project coordinators who, with the help of enumerators and local administrators, went to the randomly selected villages to administer interviews to respective randomly selected actors. Data was collected using questionnaires with both closed and open-ended questions. Questions included household biodata, demographics, agricultural production, food consumption, household incomes and expenses, as well as social perceptions on aspects of a circular economy. However, some questions were specific to certain actor segments – but some sections especially on household demographics were similar across actors. The detailed questionnaire is attached in appendix A. The household head was the primary respondent target, and where unavailable the second in line in household decision making was interviewed. Data was collected electronically using the open data kit (ODK) by project coordinators and enumerators and was instantly available to scientists in the online repository. Finally, numbers of actors interviewed per actor segment across countries were different mostly dependent on availability. However, since all actors in the respective food commodity value chains were indeed consumers of the products of the same food commodity, all actors were also asked for responses on the consumer section of the questionnaire. Subsequently, the consumers' sample data constituted 1,373 households from Rwanda, 593 from Ethiopia, and 809 from DRC. These totals are different because the composition of each value chain in each city-region was different and actor segments were differently populated. For other actor segments, sample sizes are shared in the respective sections.

Analysis of the data for this report has been largely done using descriptive methods where means / averages, or percentages are used to describe different dynamics or aspects of the sample, while tables, graphs, and charts are used to present the results of the analysis. Explanations of the data have been made largely based on observational field experiences to show the status quo of the respective food commodity value chains, and their status quo with regards to certain central aspects of a circular economy production – consumption model. Further details are presented in the respective food commodity value chains results' sections of this report.

4.1 Bukavu, Democratic Republic of the Congo

Introduction

In this section we present the summary of findings from the context study of the coffee food value chain (FVC) in DRC. Generally, this FVC is a complete one, starting from coffee input suppliers, farmers, middlemen, processors, retailers, wholesalers and consumers (Figure 4.2). The chain also has an added component of coffee waste processors. In this context study, all actors participated in consuming coffee products – and were thus all treated as consumers. Further here, we present all sample household data statistics, that includes demographics, income and consumption expenditure, food access indicators, and finally the sample's social acceptance for and stated willingness to pay for products derived from waste. Lastly, we present specific data statistics per actor segment.

Sample overview

The coffee value chain in DRC is complete with all actors and is dominated by farmers, followed by middlemen, then retailers, wholesalers, then processors, and least are the input suppliers, (Table 4.1).

Table 4.1: Composition of the coffee value chain sample in DRC.

Actor	Number of respondents (N)
Input supplier	7
Farmers	281
Middlemen	94
Retailer	50
Processor	22
Wholesalers	38
Waste processors	314
Consumers	809

The limited number of input suppliers may still imply that there is limited use of inputs in the value chain, thus an area where improvements may be necessary. However, the large number of waste processors (it is not exclusively coffee waste) may provide the entry point for recycling of the coffee waste.

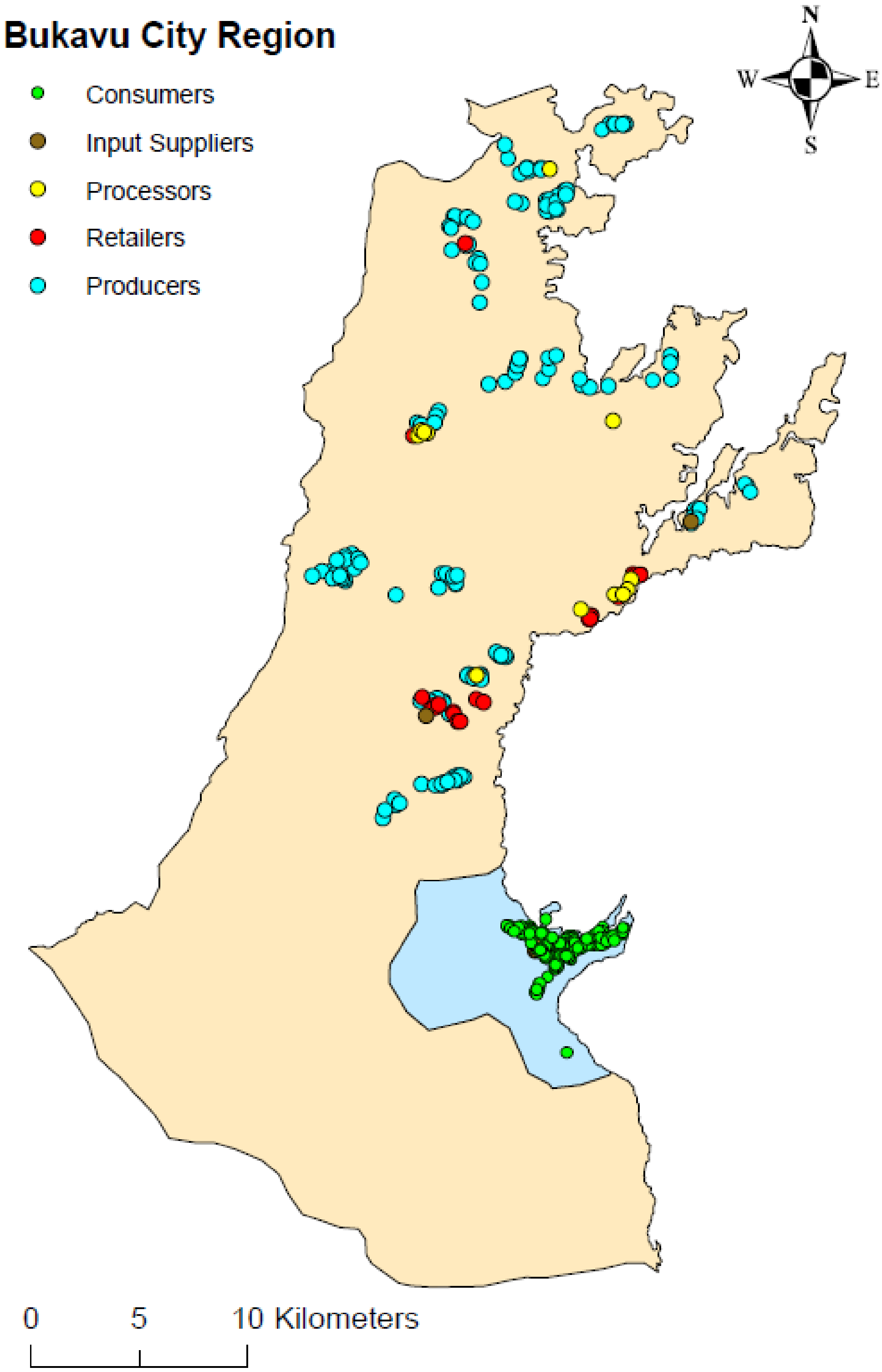

Figure 4.2: Sampled respondents of the Bukavu food value chain.

Coffee Consumers

Data was collected from the following districts: South-Kivu, Bukavu, Kabare, Mudaka, Bushwira or Luhihi. About 42% of respondents were from Kabare, 33% from Bukavu, and 22% from South Kivu. The average age of respondents was 44 years, and these lived on about 20 kilometers from the nearest main town center (Table 4.2).

Table 4.2. Descriptive Statistics on household biodata of consumers in DRC. Source: RUNRES FVC Context study for DRC, 2019

Household characteristic	Mean Statistic (Units)
Age of household head	43.7 (years)
Formal Education	7.4 (years)
Distance to nearest town center	20 (kilometers)
Household size	7.8 (persons)

The average number of school years obtained for consumers in the city-region is 7 years. Households are large with about eight (8) persons per household.

Only about 33% of consumers have a secondary education, while over 25% of consumers have never been to formal schools. With regards to gender, the majority of the sample (73%) were males. This presents an opportunity for women's penetration especially into the chain's understaffed segments, for instance input suppliers. Nearly 84% of actors are married, which may imply strong social relationships among actors. Hence, in case of cooperatives' formation that is intended to enhance economies of scale, success may be more possible. About 63% of the actors stated that they are aware about the circular economy concepts (Figure 4.3). Nearly 64% also claimed they are knowledgeable about circular economy concepts, implying that perhaps actors may have treated "awareness" nearly the same as "knowledge". Most importantly, a large percentage (over 63%) of actors was at least aware/knowledgeable about circular economy concepts, which could be a good entry point for advancing a circular economy in DRC coffee farming systems.

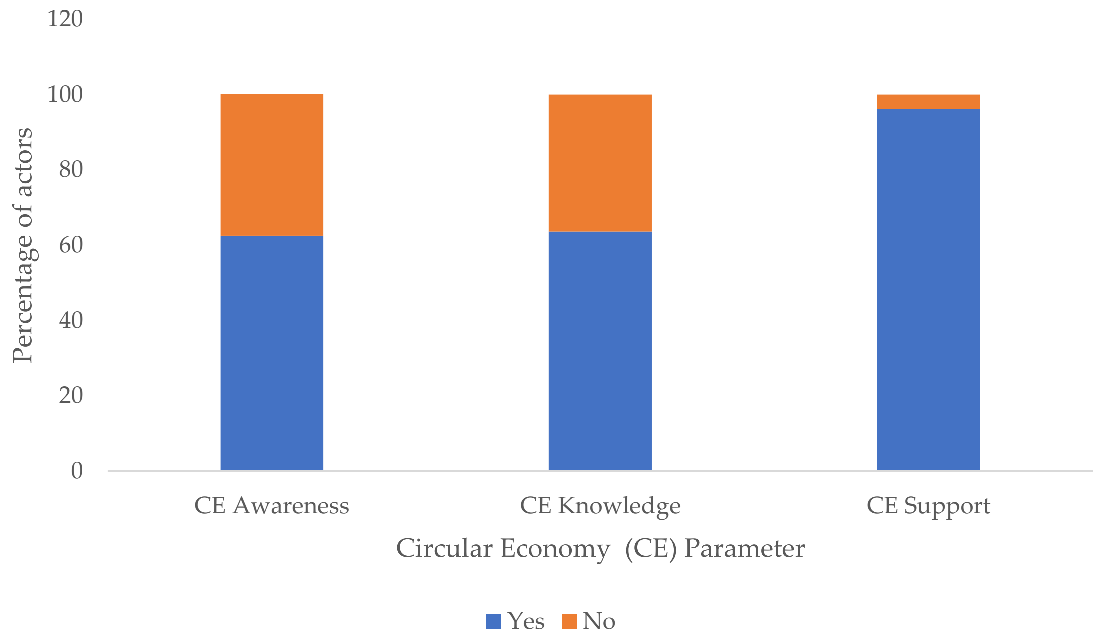

Figure 4.3: Awareness, knowledge and support for the circular economy concept (CE) by consumers in DRC.

With regards to household income sources, about 60% of consumers earn their income from agricultural activities, implying that most actors in the coffee value chain in DRC derive their livelihoods from agriculture. About 95% of this agricultural income comes from selling crops and their products, implying that a crop/food value chain focus may be more important to improve livelihoods of consumers in DRC. Table 4.3 shows that average consumers earned about 1,632 USD per season (3,264 USD annually). However, this average is about 70% composed of nonagricultural incomes that are accessed by the smaller part of the consumers. These non-agricultural incomes inflate average total incomes, a matter also depicted by the large standard deviations for these means. This implies that there are outlier consumers, who are fewer but have access to higher nonagricultural incomes. Therefore, interventions to improve incomes should thus take notice of these few outliers. Apparently, the more reliable average consumers' income would be the one from agricultural sources, which is about 486 USD per season, since the largest proportion of the sample is dependent on agricultural income.

Table 4.3. Overview of the average incomes of consumers in DRC

Type of Income per season (6 months)	Mean in USD (Std. Dev.)
Agricultural income	486.3 (807.8)
Non-agricultural income	1,146.2 (1418.8)

Household expenditure

From Figure 4.4, consumers spend on a variety of non-food consumables. Nearly 72% of consumers spent on education in the previous year, implying that households are aware of the importance of education, and this could provide a fertile ground for any awareness and knowledge dissemination-based initiatives. Health was the next item where numbers above the average (53%) of consumers spent their money. In all other non-food sectors, less than 50% of the actors reported to have spent money on them. This may still point to low levels of livelihoods, which can be improved through income generating activities based on circularity.

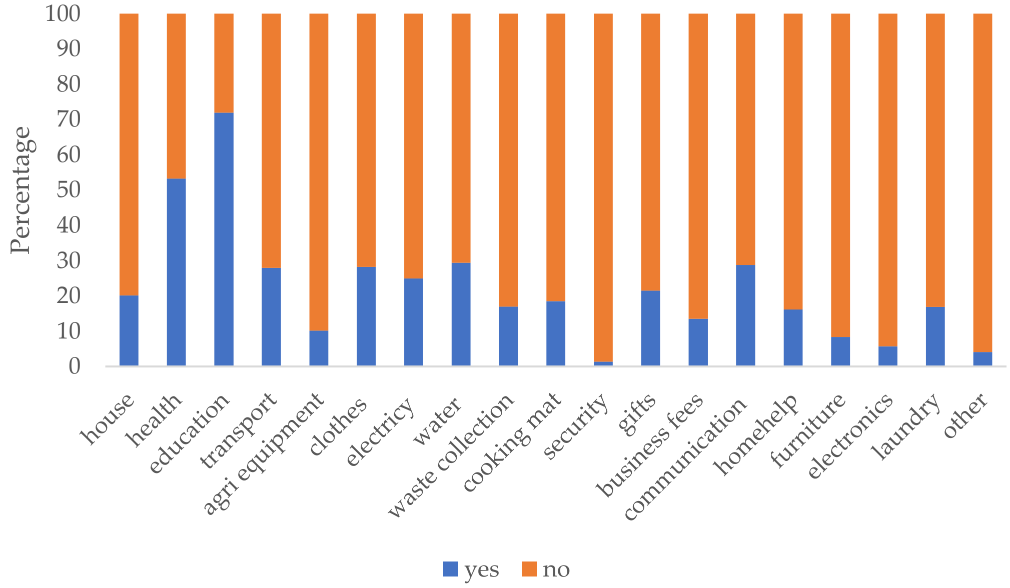

Figure 4.4: Non-food Expenditure Items for Consumers per year in DRC

Moreover, food expenditure still makes the largest component (56%) of consumers' annual expenditure (2,802 USD) in DRC (Table 4.4), further pointing to significant needs for income improvements, and thus food security. This implies that 86% of household incomes are spent on consumption, leaving only 14% (457 USD) available for savings and other investments.

Table 4.4. Expenditure items among Consumers in DRC

Expenditure on:	Mean in USD (Std. Dev)
Non-food per year	1,222.4 (1,947.9)
Food in per 7 days	31.1 (35.1)
Food per year	1,579.9 (1,566.6)

Household Food Insecurity

From, Figure 4.5 most consumers are uncertain of their food supplies and are worried about food quality. However, only a small proportion of households have insufficient quantities of food.

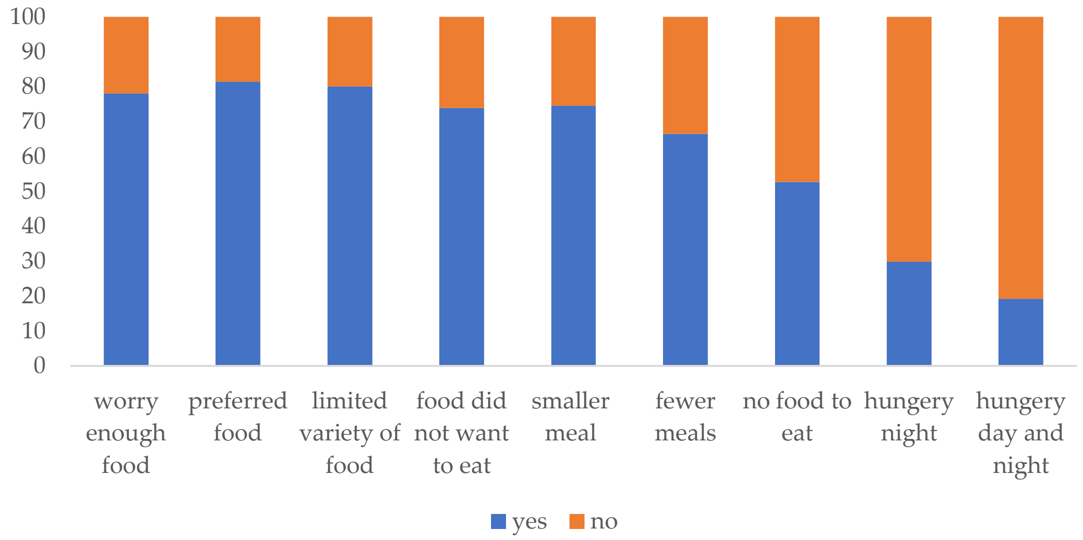

Figure 4.5: Consumers' assessment of their household food insecurity in DRC

Nearly 30% of consumers had spent a night hungry in the past four weeks, while 19% had spent both day and night hungry without food. Importantly, consumers (Figure 4.6) would accept to eat and even pay for food cultivated with compost, or urine or fecal material as fertilizer.

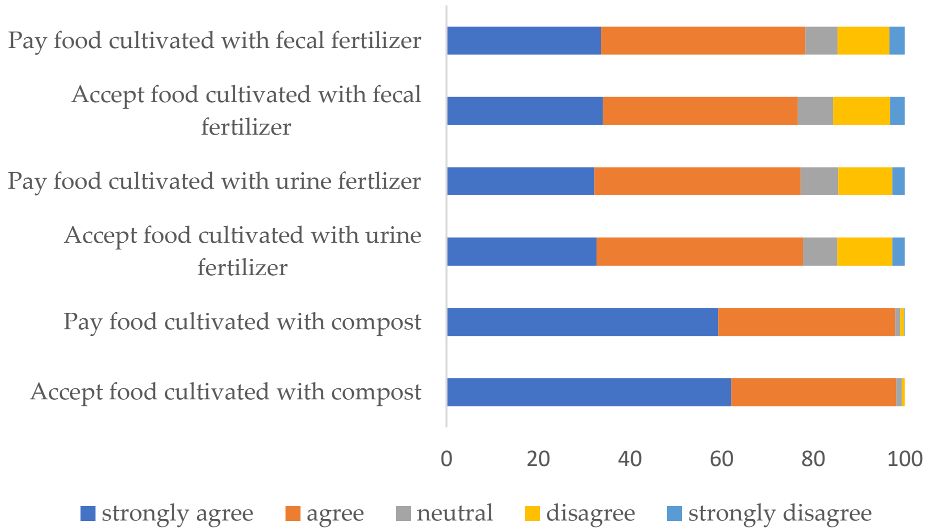

Figure 4.6: Acceptance and willingness to pay for waste derived products among consumers in DRC.

However, in this coffee value chain, input suppliers only provided fertilizers as farm inputs (100%) and did not provide other inputs such as coffee seedlings (Figure 4.7).

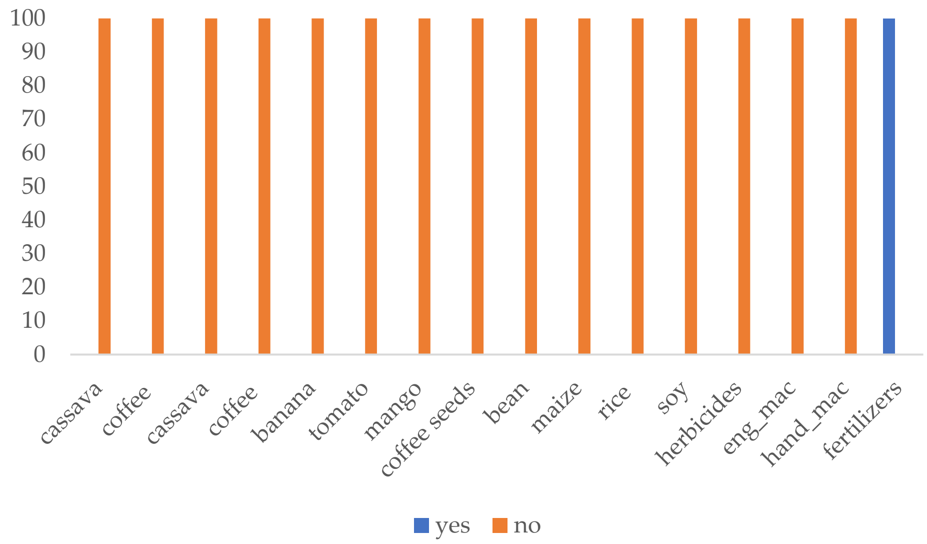

Figure 4.7: Different farm inputs sold by input suppliers in DRC.

Moreover, these fertilizers are mostly inorganic, thus a potential gap exists, for provision of organic fertilizers that would fetch farmers a premium, especially if they exported coffee to high standards markets interested in organic coffee products. Input suppliers got these fertilizers from agro-dealers (14%), importers (71%) or via their own efforts (14%). The average input supplier trades 1,705 kilograms of fertilizers per month, to an average cost of 1,378 USD and for an average income of 2,202 USD (Table 4.5).

Table 4.5. An Overview of the costs and price of fertilizers traded by input suppliers in DRC. Source: RUNRES FVC Context study for DRC, 2019.

Variable	Mean in USD (Std. Dev)
Amount of fertilizers traded (KGs / month)	1,704.8 (939.9)
Cost of stocking inputs (USD / Month)	1,377.6 (1,097.1)
Income from input sales in USD / month	2,202.4 (1,124.3)
Income margin in USD / month	824.8 (1,004.6)
Price margin per KG of inputs sold in USD	0.166 (0.092)

Only 14% of input suppliers are aware of laws governing their input supply businesses, and about 57% of input suppliers have females involved in their business activities. An average of 4 females and 2 males respectively worked in each input supply business. Women are mostly involved as shop attendants, weeders, or harvesters, while males dominate business ownership, transportation, and cleaning premises. All input sellers (100%) exchanged information with their customers by means of person to person interactions, mostly (57%) about product prices and new product arrivals (43%). About 57% of input suppliers target regular farmers for clients, while others target NGO's (about 29%). The least targeted are the random buyers (individuals) 14%. Surprisingly, most clients (71%) are located in peri-urban centers (towns), and this may still imply a huge lack of inputs supplies to farmers in rural areas. All (100%) input traders stated that offering better prices is the most important factor that keeps their clients committed, followed by product performance (43%). All input suppliers (100%) also stated that are no institutions that are willing to lend money to their input supply businesses, thus this could be one of the areas that needs attention. Nevertheless, 29% of input suppliers stated that there are still opportunities to take advantage of, for instance, high demand of inputs, and good returns in coffee trade due to an attractive business environment.

Coffee farmers

From Figure 4.8, about 74% of all farmers produced coffee as their main crop. However, farmers also produced other crops, mainly beans (42%), and cassava (33%) alongside coffee. Other dominant crops are bananas and soybeans.

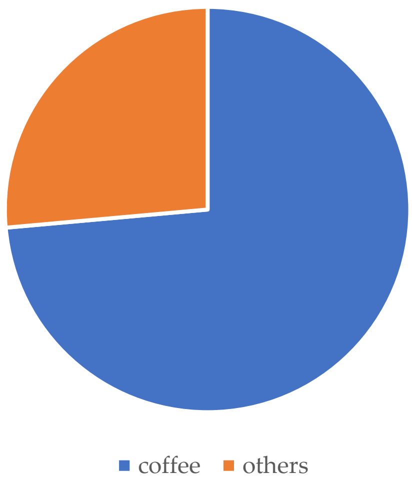

Figure 4.8: Main crops produced by Coffee farmers in DRC.

About 60% of coffee farmers grow coffee as a sole crop in their fields, and nearly 40% grow coffee in fields where they grow other crops (intercropping). From Table 4.6, farmers produced an average of 361 kilograms of coffee per season, and 318 kilograms per season for other crops, implying that the city-region is a dominantly coffee growing region.

Table 4.6. Quantities of crops produced per season (6 months) by farmers in DRC. Source: RUNRES FVC context study for DRC, 2019.

Quantity of crop harvested per season in KGs	Mean in KGs, (Std. Dev)
Coffee	361.2 (382.6)
Other crops	318.7 (343.4)

About 68% of farmers used fertilizers as an input followed by cassava cuttings (17%), then tomato seeds and banana suckers (4%). Most farmers (82%) got inputs from own efforts, implying that there is still room for certified systems to supply inputs. Only about 11% of farmers got their inputs from agro dealers. Moreover, most coffee farmers (99%) used organic fertilizers, however, since the largest source of inputs is "own effort/sources" it may be imperative to ascertain that farmers are using effective and appropriate forms of organic fertilizer. With regards to processing, only 14% processed their coffee before selling it, a clear indication that a lot of value is lost by farmers during coffee sales, where nearly 86% of farmers sold coffee unprocessed. Moreover, even those who processed coffee before selling it, only 26 % processed all produce, and the majority (58%) processed just half of the total coffee produce. About 56% of those who processed coffee, owned processing equipment, and the rest hired from either individuals or farmer associations. On average each coffee farmer produced 324 kilograms of coffee per season, with an average selling price of nearly 0.4 USD. Hence, the average income from coffee sales was about 116 USD per season (Table 4.7), while income of other crops averages at 89 USD.

Table 4.7. Overview of incomes and expenses of coffee farmers in DRC. Source: RUNRES FVC context study for DRC, 2019.

Incomes and Expenses per season	Mean, (Std. Dev)
Quantity in KGs of coffee sold	324.2 (300.2)
Income in USD from coffee sold	116.3 (125.1)
Price per KG of coffee sold	0.371 (0.180)
Income in USD from other crops sold	89.2 (84.1)
Total farm production costs in USD	66.1 (65.2)

Labor was the costliest activity for most farmers (69%), followed by fertilizers (17%), then planting materials (7%), and then equipment (6%). Interestingly, about 66% of farmers stated that the quality of planting materials they used was good, while 16% stressed that it was excellent. However, this stands to be verified, since most farmers self-supply themselves with inputs, and may not fairly judge their own supply. About 69% of farmers also stated that they produced good quality coffee, while 20% indicated that the quality of their harvest was excellent. Therefore, about 89% were convinced that the coffee quality was at least good, hence this could be an opportunity to improve households' incomes through value addition. However, from Figure 4.9, most coffee (70%) is sold as fresh harvest. This is a low value form which almost undergoes no processing at all. It could highlight areas where farmers incomes could be improved if focus on value addition would be prioritized.

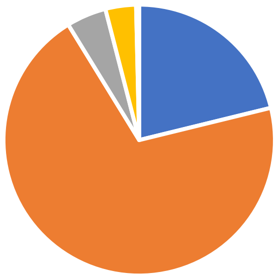

Figure 4.9: Forms in which farmers sold their coffee in DRC.

On marketing, nearly 81% of farmers sell their coffee to markets or other actors, and 18% consume their coffee at home, while about 2% report that their coffee is wasted, thus pointing to loopholes in processing and storage technologies. The wasted coffee alongside the waste from coffee processing is mostly used as compost (60%) in farmers' fields, but a good proportion of this waste (40%) is just thrown away at dumpsites. Farmers mostly (82%) exchange information with buyers of coffee and sellers of inputs by using the person-to-person mechanism. Information exchange is minimally done by phone calls or SMSs (10%). Therefore, timely and wider information access (through using telecommunication infrastructure) could be a limiting factor to farmers' optimal gains. Much of the information is about product quality (41%), prices (34%), available market (12%), and product performance (8%). Farmers keep coffee buyers committed primarily by ensuring good coffee product performance (32%), offering buyers good prices (28%), good personal relations with their customers (13%), monopolizing supply (being few suppliers in some locations – 11%), and being consistent with their coffee supplies (9%). With regards to policies, most farmers (77%) are not aware of laws or policies, nor regulations that govern their farming businesses.

However, 23% indicated that there were regulations put in place by coffee cooperatives like CPCK, REAK, TCC, etc. for instance guidelines on producing good quality coffee. Nearly equal numbers of women (80%) and men (81%) are involved equally in coffee farming within their respective households. However, about 91% of farmers can not access any credit from a financial institution for their farming businesses, be it formal or informal institutions. Of all the farmers who can access institutions to support them financially, only 9% can get such support from formal institutions. Another 91% of farmers who would access financial support can only get it from informal institutions like colleagues or cooperatives. Fortunately, 68% of coffee farmers in DRC are members of a coffee cooperative. Cooperatives are therefore an alternative avenue to channel financial and other technical support to farmers. As expected, most farmers (90%) experience challenges in their farming activities. Interestingly, 72% of farmers still see opportunities in coffee farming, and this is a firm ground to accept for co-investment by farmers. Challenges include lack of regular markets, proper guiding policies, production and processing equipment, good planting material, effective transportation means, and proper waste dumps, pest and diseases, low coffee prices, and high operational costs.

Coffee middlemen

From Figure 4.10, the largest category (78%) of middlemen are collectors, followed by fresh coffee traders (11%), then assemblers (10%), and least is transporters (1%). Most middlemen (83%) rely on coffee farmers for coffee supplies, while 17% of middlemen produce the coffee themselves.

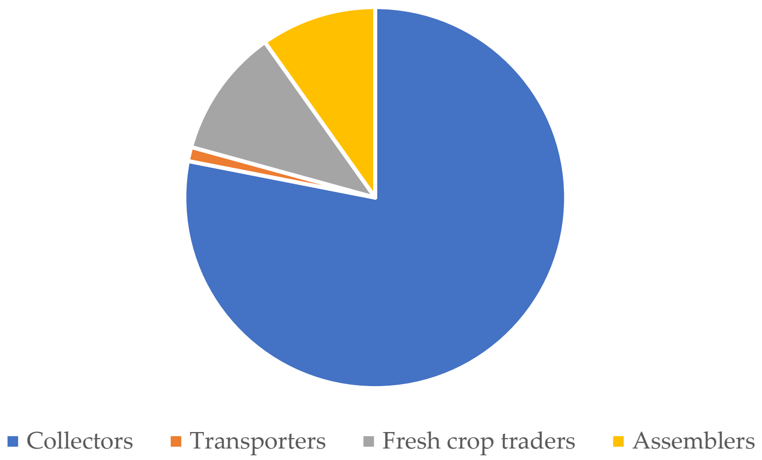

Figure 4.10: Categories of middlemen in the coffee value chain in DRC.

Middlemen keep their coffee suppliers committed mostly through good personal relations (46%), consistently keeping in the coffee middlemen business (24%) and offering them a good price (16%). Middlemen mostly (41%) handle coffee in dried harvest form but with husks, followed by dried harvests but without husks (31%). A good number of middlemen also handle fresh harvest (17%), while a small section handle dried de-husked beans (7%). All these forms are largely unprocessed, thus showing outstanding potential for value addition. The average amount of coffee that middlemen collected/assembled/transported per season was nearly 2,560 kilograms, while they traded (themselves directly) an average of 497 kilograms, (Table 4.8).

Table 4.8. Quantities of coffee handled and sold by middlemen per season in DRC. Source: RUNRES FVC Context study for DRC, 2019.

Quantity of coffee and associate incomes and costs per season	Mean (Std. Dev)
Quantity (KGs) of coffee handled	2,559.7 (4,540.0)
Quantity (KGs) of coffee handled and sold	497.2 (418.5)
Income (USD) from coffee handled and sold	513.8 (397.4)
Costs (USD) incurred from handling and selling coffee	193.6 (250.7)
Income margin (USD) from handled and sold coffee	457.0 (385.9)

Middlemen make a seasonal average income of 514 USD, costs of nearly 194 USD, and an income margin of 457 USD. About 84% of middlemen do not process coffee, they hand it to the buyer after it is collected from suppliers (farmers or middlemen themselves). However, for the 16% that process coffee before selling, about 51% of this own processing equipment. Of all those middlemen that process, 62% do it by hand. Most middlemen (70%) agree that the quality of coffee they get from farmers is good, but only 13% of these agree that the quality of coffee they hand to the next actor in the chain is good. This still points to a significant gap in value addition. With regards to policies and laws, about 35% of middlemen acknowledge to be aware of laws or policies or regulations guiding their businesses, especially those on quality control. Middlemen mention that they need laws that limited fraud. Most middlemen (74%) have involved women in their businesses and only 46% of middlemen involve only men. This, however, excludes business owners, who may be mostly males. Women dominate activities like attending to shops, while men dominate running machines and transportation. Most middlemen use the person-to-person mechanism to exchange information with customers. Only 35% of middlemen use electronic, which may point to limitations for proper middlemen business performance. The most important aspect (45%) of information exchange is product quality, followed by product prices (24%), and then availability of markets (19%). Only about 16% of middlemen access credit from financial institutions, and only just above half (54%) of these financial institutions are willing to lend to middlemen formally. Lack of access to credit could be a serious impediment to middlemen business financing.

Nevertheless, 97% of middlemen believe that they get good quality coffee from suppliers, and about 92% think that they pass on good quality coffee to the next actors. Only about 8% of middlemen add value to coffee handled, and pass on a better quality of coffee to the next actors. This could be the trading middlemen, but still it points to a very small proportion of middlemen that engage in value addition for better returns. As with other actors, most (67%) middlemen acknowledge that there are challenges in their business, however, nearly half (46%) of these also acknowledge that there are opportunities. Among the challenges are lack of proper policies, cash liquidity, regular markets, and access to expert advice. Among solutions to these challenges are improved policies, improved access to markets, frequent monitoring, proper transport equipment, and expert trainings. Among the opportunities are availability of high quality products, low cost raw materials, high demand for coffee and its products.

Coffee retailers

Most retailers (84%) get their coffee from farmers directly, and 14% do supply coffee to themselves. Cooperatives sell to only 2% of retailers. Generally, 95% of retailers are satisfied that they get good quality coffee supplies from either farmers, cooperatives, or themselves. From Table 4.9, coffee retailers averagely handle 1,221 kilograms of coffee per season, however some of these (20%) have some coffee that did not sell during the previous season. These are the retailers who handle larger sums of coffee. Retailers sell about 1,794 USD per season in incomes, with average costs being 121 USD. Generally, retailers realize an average income margin of 1,282 USD per season.

Table 4.9. Retailers' coffee quantities handled, incomes and expenses per season in DRC. Source: RUNRES FVC Context study for DRC, 2019.

Quantity, income, and expenses	Mean per season (Std. Dev)
Quantity (KGs) retailed	1,220.9 (1,524.2)
Quantity (KGs) retailed but not sold	332.8 (875.8)
Price (USD) per KG of coffee sold	0.911 (0.288)
Income (USD) from coffee retail	1,793.5 (2,627.2)
Costs (USD) due to coffee retail	121.4 (164.0)
Income margin (USD) from coffee retail	1,281.6 (1,771.6)

Females dominate coffee retail business in DRC. About 82% of retailers involve women in their retail businesses. This is a larger proportion compared to just 48% that include males. Surprisingly, most females are involved in transportation activities (26%), perhaps due to the nature of the retail business (gathering smaller amounts from various points, and selling these again in small amounts), attending to retail shops (18%), or as cleaners (10%). Only 30% of retailers are aware of laws, policies, and regulations that guide their coffee business activities. Interestingly, retailers can sell 92% of the coffee they handle per season. Most retailers (50%) exchange information by the person-to-person mechanism. This still therefore highlights a good proportion of the actor segment that uses relatively slower or ineffective communication channels to reach out to their clientele. Prices dominate (32%) the information component that is exchanged, followed by product quality (30%), available markets (16%), and then product performance (12%).

Retailers keep their customers committed to their retailer services through mostly (38%) good personal relations, followed by offering good prices to customers (36%), and then being consistent in their supplies to their clients (22%). Only 16% of retailers stated that they could have access to financial support, thus inability to access financial support could be one factor hampering optimal gains for retailers. Similarly, or even worse, only 6% of retailers are able to access technological support. Moreover, the majority of those who access financial support (63%) can only access it from informal institutions. As usual, most retailers (74%) face challenges, among which are the lack of proper transportation means, credit access, reliable market, and supportive policies, low coffee prices, pest and diseases that damage product quality, poor equipment, and high operational costs. However, most retailers (56%) stated that there are still opportunities in the coffee retail business. For example, possibilities to improve coffee productivity, coffee exportation, possible government support through cooperatives and partnerships to improve value addition, for better prices and income margins are all available.

Coffee Processors

Most processors (82%) are involved only in processing coffee, while the other 18% do also process waste. Processors are mostly supplied with coffee as a fresh harvest (72%), and they mostly sell this as dried harvest without husks (33%) to next actors (Figure 4.11). However, this processing is not necessarily in the supposedly best possible form (powder). Only just about 6% of the processors sell their coffee in a powder form. Hence innovations to ensure better value addition would be necessary.

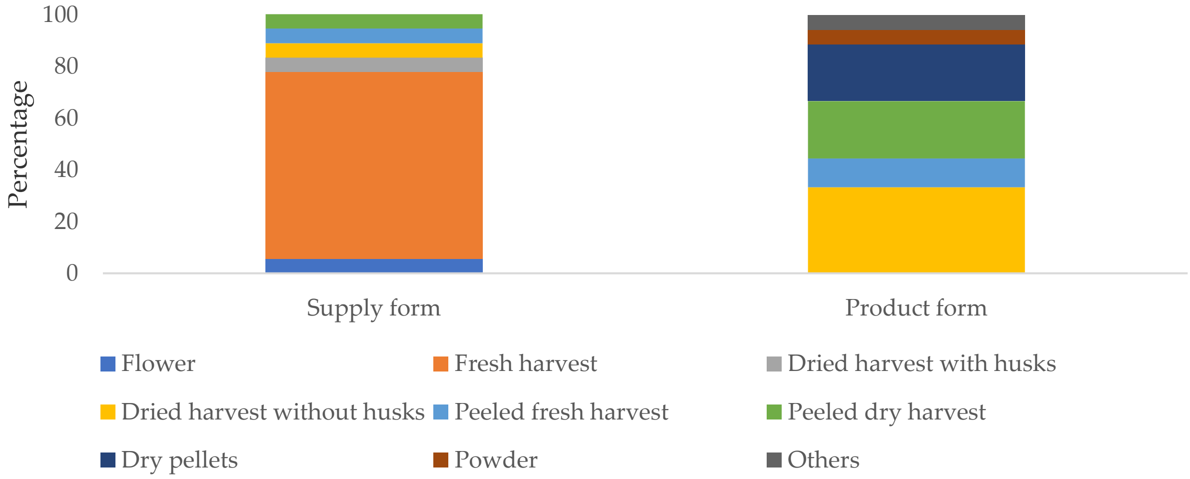

Figure 4.11: Forms in which processors were supplied or sold coffee in DRC

Customers are mostly committed to processors' products because processers are consistent with supplies (27%). Other reasons are good personal relations (18%), ensuring good product performance (18%), and engaging in promotional activities for clients (18%). Generally, all processors state that all the coffee they are supplied with is of good quality, and that the products are also of good quality. Moreover, 40% of processors state that the supplied quality is excellent, while a lower proportion (33%) state that the quality of processed product is excellent. From Table 4.10, processors handle an average of 2,858 kilograms of coffee per season, selling at price of 0.8 USD per kilogram. Processors earn a seasonal income of 2,369 USD, and spend 519 USD on this production, subsequently making a margin of 1,734 USD.

Table 4.10. Quantities of coffee handled, incomes, and expenses of processors per season in DRC. Source: RUNRES FVC Context study for DRC, 2019.

Quantity of Coffee processed, Incomes and Expenses	Mean (Std. Dev.)
Quantity (KGs) processed	2,857.9 (2,776.5)
Price (USD) at which coffee was sold	0.783 (0.341)
Income (USD) from coffee processing	2,368.6 (2,959.7)
Expenses related coffee processing	519.4 (1,305.9)
Income margin (USD) from coffee processing	1,733.8 (2,082.1)

Processors mostly (33%) sell their processed coffee as dried beans without husks, followed by peeled dry harvest, and dry pellets (22% for each). They also sell peeled fresh beans (11%). Only 6%, sell coffee in the powder form, implying gross lack of value addition, that is supposed to be enhanced especially at the processor level. Half (50%) of the processors stated that they are aware of policies, regulations, and laws governing their businesses; for instance, certification of washing stations that ensure high quality of processed products, and export permits that allow alignment to international standards. Quite a high number of females (83%) and males (94%) are employed in processing firms, implying a nearly balanced gender involvement in coffee processing activities in DRC. Females dominate harvesting activities, while males dominate the running of machines and business ownership (60%). Among buyers for coffee from DRC processors include Starbucks/American enterprise, traders, Rwanda traders, Oxfam, buyers from Belgium, Lenar Holland, Marchands, Virunga coffee, and individual consumers in DRC. Local buyers are mostly located in Kavumu.

Most processors exchange information with customers in person (50%), followed by phone calls / SMSs (17%), and least (11%) is internet. Processors are yet the only actors in DRC using internet. Processors mostly keep their customers committed through offering good product performance (44%), personal relationships (33%), and prices and promotional initiatives (11%).

Only 17% of processors can access financial/technical support in their business. Fortunately, all those processors who can access financial support, do so from formal institutions. Technical inputs can, however, be accessed from both government and private institutions. About 77% of processors acknowledge to be facing challenges. Interestingly, 82% of processors still envision opportunities around coffee processing. Among the top challenges mentioned included lack of expertise on effective processing techniques, irregular markets, lack of proper processing equipment, and lack of access to credit among others. Among sighted opportunities are high coffee quality and productivity, good marginal benefit, high coffee demand, and raw materials being cheaply available. About 89% of processors valorize their coffee waste into manure. However, most processors only process solid waste, leaving the liquid waste as a nuisance to the environment. About 91% of coffee processors have their own processing equipment. A big proportion of processors (44%) do so by hand, which compromises product quality, while 39% used traditional means (combining hand and some tools). Only, 17% use mechanical means to process coffee waste.

However, alongside coffee production and processing, households also produce waste, and we briefly show how this faired along the coffee value chain. From Figure 4.12, the largest proportion of waste is collected from households (73%), followed by other business areas (markets) at 20%, and least was from specialized markets (food markets) at 7%. This implies that the largest available waste in DRC is from households, and thus measures for proper collection, management, and recycling of waste should primarily be focused at household level.

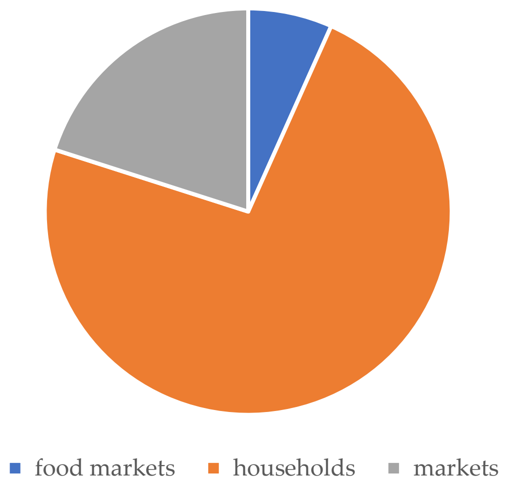

Figure 4.12: Sources of collected waste for waste processors in DRC.

However, most waste collected (57%) is mixed (organic and inorganic), while 41% is purely organic, implying that there is sufficient clean waste to facilitate recycling and reuse of waste.

However, a large proportion of mixed waste burdens waste processing activities. Most of this waste (76%) is given to waste collectors, while 19% is dumped on nearby dumpsites. Only about 5% of household waste is reused within households. Most household waste (82%) is collected by private companies, while NGOs collect 13%, the municipality (3%) and other entities collect the other waste. Therefore, focusing on private companies could be a more reliable way to valorize household waste in DRC.

Coffee wholesalers

All wholesalers are involved in the import and export of coffee and 4% of wholesalers also deal in beans. Most wholesalers (96%) receive their raw materials from farmers, while 22% of them receive raw materials from own efforts. Only 4% received raw materials from farmer cooperatives (Figure 4.13).

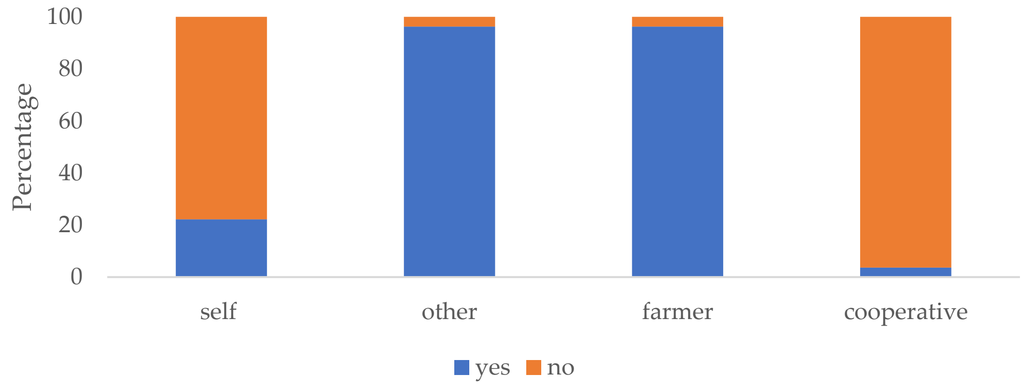

Figure 4.13: Suppliers of the raw materials to coffee wholesalers.

Most wholesalers keep their suppliers committed to them by offering good product prices (85%), and ensuring good personal relationships (41%), (Figure 4.14).

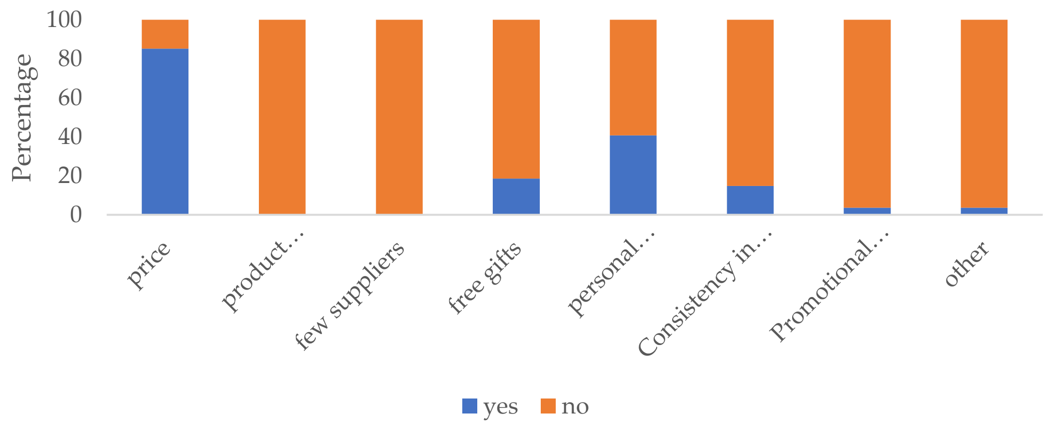

Figure 4.14: Coffee wholesalers' strategy to keep suppliers committed.

Most wholesalers (85%) receive the coffee while it is unprocessed but at least dried with husks, and 15% of wholesalers receive coffee as a fresh harvest. This still points to a huge value addition gap at the farmers' level who are the largest suppliers of coffee to wholesalers. Most coffee wholesalers (74%) sell their coffee products locally, while 37% of wholesalers export coffee products. Some 11% of wholesalers also import coffee (Figure 4.15). On average, wholesalers handle 2,491 kilograms of coffee per season (6 months), and averagely sell each kilogram of coffee products at 3 USD. About 89% of wholesalers incur operational expenses and costs, most of which are due to transportation needs (41%), communication costs (38%), vehicle hire (12%), and storage facilities (9%). Only 22% of wholesalers have their own equipment for use in their wholesale businesses.

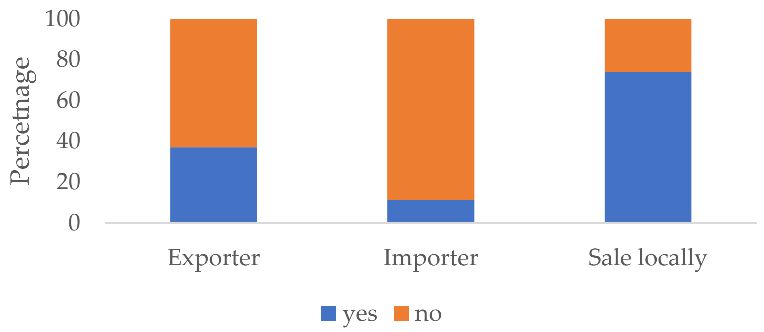

Figure 4.15: Categories of activities of coffee wholesalers in DRC.

Laws, polies and regulations

Nearly 78% of wholesalers state that are affected by laws, policies and regulations. Among the regulations that enable wholesaler business include regulations for fair taxes, packaging and quality assurance, and paying license to have the right to sell products that are authorized by laws. Among regulations mentioned to hamper wholesale businesses include those lenient to corruption, and those enforcing harassment during tax collection.

Gender

All stakeholders (100%) involve females in their wholesale businesses, while only 48% of wholesalers engage males. On average each wholesaler engages 14 females and 6 males in their business activities. Both females and males are mostly involved as either transporters or financiers/owners (Figure 4.16).

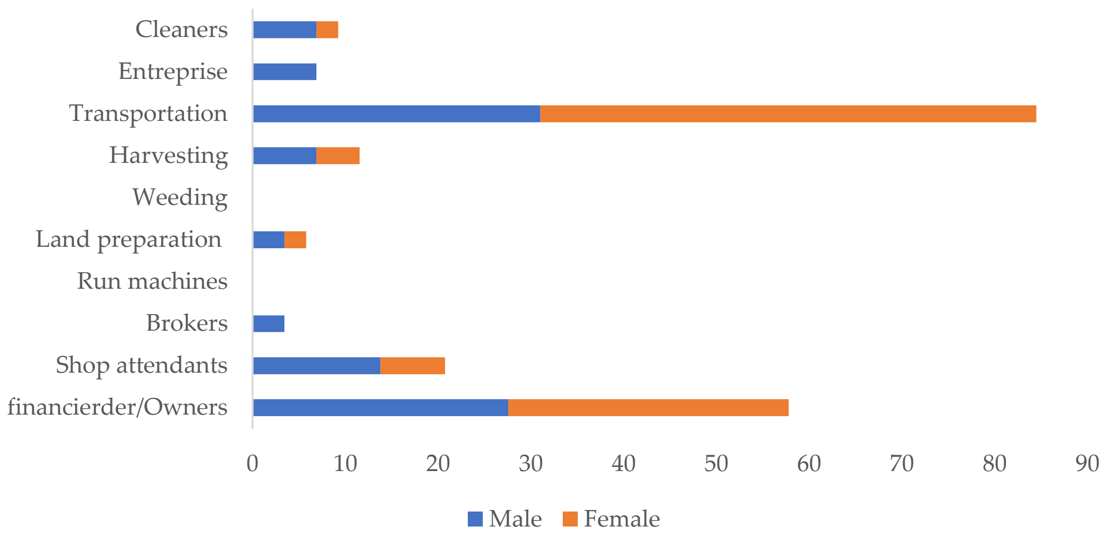

Figure 4.16: Different coffee wholesale tasks in which males and females engage.

Market information

Most wholesalers sell coffee in dried harvest form without husk (63%) (Figure 4.17). Usually, coffee is consumed mostly as a water-soluble powder but none of the wholesalers sell coffee in a powder form. This points to potential opportunities with regards to value addition, and processing of coffee into higher value products.

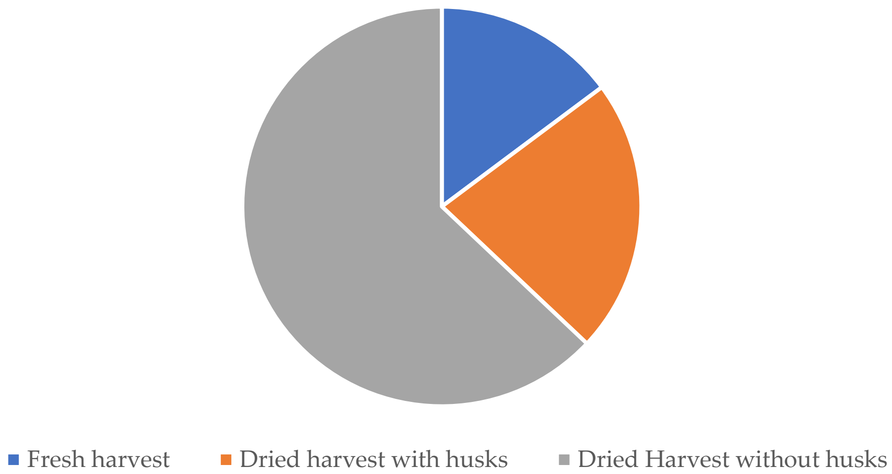

Figure 4.17: Forms of final products that coffee wholesalers sold to customers.

Almost 89% of wholesalers use phone calls to exchange information with their customers, but still a large proportion (56%) still use the person-to-person mechanism (Figure 4.18). However, interestingly, unlike in most actor segments in the coffee value chain in the DRC, wholesalers (4%) also use the internet to reach out to their customers.

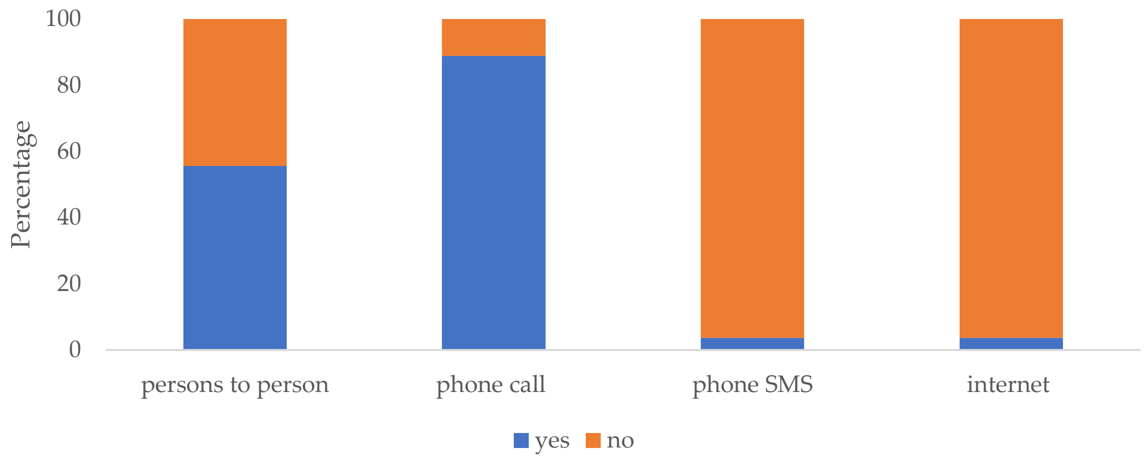

Figure 4.18: Wholesalers' communication strategies with customers in DRC.

Wholesalers mostly exchange information about new products arrivals (70%), product prices (59%), and product qualities (11%) (Figure 4.19), implying that product attributes' awareness is important for wholesale business. Wholesalers keep their customers committed through ensuring good product performance (78%), carrying out promotional initiatives (26%), and being consistent with their supplies (7%).

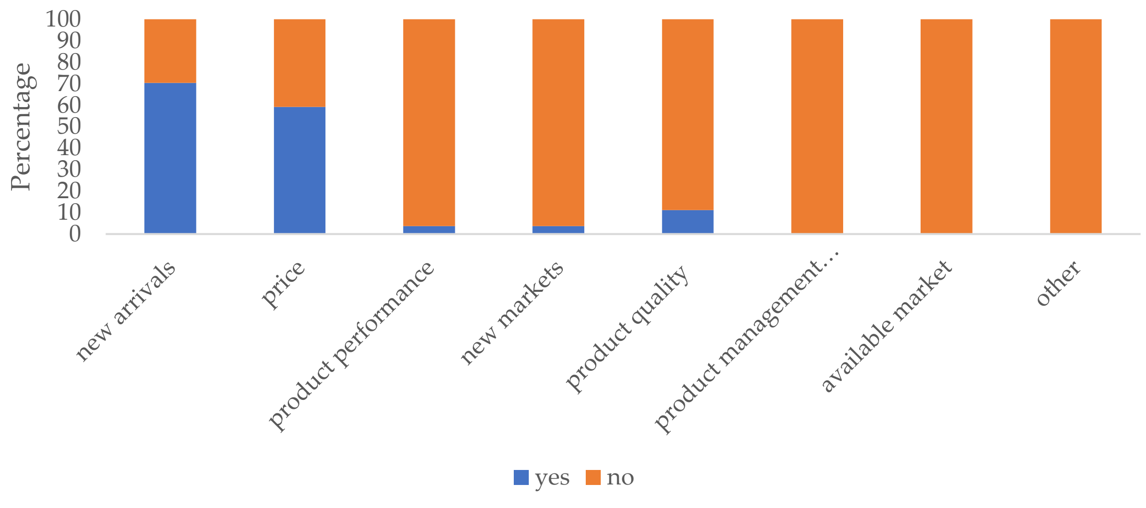

Figure 4.19: Types of information that coffee wholesalers shared with the customers.

Institutional support

Only 11%, and 15% of the wholesalers are able to access financial support, and technical support respectively, (Figure 4.20). About 67% of those who access financial support do so through formal institutions, while the rest use informal institutions. Technical support is also accessed from none for profit international organizations.

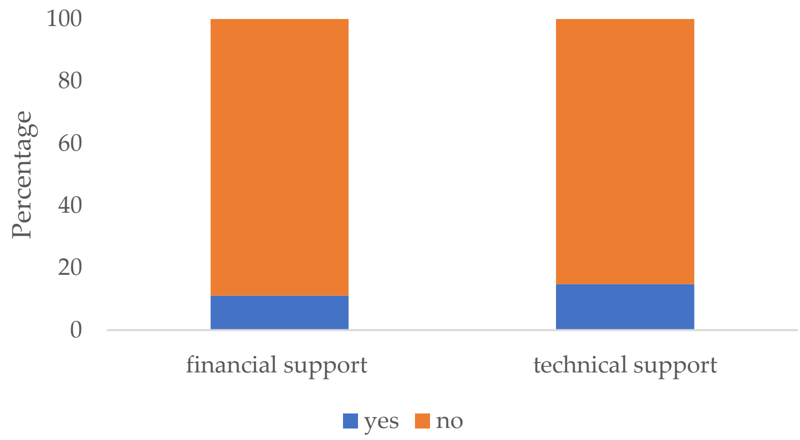

Figure 4.20: Whether wholesalers accessed financial and technical support in DRC.

Challenges and solutions

About 96% of wholesalers indicate to be facing challenges, however 81% of them note that there are opportunities in the coffee wholesale business that could be harnessed. The most notable challenges identified by wholesalers are low product price (89%), limited cash for business (31%), lack of enabling policy environment (31%), and lack of access to credit (23%) (**Error! Reference source not found.**).

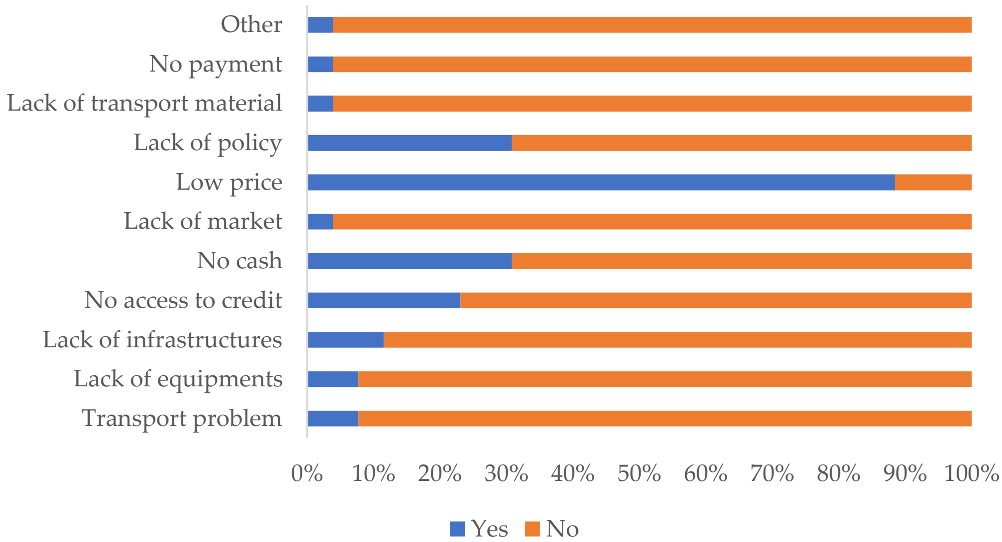

Figure 4.21: Challenges that coffee wholesalers experienced in DRC.

Several solutions to the above challenges were identified by wholesalers, and these mainly include improved access to competitive markets (63%) that would enable wholesalers get a better product price, improvements in policies and regulations governing the coffee business (48%) to standardize operations that ensure quality and eliminate corruption, and improved access to credit (37%), which would enable wholesalers finance their business operations without failure (Figure 4.22).

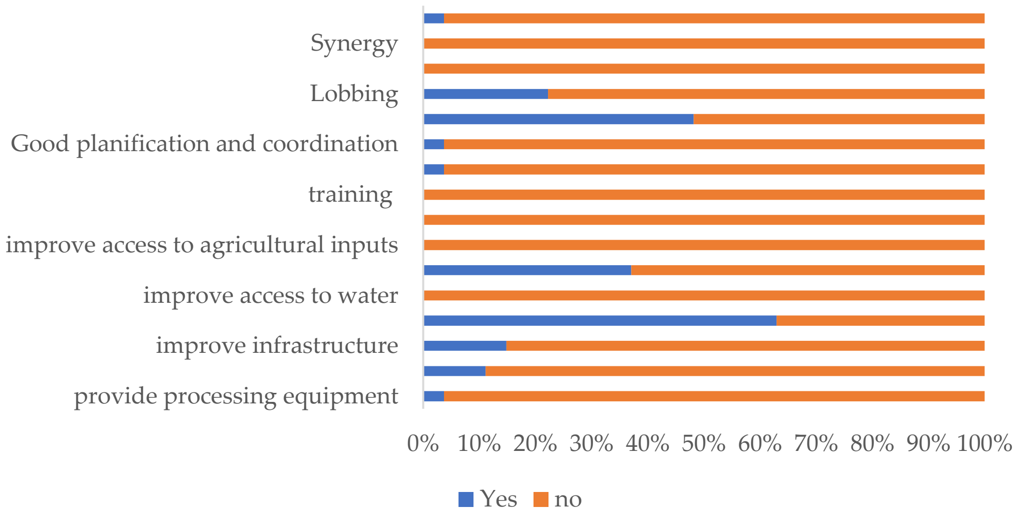

Figure 4.22: Solutions that were identified by wholesalers against challenges.

Among the opportunities identified by wholesalers were the high demand for coffee products (78%) that still prevails and guarantees market, good quality of the coffee product (26%), and possibility to leverage with existing initiatives (26%), for instance those focused on other crops or achieving community welfare improvements through enhancing the production, and value addition in the coffee chain (Figure 4.23).

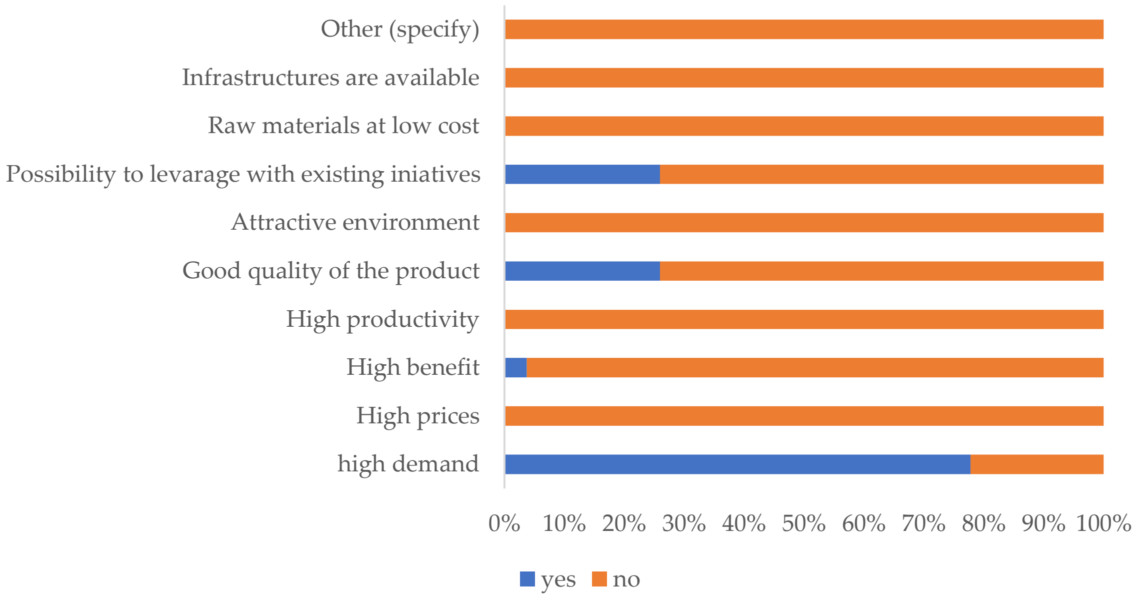

Figure 4.23: Opportunities identified in the coffee wholesale business.

4.2 Arba Minch, Ethiopia

Introduction

In this section we present findings from the banana food value chain (FVC) in Ethiopia (Figure 4.24). The chain is generally incomplete – consisting of only farmers, middlemen, processors, and consumers (Table 4.11). Again, we first present the household data of the sample (all considered as consumers) that includes information on income, expenses, access to food, and social acceptance and willingness of households to use products derived from waste. Lastly, insights around specific questions per actor segment were presented. Note that consumers are inclusive of other actors.

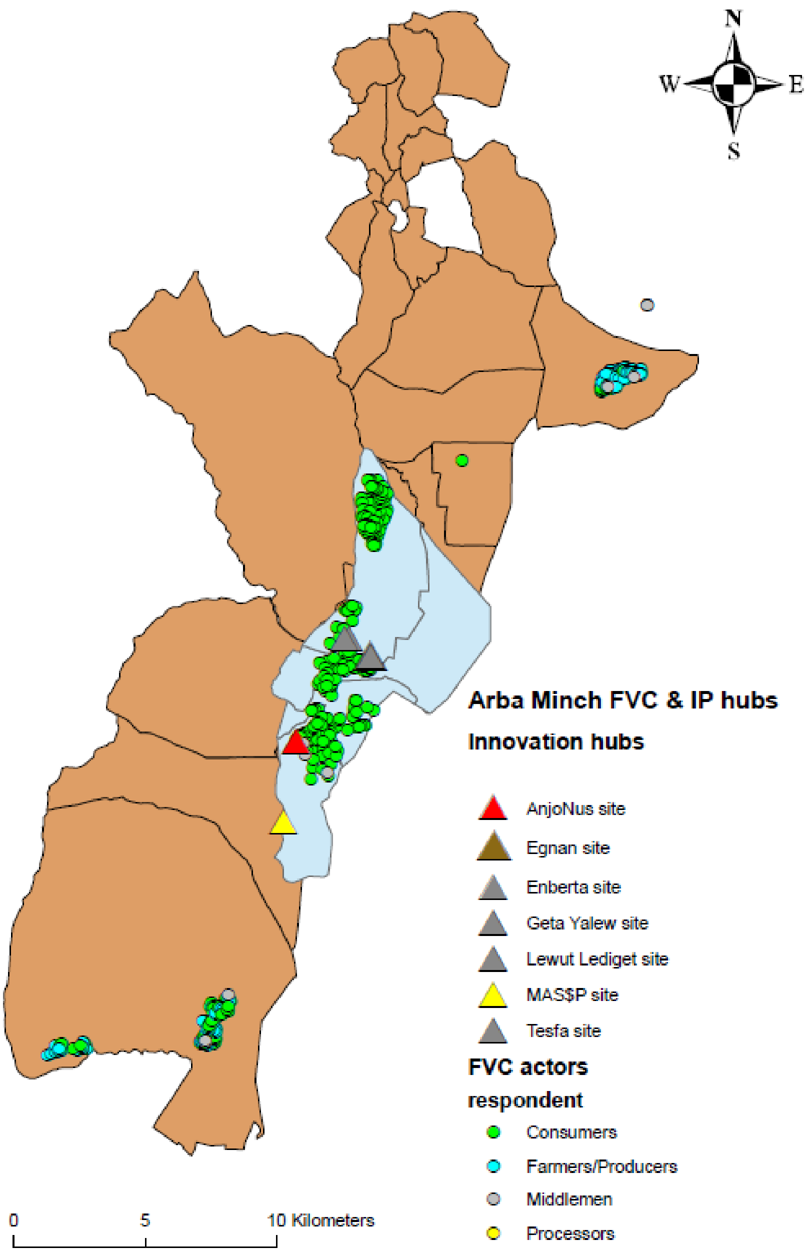

Figure 4.24: Sampled respondents across the banana value chain. (n = 795).

Table 4.11: composition of the banana value chain in Ethiopia. Source: RUNRES FVC Context study for Ethiopia, 2019.

Actor	Number of respondents
Farmers	190
Middlemen	10
Processors	1
Consumers	594

Results

Banana consumers

All sample data were collected from the Arba Minch region. The average age of respondents was 45 years. Most respondents live within 11 kilometers from the city center and have 6 years of formal education. (Table 4.12).

Table 4.12. Descriptive statistics of demographics of the sample. Source: RUNRES FVC Context study for Ethiopia, 2019.

Variable	Mean
Age (years)	44.9
Formal education (years)	5.9
Distance to nearest big town (KMs)	11.4
Household size (persons)	5.8

Moreover, about 35% of the consumers did not receive any form of formal education, and 34% have only accomplished primary school, (Figure 4.25). With regards to gender dimensions, about 79% of the sample were males, and 84% of the sample were married.

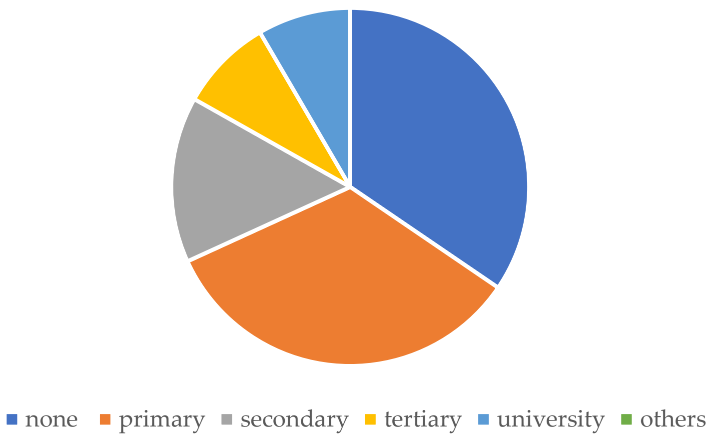

Figure 4.25: Educational background of the consumers in Ethiopia.

This may reflect a largely dominated male society that is also still observant of strong social relationships. About 67% of the study's respondents were family heads of the household.

Circular economy awareness, knowledge and support

From Figure 4.26, the majority (80%) of the consumers indicated that they are at least aware of the circular economy (CE) concepts (39% strongly agree, and 41% agree). Another nearly 80% at least agreed to having knowledge about CE concepts (32% strongly agree and 48% agree), while nearly 74% at least agreed to be willing to support CE concepts (31% strongly agree, and 43% agree). This may imply significant societal support for CE concepts not identified in other city-regions. This could indicate potential societal support for innovations that would employ CE concepts in closing nutrient loops in food systems in Ethiopia.

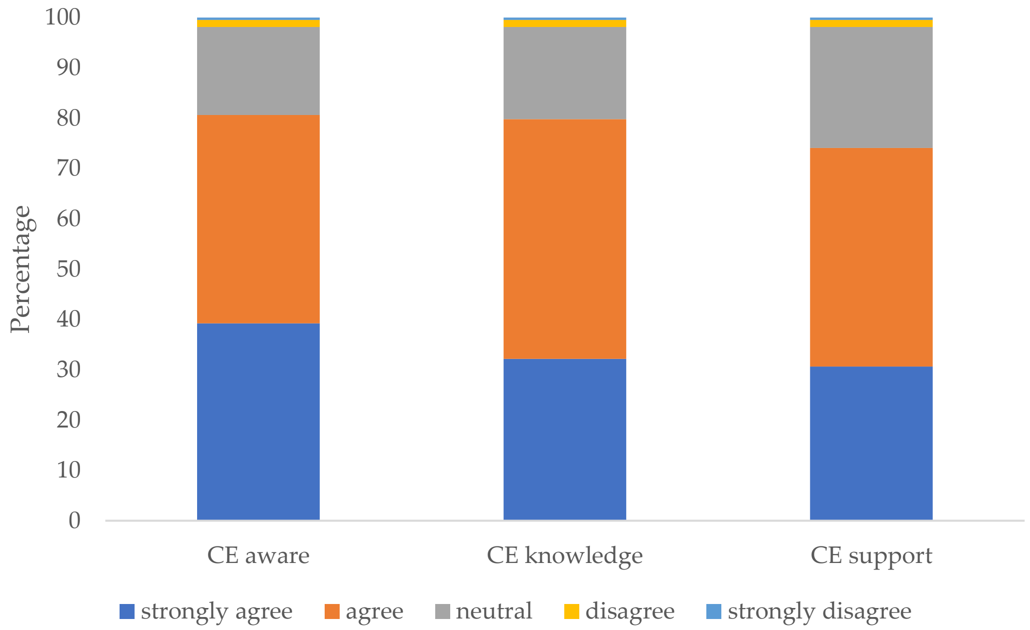

Figure 4.26: Consumers' awareness, knowledge and support for circular economy concepts in Ethiopia

Income

About 47% of consumers in the banana value chain in Ethiopia derive their livelihood incomes from agricultural activities (Figure 4.27); 98% of this agricultural income is from crop sales.

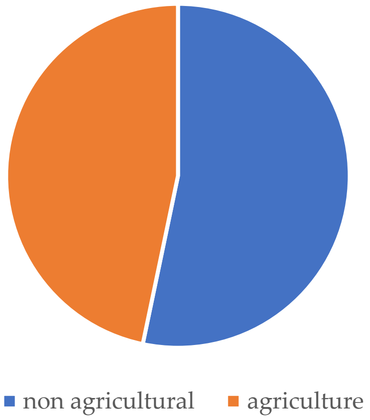

Figure 4.27: Sources of consumer incomes in Ethiopia.

More importantly, from Table 4.13, on average the agricultural income per season (6 months) is higher (1,326 USD) than the non-agricultural income for the same period (963 USD). This also includes households that depend on both types of incomes and exclusively on one type. Further, this may imply that agriculture is still a very important source of livelihood sustenance in Ethiopia.

Table 4.13. Different types and quantities of consumer incomes in Ethiopia. Source: RUNRES FVC Context study for Ethiopia, 2019.

Type of Income per season	Average (USD)
Agricultural income	1325.8
Non-agricultural income	962.5
Household income	1139
Annual household income	2278

Expenses

From Table 4.14, nearly 72% of total household annual expenditure of consumers in Ethiopia iss dedicated to food consumption. This may imply that the sample is considerably a poor one, since the largest proportion of their earnings are all spent on food consumption. On average, each household consumes about 39 kilograms of food weekly.

Table 4.14. Types of Household Expenses per season (6 months). Source: RUNRES FVC Context study for Ethiopia, 2019.

Types of Household Expenditure	Average (USD)
Non-food (Annual)	482
Food (Weekly)	23.4
Food (Annual)	1,214.3
Total food and non-food (Annual)	1,697.5

Household food insecurity access

From Figure 4.28, between 2 – 20% of consumers are concerned that they do not have enough food, or do not consume the preferred food, or consume limited variety of foods, or eat food that they do not want to eat, have low quantities to eat or even sometimes go without food. Interesting, nearly 80% of consumers do not have these experiences or worries – an implication of relatively ample food access.

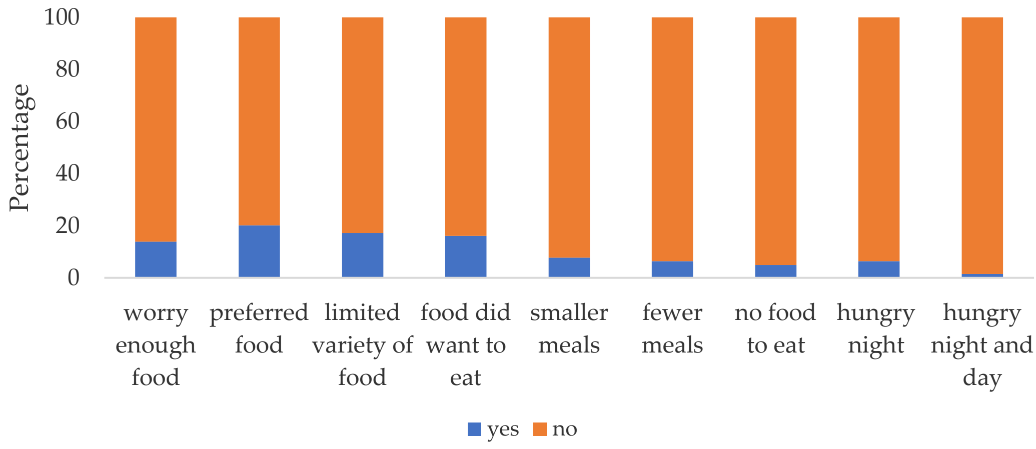

Figure 4.28: Assessment of consumer households' food insecurity access in Ethiopia.

In Figure 4.29, we assess the consumers' food security through a frequency measure of food access aspects. At least 67% of the consumers reported the frequency of these food access concerns as being rarely experienced. Unfortunately, 7 – 15% of consumers reported to experience indicators of severe hunger (having no food to eat, being hungry through the night, or staying hungry both night and day.

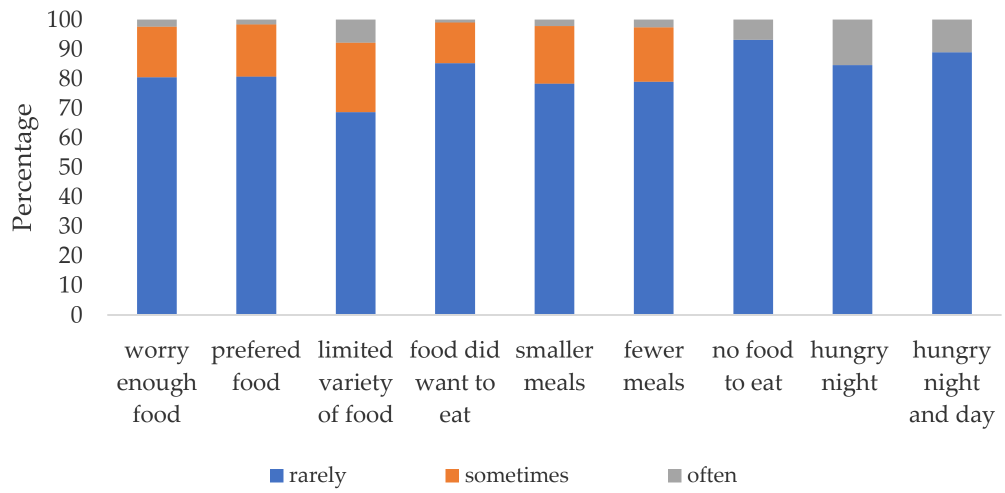

Figure 4.29: Frequency of the food insecurity access among consumers in Ethiopia

Consumers' social attitudes and willingness to pay for waste derived products

From Figure 4.30, most consumers agreed (at least 68% across all CE aspects) that they are willing to pay for fertilizers derived from organic waste (compost, urine, and feces), and would accept to consume foods grown using these fertilizers. However, the stronger agreement was with regards to compost and its food products, followed by urine, and least with fecal matter.

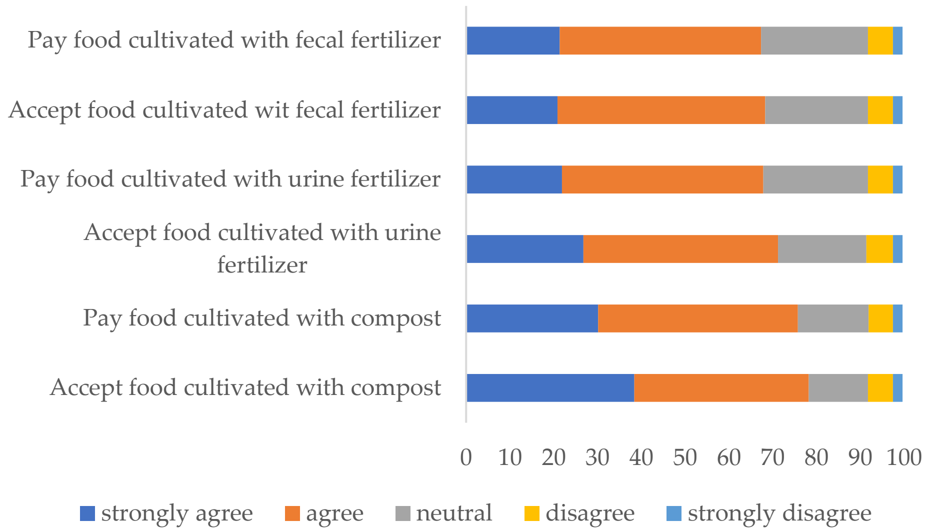

Figure 4.30: Consumers' acceptance and willingness to pay for waste derived products in Ethiopia.

Banana farmers

All farmers interviewed in the banana FVC in Ethiopia produce crops on their farms. However, a majority (78%) of these farmers use mono-cropping (grow one crop per plot at ago). The other 22% use intercropping. On average, farmers produce about 4,116 kilograms of bananas (fresh fruits) per season. In addition to bananas, about 69% of banana farmers also grow mangoes, and 29% also grow maize. All farmers (100%) do not treat their bananas before selling them to customers, implying a huge gap in value addition through innovative processing activities. Furthermore, when asked to rate the general importance of the other crops to the household with regards to the RUNRES crop (bananas), the majority of the farmers (59%) rated these as less important compared to the RUNRES crop (figure 4.32). This highlights that the banana value chain chosen by RUNRES is quite important in enhancing household and community livelihoods in the region.

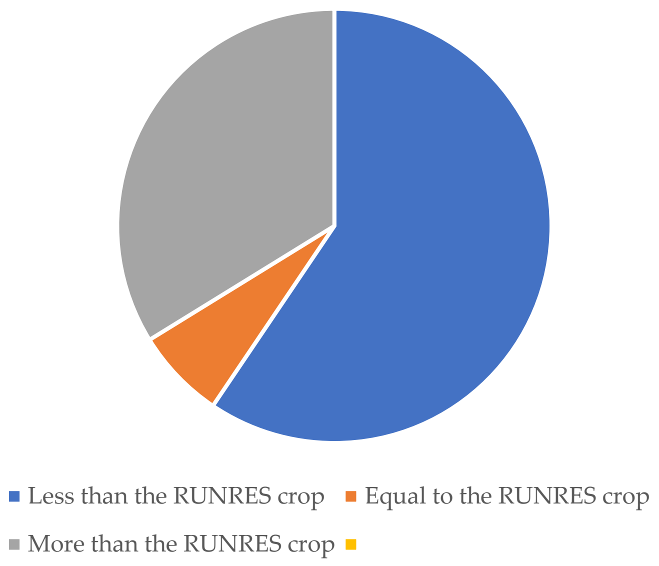

Figure 4.32: The importance of the other crops compared to bananas in Ethiopia

Farming inputs

The most sought-after inputs by farmers in the banana FVC in Ethiopia is planting materials (91%) (Figure 4.31). About, 46% of farmers buy mango seedlings, 41% buy banana suckers, and 4% maize seeds. Only about 8% of farmers buy fertilizers. Yet, all (100%) of the fertilizers bought by farmers is inorganic. Therefore, this points to an opportunity for success with innovations focused on organic fertilizer production from waste recycling in Ethiopia.

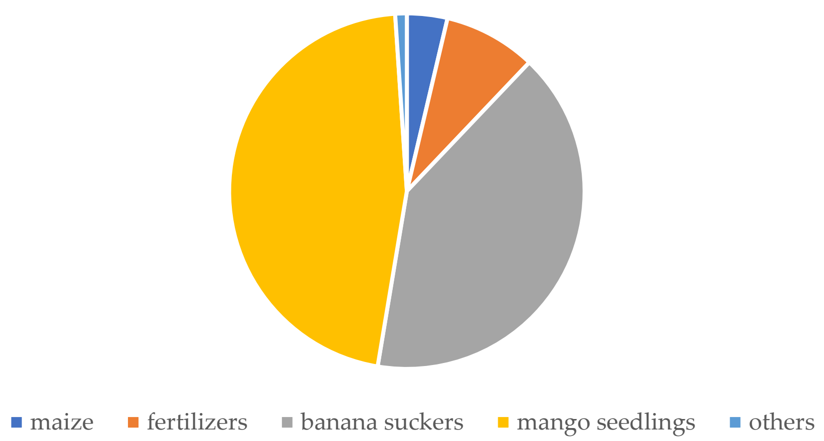

Figure 4.31: Inputs bought by banana farmers in Ethiopia.

All farmers in the banana food value chain of Ethiopia that use fertilizers also grow maize (100%), while among tomato farmers only 13% use fertilizers, while among exclusive banana farmers, only 7% used fertilizers (Figure 4.32).

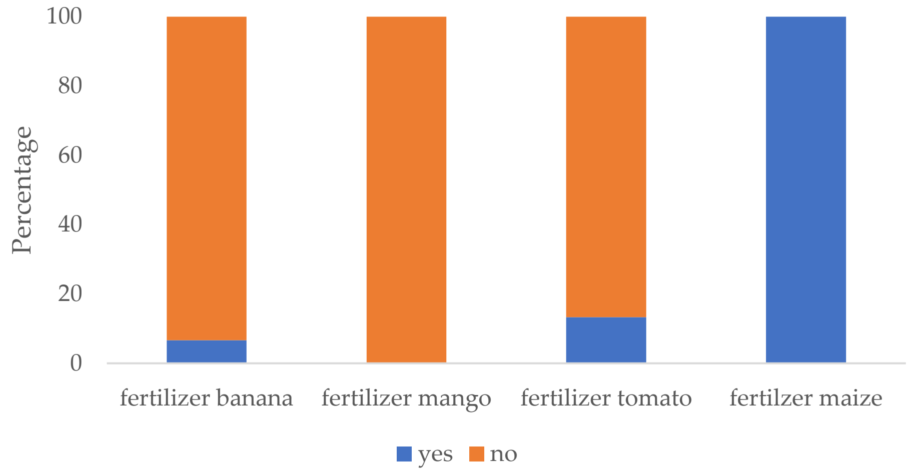

Figure 4.32: Crops for which farmers used fertilizers in Ethiopia.

The majority of the farmers (89%) source farm inputs from their own efforts, implying existence of somewhat needy seed systems, since most farmers seek planting materials as the main input. However, about 9% of farmers source inputs from government agencies (Figure 4.33).

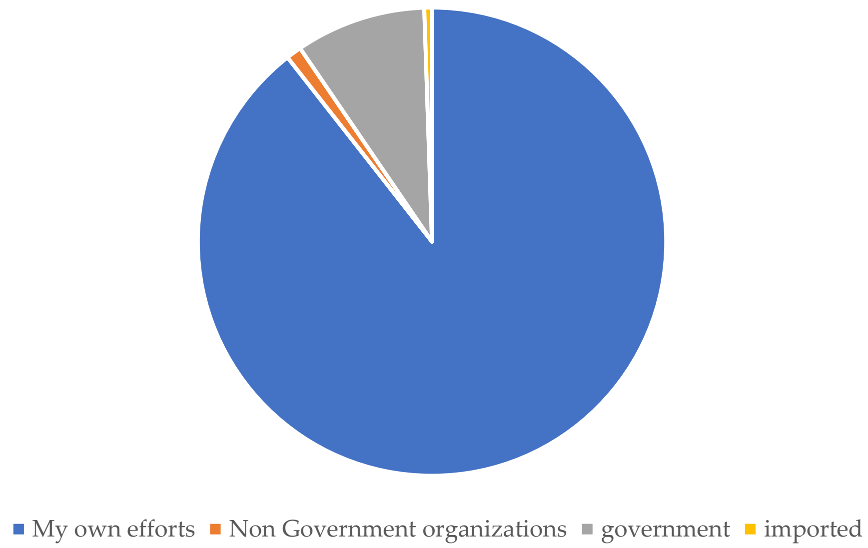

Figure 4.33: Sources of farming inputs in Ethiopia.

Income and expenses

From Table 4.15, the average farm household income per season is 1,068 USD, and about 11% of this is derived from production profits. The average price per kilogram of bananas is around 1 USD. The figures imply that on average a farm household made about 900 USD over six months (per season) from banana farming.

Table 4.15. Farmers' incomes and production costs in Ethiopia. Source: RUNRES FVC Context study for Ethiopia, 2019.

Farmers' incomes and costs per season	Average (USD)
Farm income	1,067.7
Farm production costs	122.4

However, only about 64% of farmers incur production costs, and the largest component of these costs is from planting materials (44%), equipment (35%), labor (20%). Fertilizers are spent on the least (1%) (Figure 4.34).

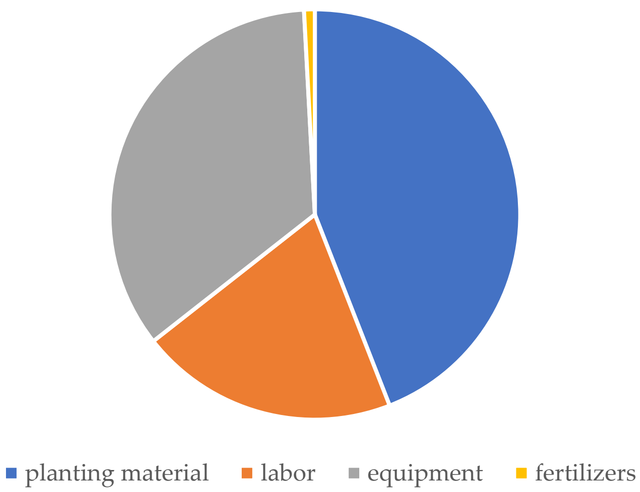

Figure 4.34: Activities on which farmers' incurred costs in Ethiopia.

Quality of the inputs used and that of banana harvests

From Figure 4.35, only about 32% of farmers stated that the quality of their planting materials is at least good. A very large proportion (65%) believe that the quality of the planting materials is fair, something which could still point at gaps in the banana seed systems in this city region.

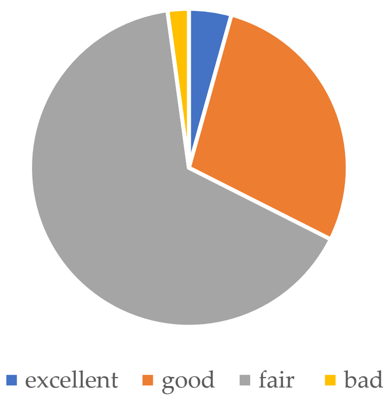

Figure 4.35: Farmers' opinions about the quality of the planting material.

Also, about 39% of the farmers stated that the quality of their harvested bananas is at least good, and the largest proportion (59%) could only state that the quality of harvests is fair (Figure 4.36). This points to some gaps in the value chain that can be exploited to enhance the value of the chain's products – either through productivity enhancing innovations and mechanisms (like organic fertilizer application) or small-scale processing techniques to improve the quality of the final product.

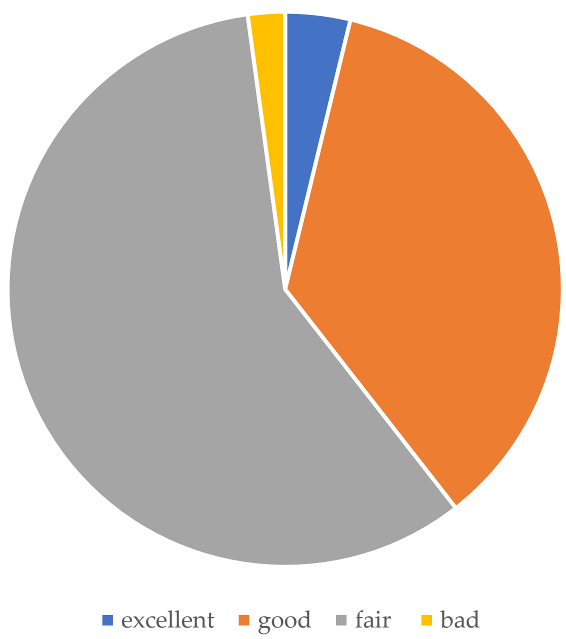

Figure 4.36: Farmers' opinions about the quality of bananas harvested in Ethiopia.

Markets and Information

About 95% of the farmers sell bananas, while about 91% also consume the bananas. Just a few farm households (2%) reported wastage, (Figure 4.37).

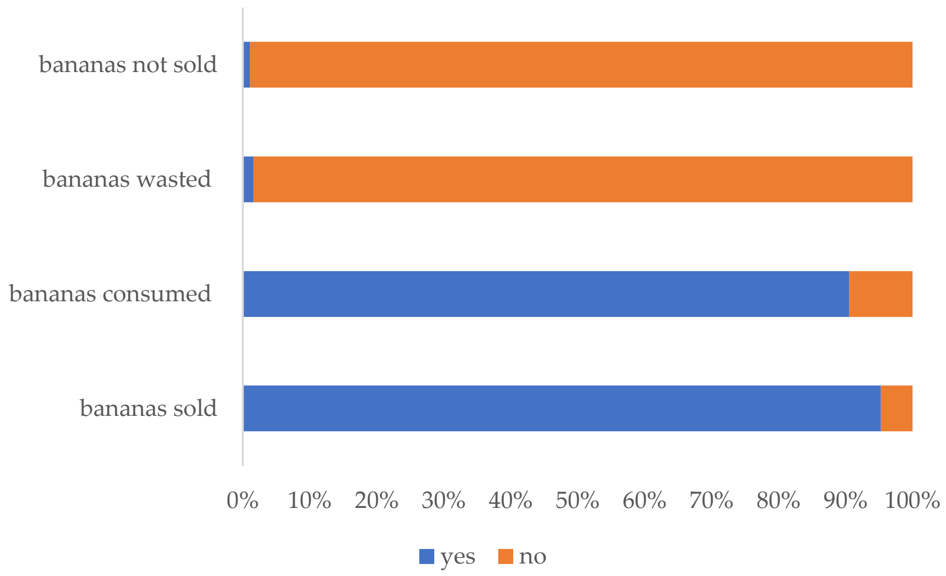

Figure 4.37: Destinations of the farmers' bananas in Ethiopia.

On average farmers sell 2,581 kilograms of fresh bananas per season and consume 89 kilograms (Table 4.16). The existence of relatively large farmers as well as small-scale farmers may explain the bigger average for sales and a comparatively small average for consumption. Moreover, bananas in Arba Minch could also be mostly farmed for commercial purposes. The potential existence of relatively large farmers may also be highlighted by the relatively large wasted average (113 kilograms).

Table 4.16. Quantities of bananas sold, consumed, wasted or not sold in Ethiopia

Quantities of Bananas	Average (kilograms)
Sold	2581
Consumed	89.2
Wasted	112.5
Unsold	50

Most of the bananas sold in Arba Minch region (98%) are sold as fresh harvests without any processing (Figure 4.38). This is an indication of the big potential for value addition in the banana FVC through processing.

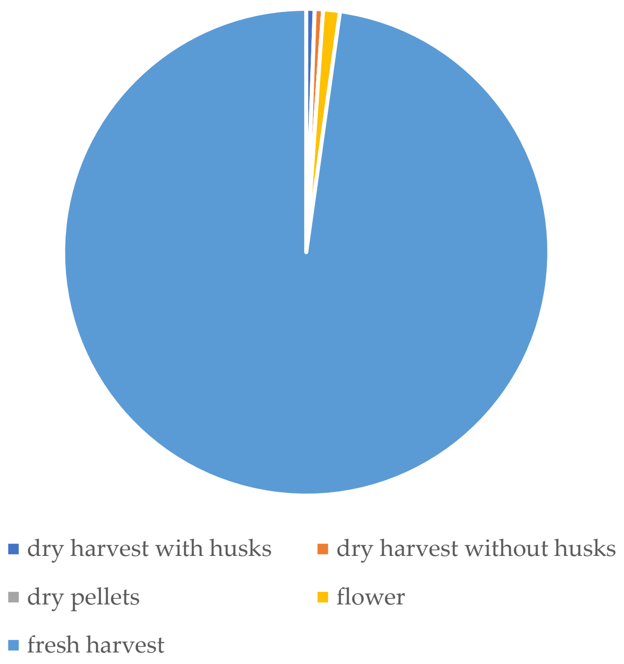

Figure 4.38: Different forms in which bananas are sold in Ethiopia.

Cooperatives also play a very big role in the marketing of bananas in Arba Minch. For instance, most farmers (56%) sell their bananas to cooperative unions, and only 39% sell to traders (Figure 4.39). Most of the clients are located at Arba Minch region, which points to an opportunity of an existent export market.

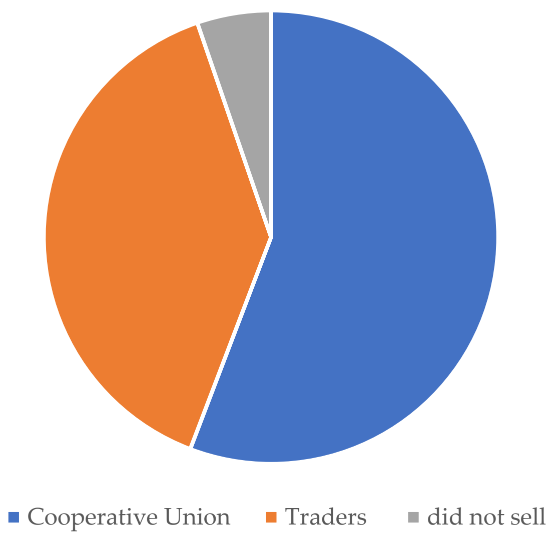

Figure 4.39: Destinations where farmers sold their bananas in Ethiopia.

The majority of the farmers (95%) share information with their customers in person, or by phone call (81%), or phone SMS (20%). The internet is not used by farmers for information exchange, which could point to causes of inefficiencies with regards to access to quick and reliable information (Figure 4.40). Other mass communication channels like radio and television are also not used by farmers.

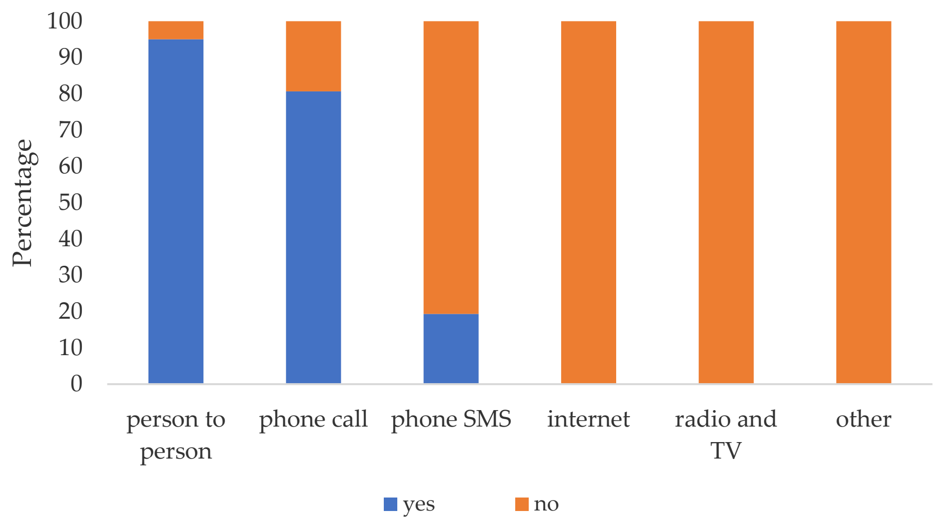

Figure 4.40: Farmers' communication strategies in Ethiopia.

As expected, the highest volume of information is exchanged about product prices (86%), then product quality (66%), product performance (57%) and new potential markets (54%) (Figure 4.41). This implies that market actors, especially customers, are keen about a number of product attributes, which would be the areas where value addition would happen so as to enhance value chain gains to the various actors.

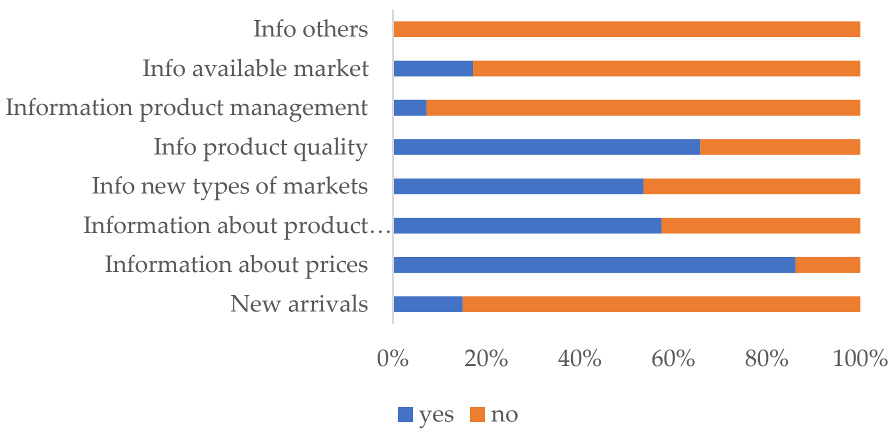

Figure 4.41: Types of information that farmers shared with customers in Ethiopia.

Most farmers keep their customers committed to their products through offering their customers good product prices (56%), free gifts (51%), and ensuring good personal relationships with their customers (50%).

Laws, policies and regulations that impact the banana business activities

About 99% of farmers in the banana value chain in Ethiopia, do not think they are affected by any policies, laws or regulations in guiding their businesses. Only one farmer stated to be positively impacted by policies (the agriculture development policy). Perhaps, this may indicate some awareness gaps among farmers about policies and regulations that may be relevant for their businesses development.

Gender

The majority of the individuals involved in the banana farming business activities are mostly males. Nearly 83% of farmers involved males in their activities, while only 43% did involve females (Figure 4.42). This reflects a sharp gender divide with regards to involvement at the farmers' segment. Generally, on average one female is employed in farm activities, for every three males involved.

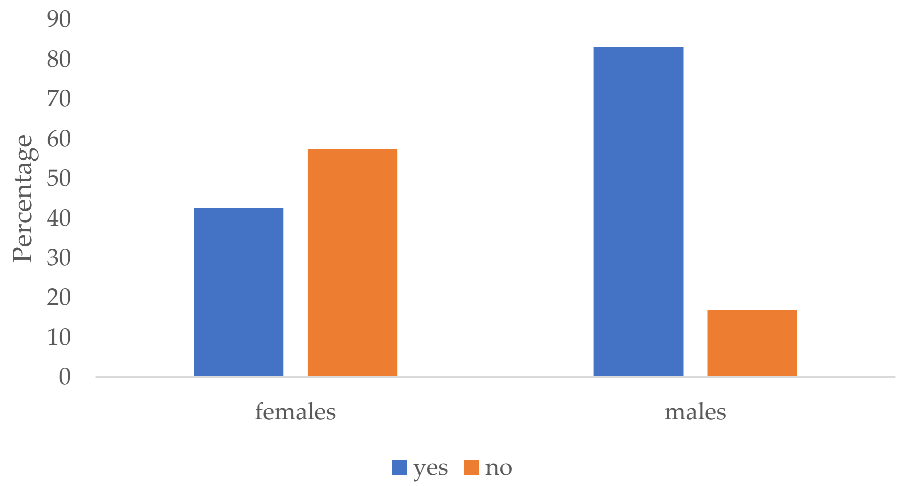

Figure 4.42: Proportions of females and males involved in farm activities in Ethiopia.

Moreover, most of the females are engaged as cleaners (56%), dominate the harvesting and transportation activities. Interestingly, however, a good proportion of females (26%) in the banana farming businesses are financiers/owners. (Figure 4.43).

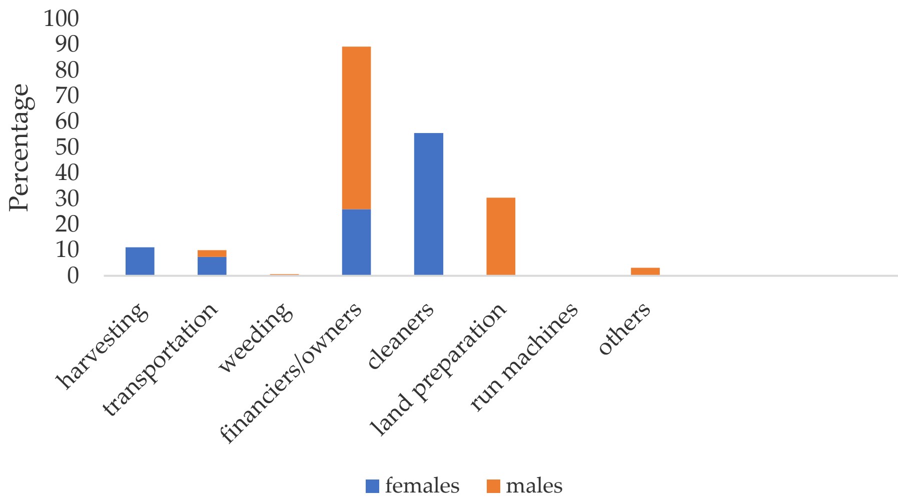

Figure 4.43: Roles of females and males in farming activities in Ethiopia.

Institutional support

Only 5% of the farmers in the Arba Minch region have accessed financial support. Moreover, those who did indicate to accessing financial support did so from informal institutions only.

Challenges and opportunities

Most of the farmers (67%) agreed that they face challenges in their farming activities, yet even a bigger proportion (80%) do not seem to realize any opportunities to overcome these challenges (Figure 4.44). Therefore, innovations that could overcome these challenges would significantly help to improve farmers' wellbeing.

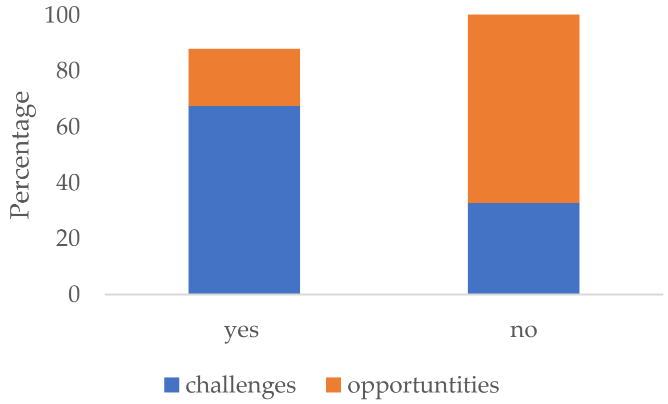

Figure 4.44: Challenges and opportunities faced by farmers in Ethiopia.

Among the challenges most mentioned by farmers include low crop productivity, lack of water, low soil fertility, and lack of good transport infrastructure. However, most farmers proposed solutions that would help them overcome these challenges, for instance access to credit, water, infrastructure (technical and physical), markets, and trainings. Opportunities highlighted by some farmers include high productivity of bananas in the region, high benefits through high prevalent prices, and relatively cheap raw materials.

Banana middlemen

Most middlemen (100%) also consider themselves as traders, while another 30% consider themselves as either assemblers or collectors or transporters.

All middlemen (100%) get some bananas supplied to them by farmers, while about 70% of middlemen are also farmers (self-supplying). Only 20% of middlemen get supplies from cooperatives, thus pointing to a limited interaction between middlemen and farmer cooperatives. About 80% of middlemen believe that the quality of banana supplies is of good. A majority of the middlemen keep their banana suppliers committed by ensuring consistent markets (40%), good personal relations with suppliers (30%), offering suppliers good prices (10%), and promotional initiatives (10%). Only about 20% of middlemen have their own equipment used in banana business activities.

Quantities handled, incomes, and expenses

On average, middlemen handle 68,400 kilograms of fresh bananas per season, but can only manage to move about 90% (61,320 kilograms) of this volume to intended clients, with nearly 10% wasted in the process, (Table 4.17). This may point to needed improvements in physical and technical infrastructure to preserve the fresh produce.

Table 4.17: Quantities of bananas handled by middlemen, their incomes, and costs per season in Ethiopia. Source: RUNRES FVC Context study for Ethiopia, 2019.

Quantities of bananas, and incomes / costs	Average (USD / Kilograms)
Quantity handled (kilograms)	68,400
Quantity treated (kilograms)	61,320
Income (USD)	8,337.6
Costs (USD)	3,373.2

On average, middlemen made 8,338 USD in revenues per season, and incurred 3,373 USD on business related services and costs, leaving them with a net of 4,965 USD. All middlemen spend money on services. It is important to note that there are two large-scale middlemen with an income above 15,000 USD and this could have driven the net average revenues high.

Laws, policies and regulations

Only 20% of middlemen stated that they follow any policies, regulations or guidelines in their business activities. This may still reflect a significant non-awareness on policies among middlemen in the banana value chain in Ethiopia. Middlemen highlighted the peace and stability impact of the regulations that allows them proper business activities, while high taxes are seen to bring about disabling business environments. Middlemen stated that they are aware that the government is responsible for regulation of the banana business.

Gender

All middlemen (100%) involve males in their business activities, and only 60% of middlemen involve females. Moreover, majority of the females involved are engaged as cleaners (50%) or station/shop attendants (33%). Only about 17% of females are involved as financiers or owners, as males dominated (20%).

Market information

All middlemen (100%) exchange information with their customers using the phone call mechanisms, and a huge proportion (80%) still rely on the person-to-person mechanism, (Figure 4.45). Still, middlemen did not use the internet for communication.

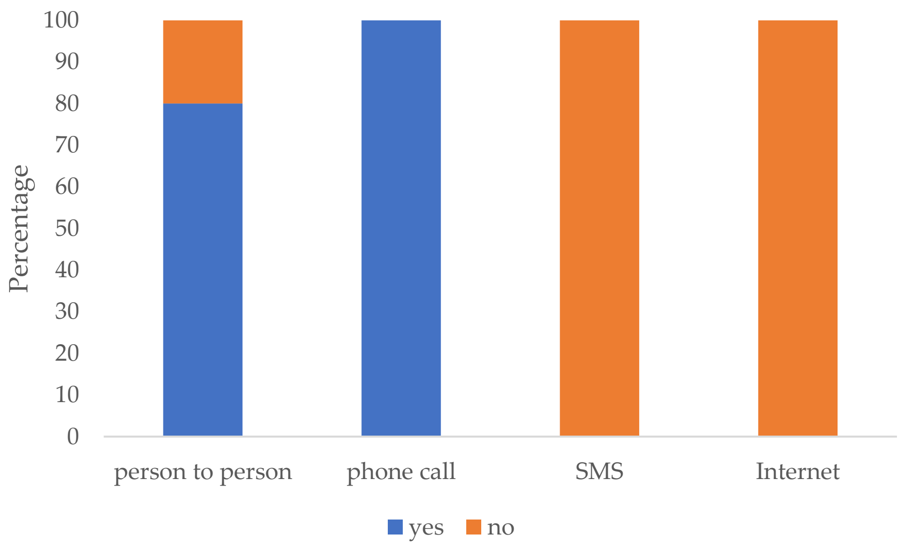

Figure 4.45: Middlemen's communication strategy with customers in Ethiopia.

All middlemen exchange information with their customers about prices, product quality, and available markets. This implies that information about product attributes and markets was essential. All middlemen (100%) sell bananas in a fresh form, and a majority of them (70%) keep their customers committed to their business activities by offering customers a good price.

Institutional support

None of the middlemen in the banana value chain in Arba Minch reported to receive any technical support, moreover only 10% of middlemen receive financial support via formal institutions. This points to existent gaps with regards to extension services that could help middlemen add value to their products.

Challenges and opportunities

All middlemen (100%) stated that they face challenges, as well as envision opportunities within the middlemen banana businesses in Ethiopia. Among highlighted challenges are lack of proper transportation infrastructure, proper guiding policies, and technical expertise to improve the value of their products. Among the solutions highlighted by middlemen that could help alleviate these challenges are improved market infrastructure, provision of transport equipment, and proper technical and financial support.

Banana processors

The banana value chain in Arba Minch largely lacks several actors; it only has one processor. The processor produces processed banana products. He is supplied with fresh bananas by farmers, and he grades the quality of the supplies as good. The processor has his own equipment to process bananas, which he does mechanically. The processor handles on average 72,000 kilograms of bananas in a season (six months) and makes roughly 115,676 USD, while incurring 5,124 USD in related services and costs. The processor involves five females and two males in the business activities. Females participate primarily in tasks such as cleaning, while males run machines and transport raw-materials and products.

He indicated that there are policies, regulations, and laws that affect the banana processing business activities. He highlighted local government policies that enhance small-scale processing, provision of free production, and shopping area for organized small scale enterprises as enabling regulations. However, he mentioned bureaucracy for licenses and insurance as particular regulations that hamper business activities in the processing segment of the banana value chain.

The processor categorized the quality of the processed banana as excellent. Customers for the processor are supermarkets located in Addis Ababa. The processor uses phone calls and in person conversations to interact with his customers, exchanging information mostly about prices, new products, product quality, and product management means. The final product is processed into a powder form, and the processor keeps his customers committed through consistent supplies. About 3,000 kilograms of the processed bananas are not sold due to unavailable market.

The processor receives financial support from formal institutions and technical support from government and international NGO’s. However, the processor faces challenges, for instance lack of proper processing equipment, but also identified available high demand for the processed products as an opportunity.

4.3 Kamonyi, Rwanda

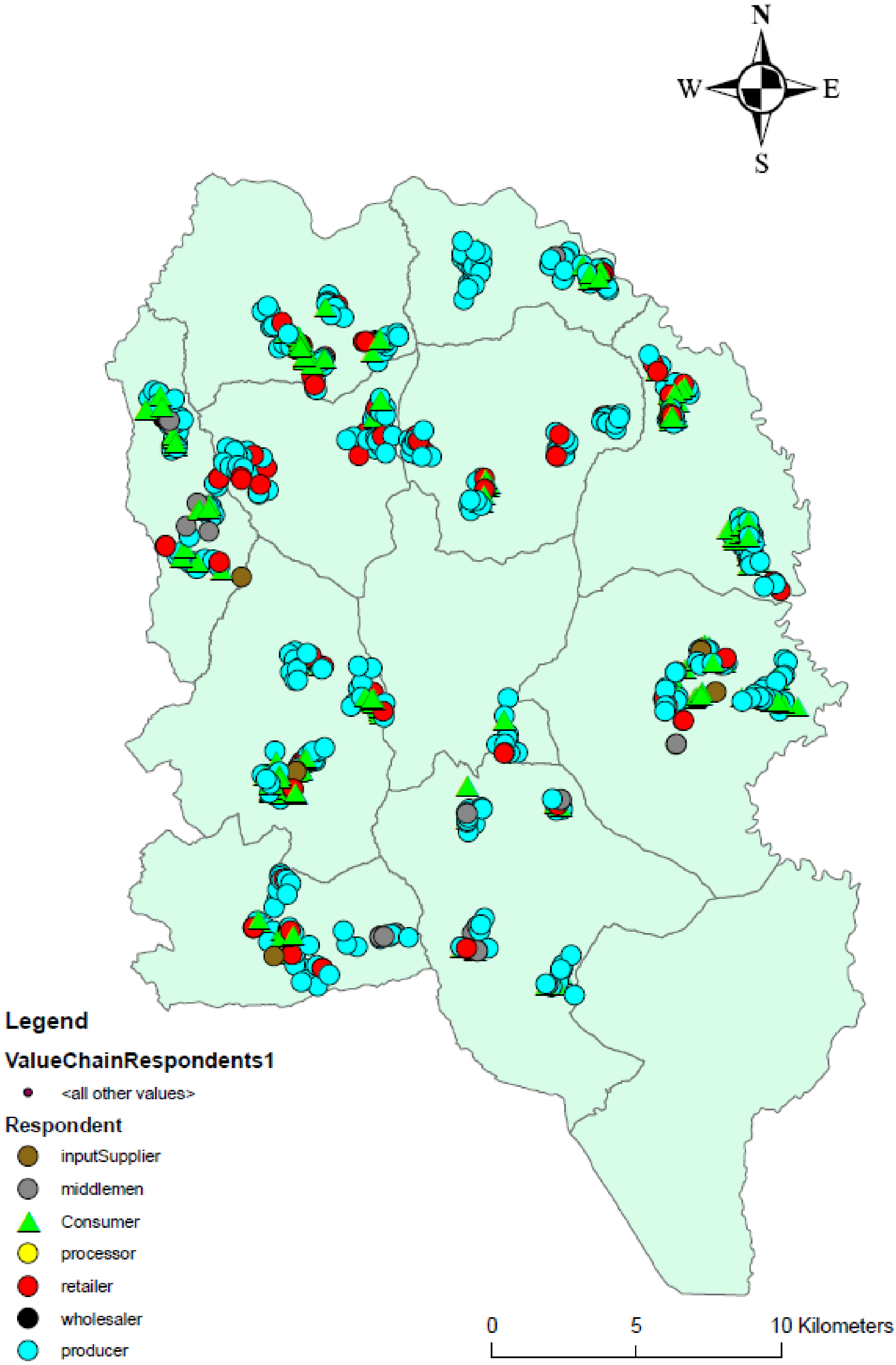

Figure 4.46: Kamonyi food value chain respondents.

Introduction

This section presents the findings of the cassava value chain context study in Rwanda (Figure 4.46). The cassava value chain in Rwanda is complete with input suppliers, farmers, middlemen, processors, retailers, wholesalers, and consumers (Table 4.18). First, we present descriptive results from the whole sample (considered all as consumers), covering information on household biodata, income and expenses, food access, and social acceptance for products derived from organic waste recycling. Afterwards, specific results per actor segment in the cassava value chain are presented.

Table 4.18: composition of the cassava value chain in Rwanda

Actor	Number of respondents (N)
Input suppliers	25
Farmers	519
Middlemen	61
Retailers	154
Processors	23
Wholesalers	12
Consumers	1318

Source: RUNRES FVC Context study for Rwanda, 2019

Results

Cassava consumers

The average age of the consumers sampled was 44 years, and households live an average distance of 6 kilometers from the nearest big town, (Table 4.19). Consumers on average have 6 years of formal education, and a majority of consumers (61%) have only attained a primary level of education.

Table 4.19. Description of the sample using key demographic variables. Source: RUNRES FVC Context study for Rwanda, 2019.

Demographic variable	Average
Age (years)	44
Formal education (years)	6.4
Distance to nearest big town (kilometers)	6.2
Household size (persons)	5.2
Gender (males’ percentage)	51

About 69% of consumers in the cassava value chain of Rwanda have only accomplished primary school at most, while approximately only 10% have a university degree (Figure 4.47). Nearly, 78% of the sample are males, and 83% are married.

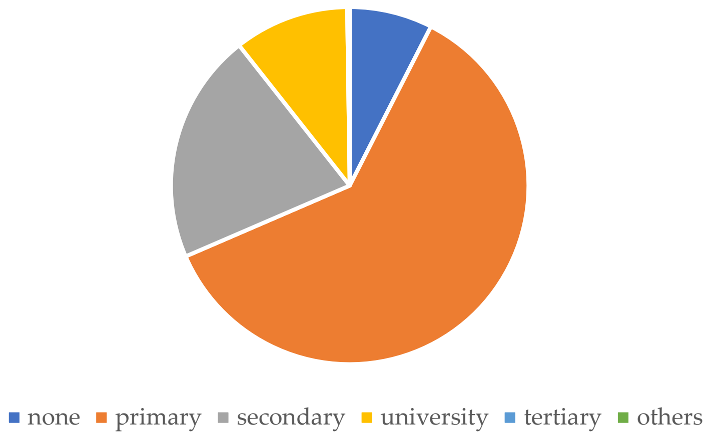

Figure 4.47: Categories of educational levels attained by consumers in Rwanda.

Circular economy (CE) awareness, knowledge, and support

About 88% of the consumers at least agreed that they are aware and knowledgeable of circular economy concepts, and that they would support these concepts if put into practice (Figure 4.48). This is an indication that the sample (consumers) would support innovations fostering a circular economy model through activities such as organic waste recycling and reuse in the production systems. This social support for CE concepts presents a good opportunity to predict success for CE innovations if they are rolled out around the cassava value chain in Rwanda.

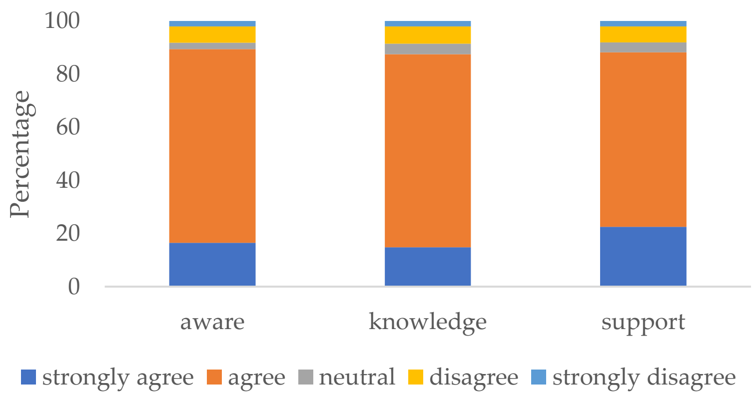

Figure 4.48: Awareness, knowledge and support for the circular economy concept (CE) in Rwanda.

Incomes and expenses

About 54% of the consumers earn their income from agricultural activities – of which most income comes from crop sales (46%), and 18% is from livestock. This indicates the importance of the crop value chains in Rwanda.

From Table 4.20, the average income from non-agricultural activities (1,236 USD) is higher than that from agricultural activities (429 USD). This may still imply that there could be a large number of consumers depending on agriculture but with minimal earnings from agriculture, hence pointing to an opportunity to enhance value addition in agriculture so that reasonable earnings could be realized.

Table 4.20. Values of consumer incomes and expenses in Rwanda. Source: RUNRES FVC Context study for Rwanda, 2019.

Annual Incomes and expenses	Average (USD)
Agricultural income	429
Non-agricultural income	1,236
Household income	1,683
Non-food expenses	630.1
Food expenses	629.7

Nearly 75% of annual incomes of consumers in Rwanda is spent on consumption (food, and essential non-food services like education, health, housing, and other utilities). This points to minimal reserves (25%) that could be available for investment.

Household food insecurity access

From Figure 4.49, at least 32% of all consumers expressed some sense of being food insecure, to the levels of having less meals, and at least 6% have been hungry without food. This may imply some food insecurity tendencies among consumers in the cassava value chain in Rwanda.

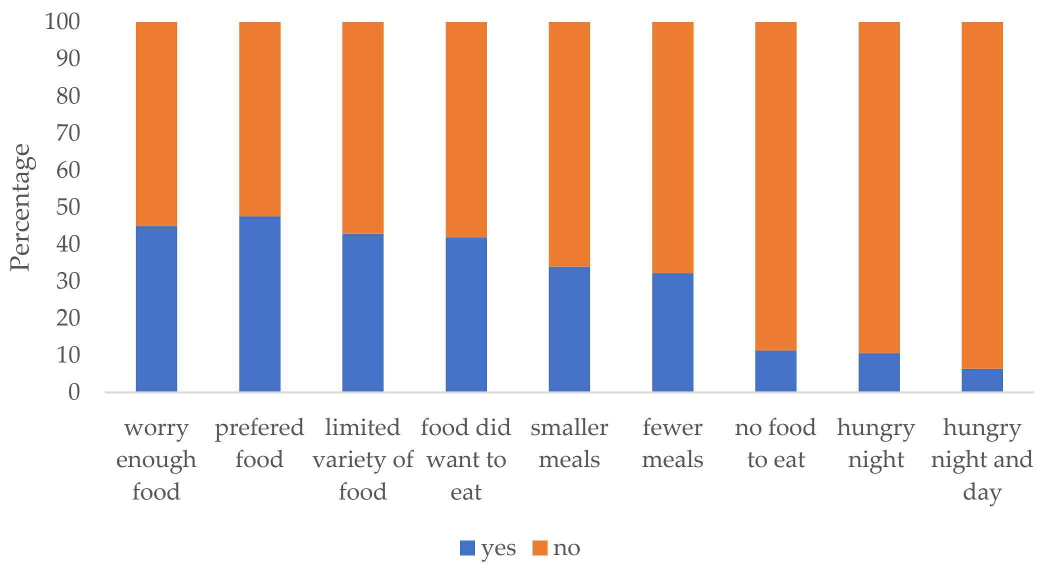

Figure 4.49: Consumers' assessment of their food security and access in Rwanda.

In Figure 4.50, we looked at the frequency of food insecurity access aspects assessment among consumers. Unfortunately, over 13% of the consumers reported to having experienced ***often*** the scenarios of food insecurity, including going hungry for a night without food. Those who experience these food insecurity scenarios at least ***sometimes***, ranged from 33% to about 52%, which is also a substantial range. Therefore, this could point to prevalent food insecurity among consumers in the cassava value chain in Rwanda, thus presenting an opportunity for appropriate innovations to foster improvements in the food security status of consumers in this chain.

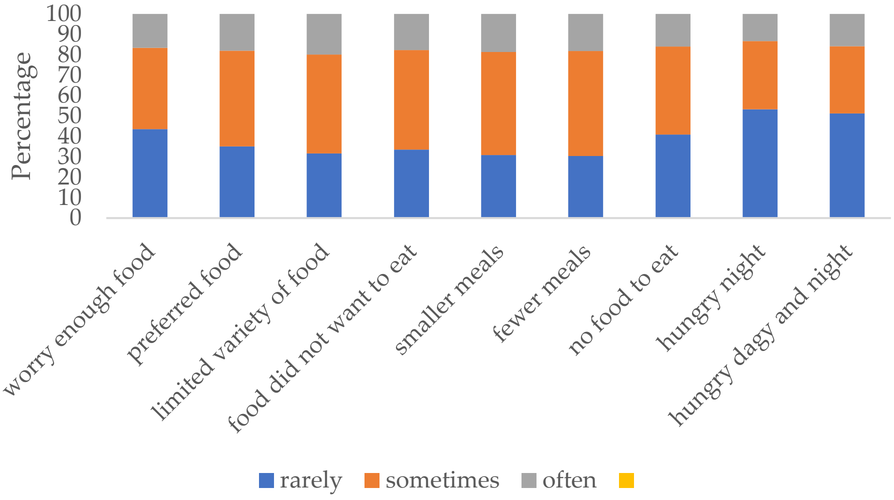

Figure 4.50: Frequency of the food insecurity access among consumers in Rwanda.

Consumers' social attitudes towards circular economy aspects and products

At least 85% of the consumers in the cassava value chain in Rwanda, would accept food or pay for food cultivated from circular economy (CE) model reliant production concepts, for instance composting, use of urine, or feces, (Figure 4.51).

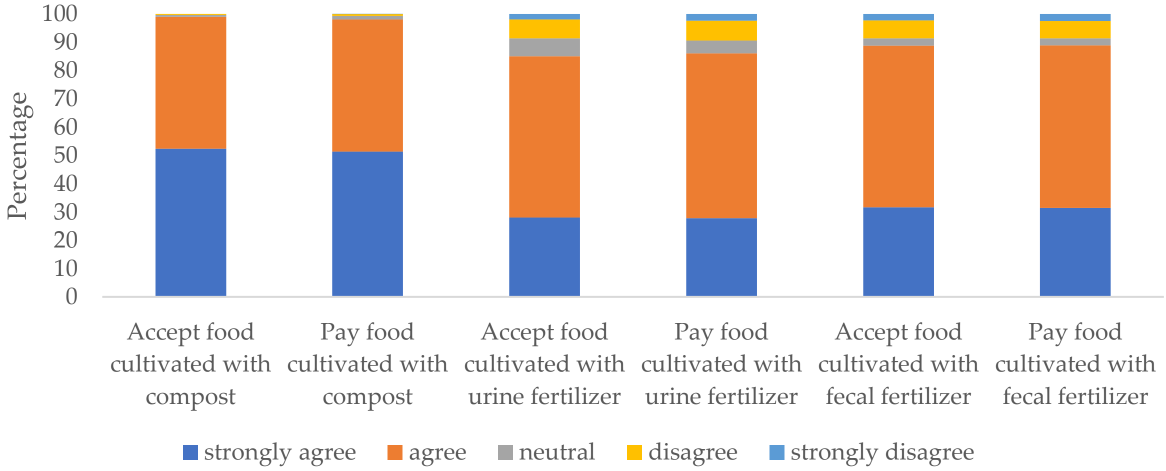

Figure 4.51: Acceptance of circular economy aspects, and willingness to pay for waste derived products.

However, this acceptance (consumption or payment) of food products is strongest for composting (up to 99%), while for consumption and payment for food products produced using human waste (urine or feces), there was disagreement of up to 9% among consumers. Therefore, this could point to areas of awareness needs for certain CE concepts (human waste use) among consumers, and as well as proper innovations that would make it possible to use these CE concepts in ways that would enhance consumer acceptance.

Cassava input suppliers

Most of the input suppliers (85%) in Rwanda's cassava value chain supply fertilizers, while another substantial proportion supply seeds for maize (54%), rice (50%), and tomato (31%). Only 12% of input suppliers sell cassava cuttings. This could point to needs in improving the cassava seed systems, as these currently seem to be less supported by input suppliers.

Fertilizers are mostly provided to input dealers by government (54%), agro-dealers (19%), and NGO's (19%), while farmer associations provide about 4%. This could point to potential existent platforms to work with government agencies on fertilizer input supplies within the cassava value chain.

Income and expenses

On average input suppliers provide 2,968 kilograms of fertilizers per season, at an average cost of 0.44 USD, and a price of 0.59 USD per kilogram of fertilizers. Subsequently, the average net revenue of input suppliers per season was 569 USD, (Table 4.21).

Table 4.21. Quantities of fertilizers, incomes, and costs of input suppliers per season. Source: RUNRES FVC Context study for Rwanda, 2019.

Quantities of fertilizers, incomes, or expenses	Average
Quantity handled (kilograms)	2,968
Net revenue (USD)	569.4
Cost per kilogram (USD)	0.44
Price per kilogram (USD)	0.59
Price Margin per kilogram (USD)	0.15

Market information

All input suppliers (100%) exchange information with their customers using the person-to-person mechanism, while 62% of these also use phone calls, and 4% use the SMS texts. None of the input suppliers use the internet – which could be an avenue to enhance customer information access more effectively and cheaply. Many of the input suppliers exchange information about product prices (69%), new arrivals (46%), and product performance (13%). Most input suppliers keep their customers committed by offering these customers good product prices (73%), good product performance (62%), and ensuring good interpersonal relations (8%).

The largest clientele (96%) of input suppliers are the farmers, and farmer cooperatives provide only 4% of the market. This may imply that input suppliers in the cassava value chain in Rwanda, may still be lacking largescale sales, due to the limited access to markets from cooperatives.

Regulations, Laws, and policies

Eighty-five (85%) of input suppliers in the cassava value chain stated to be affected by laws, and policies. Among mentioned policies that enable input sellers' businesses are those guiding farmers on proper planting and management of cassava fields, providing information on genuine pesticides and seeds, and those sensitizing farmers on proper application of fertilizers and other inputs. Input sellers also mentioned that failure by government to set prices for inputs is one way which hampers their input sales businesses. Input sellers consider the government to be responsible for regulating their input sales businesses.

Gender

Input suppliers generally engage females and males in their input sales businesses in a nearly 1 to 1 ratio. Each gender is mostly involved in input sellers' businesses as shop attendants or financiers/owners, but males also dominate the transportation activities (Figure 4.52).

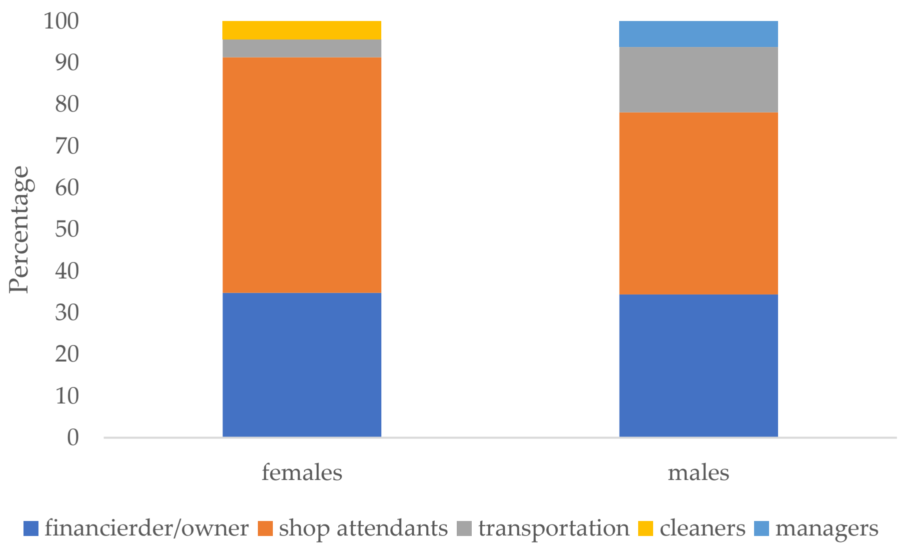

Figure 4.52: Different roles of females and males in Rwanda's input seller businesses.

Institutional support

About 65% of input sellers stated that they are able to access financial support for their business activities. However, this support is mostly accessed through informal institutions. This would indicate a gap in the value chain for the contributions of formal financial institutions towards value addition and other activities of input sellers in the cassava value chain.

Challenges and opportunities

A majority of the input sellers (58%) acknowledge that they face challenges in their business, however, a larger proportion of these (92%) still also believe that there are opportunities in the input seller business in Rwanda. Among the challenges mentioned are the lack of access to credit, pests and disease problems that limit productivity, lack of markets, and high operational costs. With regards to opportunities, many input sellers still predict high business benefits (64%) that could be premised on the existence high demand (20%) of their products. This may point to prevalent room for improvements at the input seller segment that could enhance returns to input sellers. This may be well aided with appropriate innovations to address the identified challenges that still inhibit realization of these opportunities. Input sellers suggest that innovations that help to enhance access to credit, functional markets, and knowledge on pest management can help them realize these opportunities.

Cassava farmers

All farmers produce crops on their farms and a majority of them (58%) do so under the mono cropping method. The rest (42%) use intercropping. However, about 75% of the farmers also grow other crops on their farms. On average, each farmer produces 549 kilograms of fresh cassava per season, and an average of 619 kilograms of other crops.

Nearly 57% of farmers indicated that the other crops that they grow are, in their view, more important for their livelihoods than the RUNRES crop (cassava). This may point to other existent important food value chains in Rwanda – and these could be for those crops that are dominantly farmed for cash. However, 43% farmers indicated that the other crops grown on their farms are either equal to, or less important than, cassava for their livelihoods than the RUNRES crop (cassava) – implying that cassava is still a very important food value chain in Rwanda

Farming inputs

The inputs most used by farmers are cassava cuttings (90%), bean seeds (87%), maize seeds (35%), and fertilizers (34%). Other inputs, especially seeds of various crops are also used, for instance, soybean, tomato, and bananas. Unfortunately, most of the inputs (55%) used by farmers are sourced from non-official sources (own efforts), which would be an avenue for poor quality seeds. Moreover, government sources provide only 7% of the inputs used by farmers. Therefore, innovations to guarantee proper and functional seed systems could significantly improve crop productivity in this cassava value chain. With regards to fertilizers, the majority (77%) of the farmers using fertilizers use organic fertilizers, which implies that farmers are comfortable using organic fertilizers. Therefore, innovations that would enhance recycling and availability of organic fertilizers could potentially boost productivity in the cassava value chain.

Moreover, 88% of the fertilizer using farmers source the organic fertilizers from their organic produce, while 9% either buy the organic fertilizer or source it from their organic produce, and only 4% buy the organic fertilizer. This therefore implies that some farmers are even already buying organic fertilizers, and with innovations to ensure abundant and quality organic fertilizers, more farmers could be willing to buy such organic fertilizer.

Most farmers use fertilizers, however, on beans (66%), cassava (61%), maize (40%), bananas (16%), coffee (12%), and tomatoes (9%), (figure 4.151). A majority of the farmers (69%) keep their input suppliers committed by paying for inputs in cash.

Cassava Equipment

All farmers (100%) process (handled to add value) their crop traditionally by hand, and only 44% of farmers treat (pealed and dried) their cassava. Yet, over 80% of those who treat their cassava merely dump the waste.

Income and expenses

From Table 4.22, cassava farmers make an average income from cassava of 150 USD per season, and an average of 77 USD from other crops, thus an average agricultural income from crops of 164 USD. This still shows relatively smaller incomes to farmers.

Table 4.22. Farmers' farm income and expenses per season (6 months) in Rwanda. Source: RUNRES FVC Context study for Rwanda, 2019.

Type of income or expense per season	Average (USD)
Cassava income	149.9
Other crops income	76.6
Agricultural income (crops)	163.7
Price per kilo of fresh cassava	0.197

Production costs	56.7

Production costs average at 57 USD per season, and nearly 58% of farmers incur production costs, but spend these mostly on hiring agricultural labor (41%), buying fertilizers (25%), hiring land (20%), and then acquiring/renting equipment (13%).

Quality of inputs, and harvested cassava

At least 81% of farmers believe that the quality of cassava seeds used, as well as that of cassava harvested are at least good. This implies that farmers still have trust in the cassava seed systems available, even when they are largely run by farmers themselves in an informal setup.

Additionally, this shows that there is still quality in the cassava seed inputs and the product in the chain, in that innovations that help enhance and preserve this quality would potentially bring about sizeable benefits to farmers and other actors.

Markets and information

As nearly 88% of the farmers also consume cassava, 48% of farmers instead sell a part of this cassava, an implication of commercial activities at the farmers' level. On average, each farmer household harvests 549 kilograms of cassava per season, processes half a kilogram (0.09%) of the harvest, sells 342 kilograms (62%) at an average price of 0.19 USD, and wastes about 57 kilograms (10%), while 165 kilograms (30%) is consumed, (Table 4.23). Less than 2% of farmers reported to have had some cassava wasted (neither sold nor consumed).

Table 4.23. Quantities of cassava sold, consumed, wasted per season in Rwanda. Source: RUNRES FVC Context study for Rwanda, 2019.

Quantities of cassava	Average (kilograms)
Harvested	548.6
Processed	0.441
Sold	342.2
Consumed	165.0
Wasted	57.1
Unsold	0.00

Source: RUNRES FVC Context study for Rwanda, 2019

Most of the customers to farmers are individual consumers and retailers. Most farmers (80%) sell cassava as peeled dry harvest, while another proportion (15%) sell cassava as fresh harvest. This implies selling cassava with limited value addition due to low processing levels, some 3% of farmers sell cassava in powder form. Thus, this implies that innovations that can process cassava at the farmer level could still enable farmers to earn significantly from their cassava sales – more so that a big proportion (95%) of farmers still sell cassava at most as peeled pellets.

Farmers also sell their cassava products to collectors, cooperatives, middlemen, exporters, processors and wholesalers.

Most farmers (96%) exchange information with their customers via person-to-person mechanism, while 45% use phone calls. There are no farmers using the internet or mass media channels like radio or TV to reach out to their customers. Innovations aiding farmers to use these avenues could enhance farmer gains in the cassava value chain through facilitating access to a bigger cassava demand market. Most of the information exchanged between farmers and customers is about product price (51%), product performance (49%), product quality (25%), and new product arrivals (18%). Farmers keep their customers committed by ensuring good product performance (86%) and offering customers good product prices (40%).

Laws, policies, and regulations

Only 2% of the farmers stated to be affected by policies and regulations during their farming business. Again, this could point to a gap in policy awareness among farmers. However, those that are affected gave examples of policies that enhance use of fertilizers to increase the productivity, training on cultivation (e.g. planting and the use of fertilizers), and land preparation, as those that have enable their farming businesses. All farmers consider themselves as the responsible authorities to regulate their cassava farming business.

Gender

All farmers (100%) involve males in their farm business activities, while about 92% of farmers involve females. The average number of females involved in farming activities is 2 females compared to 3 males. The majority of the females and males involved in farming activities are engaged in land preparation, weeding, harvesting and transportation activities.

Institutional support

About 29% of farmers receive financial support, but only 48% of these receive this from formal organizations. Only 3% of farmers are part of farmers' cooperative.

Challenges and opportunities

About 73% of farmers stated that they face challenges in their farming business activities. However, 87% of farmers stated to be able to vision plausible opportunities in the farm business, and solutions against these challenges. Among the pressing challenges mentioned by farmers include lack of credit, expertise, markets, crop seeds, proper policies, planting material, waste dump sites, and proper knowledge on how to manage waste, low soil fertility, and pest and diseases. Some of the solutions to these challenges identified by farmers include improving access to agricultural inputs (e.g. fertilizers and seeds), markets, knowledge on pest and diseases and access to credit, and enabling policy.

In figure 4.158, farmers identified various opportunities that are still prevalent in the cassava value chain in Rwanda, that would enable enhance farmers' returns in the future. Farmers mostly identified cassava's high productivity (37%), good quality of products (29%), and potential high benefits (25%) that would render cassava useable as a cash crop, animal feeds raw material, and a reliable staple food crop – as opportunities upon which farmers could still leverage on in the future.

Cassava middlemen

All middlemen (100%) in the cassava value chain of Rwanda are collectors. All middlemen get their cassava supplies from farmers, but another 33% of middlemen supply cassava to themselves (are also farmers), (Figure 4.53). Interestingly, no middlemen source cassava from farmer cooperatives. This could point to possible tendencies of exploitation of farmers prevalent in the cassava chains, especially for those farmers who are not cooperative members nor selling to cooperatives.

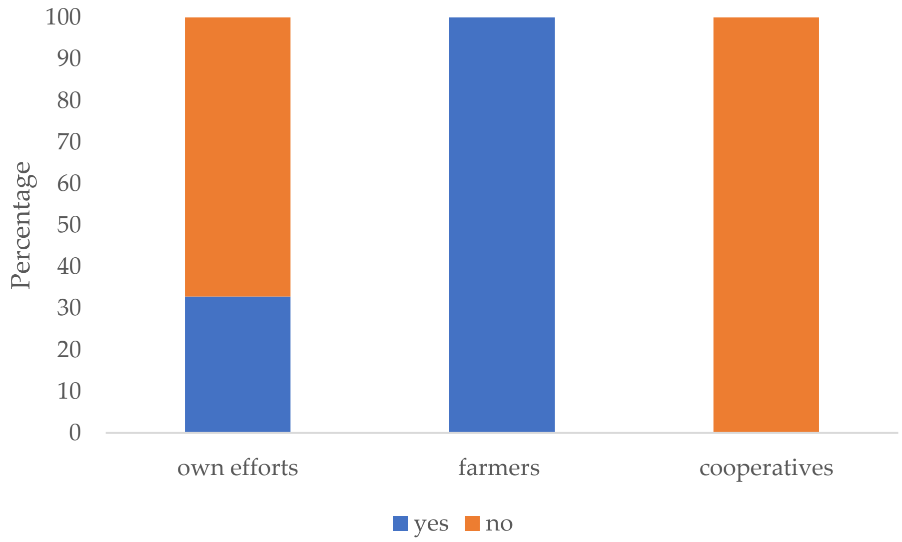

Figure 4.53: Sources where middlemen got their cassava supplies in Rwanda.

On average, each middleman handles (including where middlemen were hired to make deliveries only) about 18,852 kilograms of fresh cassava per season, while 6,425 kilograms of this cassava is successfully traded as own business commodity (treated), (Table 4.24). This implies some middlemen are actually also partially traders.

Table 4.24*:* Quantities of cassava handled and treated by middlemen per season in Rwanda. Source: RUNRES FVC Context study for Rwanda, 2019.

Quantities of cassava	Average (kilograms)
Handled	18,851.8
Treated	6,425.4

The majority of middlemen keep their customers committed by providing a good collection facilities' condition to maintain good product quality (69%), and charging a good price (54%) for the services.

Equipment

About 79% of middlemen have and use their own equipment in handling cassava, but 89% of them use just traditional equipment. This could point to a dire need for innovations that are built with modern expertise, to enhance the value of the cassava handled, and processed by middlemen.

Income and expenses

The average income of middlemen from their cassava business per season is 602 USD, while costs average at 55 USD, (Table 4.25). The average final price per kilogram of cassava handled is 0.12 USD. However, this price is inclusive of those middlemen who are also farmers, and those who are purely (trading collectors), hence it could be slightly deflated, since about 33% of middlemen use an estimated price for the raw materials (these are famers but also middlemen).

Table 4.25. Incomes and costs of middlemen per season in Rwanda. Source: RUNRES FVC Context study for Rwanda, 2019.

Incomes and costs	Average (USD)
Income	602.36
Costs	55.04
Price per kilogram	0.117

About 70% of middlemen indicate that the quality of the cassava they are supplied with, and that of the product they hand over to the next actor in the chain, is good. While the remaining 30% stated that this was instead excellent quality.

Laws and regulations

All middlemen stated that there are no laws and regulations that guide their business, something which could still point to existent gaps around awareness of policies, laws, and regulations. This is something that could hinder business growth for middlemen in Rwanda.

Gender

All middlemen (100%) included males in their business activities, while about 95% of middlemen involved females. An average of 4 females, and males are involved in each middleman's business activities in Rwanda.

From figure 157, indeed the roles of females were quite diverse. However, most females were involved as financier/owner (18%), or in harvesting (17%), or as cleaners (17%), and other activities (20%). Most of the males were involved in transportation (33%), harvesting (23%) or financier/owner (17%).

Market information

The majority of middlemen sold/handed their crops to retailers or consumers. About 60% of middlemen sold their cassava as a peeled dry harvest, or fresh harvest (25%), or as a powder (15%). This still points to large opportunity into processing, and innovations that could aid with processing could earn middlemen better returns. Middlemen used only the person-to-person (95%), and the phone calls (44%) mechanisms to exchange information with their customers. None of middlemen uses internet or mass media like radio or TVs. Therefore, innovations enabling effective, rapid, and timely information exchange could enhance middlemen business activities. Middlemen mostly exchanged information on product attributes like prices, quality, and performance.

Institutional support

About 39% of middlemen received financial support and 88% of these got it from formal institutions. However, none of the middlemen was able to receive any technical support.

Challenges and opportunities

With regards to challenges, 69% of middlemen stated that they face challenges in their business activities, However, 98% of middlemen envisioned opportunities in the business. Key challenges mentioned are lack of markets, lack of credit, transportation difficulties, equipment, and the lack of waste dumping sites. Among the opportunities that could be harnessed around the cassava middleman business are potential high benefit (53%) (cassava could soon have multiple purposes like use in confectionaries and animal feeds production), high demand for its consumption being a traditional staple (22%), and high productivity (19%).

Cassava retailers

All retailers deal in cassava, and most of these (67%) get their raw materials from farmers, as nearly 10% supply themselves (were also farmers) (Figure 4.54).

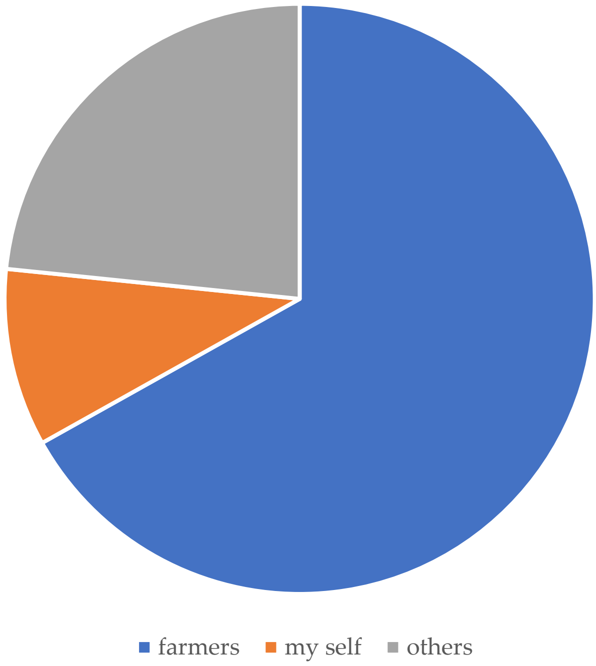

Figure 4.54: Retailers' cassava suppliers in Rwanda

Most retailers are supplied with cassava in the form of dry pellets (61%), or peeled dry harvest (4%), or fresh harvest (2%), and others forms (32%) (Figure 4.55). Most retailers keep their customers committed by ensuring good product performance (65%) and offer these customers a good price (51%). On average, each retailer handles 4,930 kilograms of cassava per season.

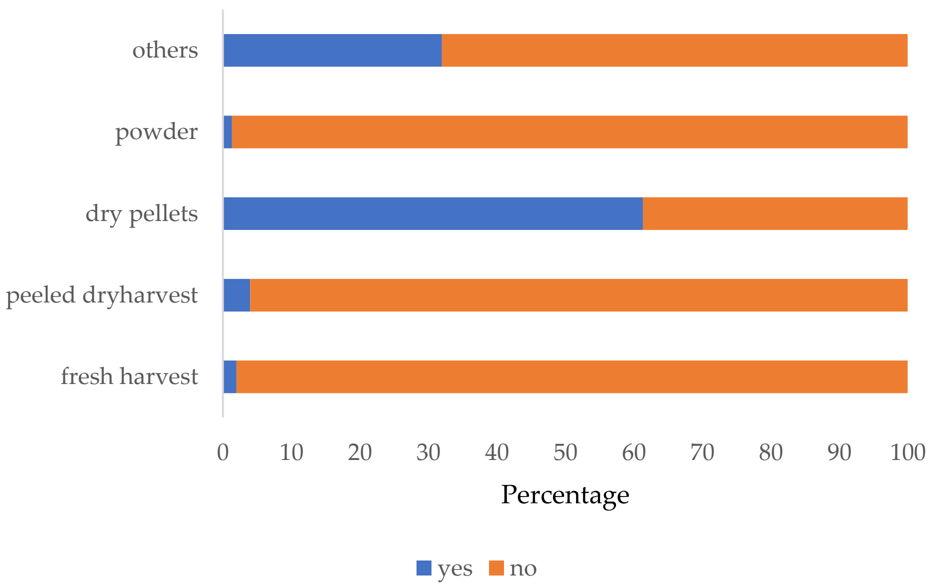

Figure 4.55: Forms in which cassava was received by the retailers in Rwanda.

Equipment

Nearly 92% of retailers have their own equipment for handling their cassava retail businesses.

Incomes and expenses

A retailer on average earns 545 USD per season, while incurring costs of 81 USD (Table 4.26). The average selling retail price per kilogram of cassava is 0.30 USD. About 56% of retailers incur retail business related costs, for instance transportation, licenses, and storage facilities.

Table 4.26. Retailers' incomes, and expenses per season in Rwanda

Incomes and expenses	Average (USD)
Price per kilogram	0.302
Income	544.8
Retail business costs	45.0

Source: RUNRES FVC Context study for Rwanda, 2019

Quality of cassava

Nearly 98% of retailers stated that the quality of the cassava raw material they receive from suppliers, as well as the quality that retailers pass on to the next actor in the chain is at least good (of which slightly over 33% labeled it as excellent quality), (Figure 4.56). This may imply that retailers are comfortable with the quality of available cassava, which may give ground for investment in innovations that could enhance this quality, and hence income returns to chain actors.

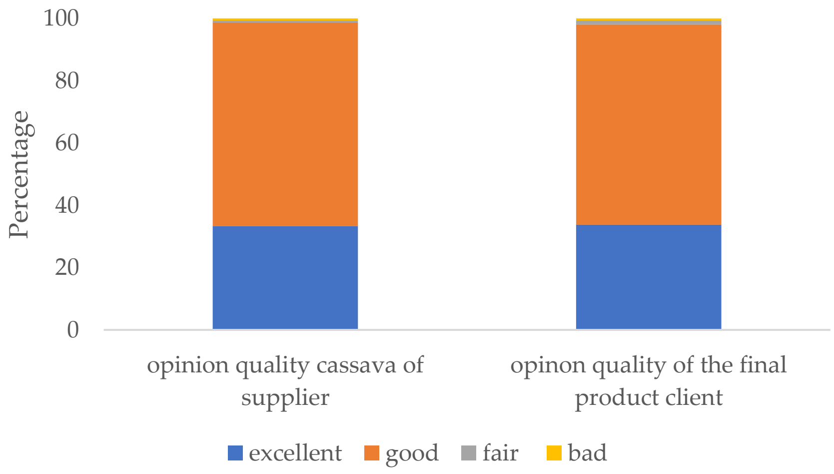

Figure 4.56: Retailers' opinion about cassava quality in Rwanda.

Gender

Retailers slightly employ more males (76%) compared to females (71%) in their business activities. The majority of the females and males are mostly employed as shop attendants or as owner/financier of the business. Males also dominate the transportation activities of the cassava retail business.

Laws, policies and regulations

Only 2% of retailers indicated that they are affected by policies and regulations. This could also point to enormous needs around policy awareness among cassava retailers. Nevertheless, those affected by laws, mentioned the tax law and hygiene, which helps enhance their clientele base as customers would prefer buying from hygienic places.

Markets and information

An average of 63 kilogram of cassava is not sold per retailer per season, mostly due to the deterioration of the cassava quality. This may point to the need for innovative technologies that can improve the quality of the cassava during storage before it is sold. To a lesser extent, lack of market contributes to the unsold cassava quantities. All customers (100%) to retailers are consumers. About 90% of retailers sell cassava flour (powder form) as the final product to their customers or peeled dry pellets (9%). Nearly, 99% of retailers exchange information with the customers via the person-to-person mechanism, and another proportion (52%) use phone calls or SMSs. Retailers as well never use the internet.

Retailers mostly exchange information with customers about cassava attributes, for instance product performance (68%), product prices (53%), and quality (15%), as well as information on arrival of new products (24%). On the other hand, retailers keep their customers committed by ensuring good product performance (87%), offering customers a good price (35%), ensuring good personal relations (9%), and consistent supplies (6%).

Institutional support

Only about 35% of retailers receive financial support for their businesses – and only 56% of these could get such support from formal financial institutions. None of the retailers could access any technical support. This points to areas of need especially with storage expertise, handling, and packaging where effective and appropriate innovations could be used to enhance retailers' returns from the value chain.

Challenges, solutions, and opportunities

About 66% of retailers stated that they face challenge in their business activities, while about 98% still have their sights on opportunities around the cassava retail business. Among the challenges identified are the lack of markets, expertise, proper transportation equipment, and lack of credit. Retailers also suggested solutions that include improving access to markets, transportation equipment, and expert knowledge on proper handling and storage of cassava. Opportunities sighted include high potential to increase raw materials supply, financial capital from investment companies, and potential of good quality products from cassava.

Cassava processors

All processors (100%) in the cassava chain deal in crops. Most of the processors (96%) receive supplies from farmers directly, while 9% of processors are also farmers (self-supply), and 4% are supplied by cooperatives (figure 4.169).

Most processors are supplied with cassava as peeled dry pellets (57%), while another proportion are supplied with fresh harvests (30%), and the least (17%) are supplied with flour (powder form). On average each processor handles about 9,292 kilograms of cassava per season. The largest proportion of processors (87%) keep their suppliers committed by ensuring good quality of the processed cassava, as well as offering good prices (61%) for the raw material. About 90% of the processors own their equipment for processing cassava into other products that they sell to other chain actors.

Incomes and expenses

On average each processor earns 2,354 USD per season, selling at an average price of 0.30 USD per kilogram of processed cassava, and incurring costs of 93 USD on processing services and needs (Table 4.27). However, only 65% of the processors stated that they incur such costs (processing related production costs).

Table 4.27. Processors' incomes, costs, and price per season (6 months) in Rwanda. Source: RUNRES FVC Context study for Rwanda, 2019.

Price, income, and costs	Average (USD)
Price per kilogram	0.300
Income	2,354.2
Production costs	92.59

Most of the expenses are due to transport, licenses and taxes, labor, rent/building, repairs, fuel, communication, and parking costs.

Quality supplied cassava and that of products

All processors (100%) stated that the quality of the raw materials they supply or the products they sell are at least good. Moreover, 38% of processors stated that the quality of raw materials is excellent, while 35% stated that the quality of the processed product is excellent.

Laws, policies, and regulations

Only 13% of the retailers stated that they are impacted by laws, policies, and regulations with regards to guidance of their business activities. This could also point to a lacking awareness with regards to regulations and policies. Among the laws stated to be enabling processing businesses are the hygiene, and price standardization laws. Affected retailers did not cite any regulations that hamper their business activities. Processors consider themselves as the ones that are mandated to formulate laws or norms to regulate their businesses.

Gender

About 39% of processors involve females in their business activities, while the larger proportion (83%) involve males in their processing activities. Most of the females are involved as shop attendants (50%), or financiers/owners (43%). Most of the males (54%) are involved as a financier/owner, but these are also engaged in other activities like transportation, harvesting, and running machines.

Markets and information

All processors sell their products and most of the buyers are also consumers or retailers. Most processors (65%) sell cassava as flour (powder) or other products (30%). This still points to an opportunity for improvement at the processor segment in the cassava value chain and for increased returns to the processors. Most retailers exchange information with clients using the person-to-person mechanism (96%), and only 44% use the phone calls. None of the processors use the internet nor mass media like radios or TVs. The majority of the processors (61%) exchange information with customers about product prices, new arrivals (48%), product performance (44%), and product quality (4%).

Processors ensure that they keep their customers committed by ensuring good product performance (91%), offering good product prices (52%), and ensuring good personal relations (17%).

Institutional support

Only 13% of the processors receive financial support. Interestingly, 66% of those who receive financial support do so through formal institutions. Unfortunately, none of the processors have access to technical support. Yet, technical innovations that can help with more efficient processing mechanisms, as well as handling and packaging of processed products, add value to the final products and enhance business returns to the processors.

Challenges and opportunities

A majority of the processors (61%) stated that they face challenges in their business activities. Interestingly, even a larger proportion of the processors (96%) is confident that there are still opportunities in the cassava processing business. Some of the challenges mentioned are lack of effective pest and disease management, proper processing and transport equipment, and proper seeds among others. Processors suggested solutions to these challenges which include improving access to proper knowledge on pest and disease management (54%), provision of proper transport equipment (15%), and improvements in access to market (15%). Among the opportunities sighted by majority of the processors are high demand of cassava products (38%) that could be used in confectionary industry as well regular flour consumption and good quality of the cassava product (29%).

Waste from processing activities

From Figure 4.57, most processors (52%) dump the solid and liquid waste from their processing activities.

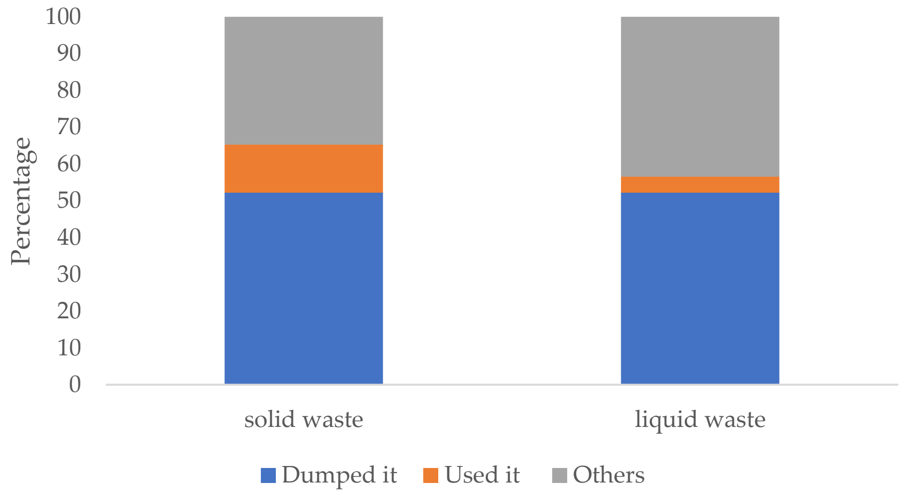

Figure 4.57: End-destination of waste produced by processors in Rwanda.

This is not only dangerous to the environment, since the cassava waste is acidic, but could also deny processors a descent income to improve their net returns from the cassava value chain. Therefore, innovations that could valorize the solid waste into animal feeds or manure, and liquid waste into pesticides or herbicides, could tremendously reduce the risk to the environment, while also enhancing incomes of processors. Interestingly, already 13% and 4% of processors use the solid and liquid waste in their businesses either as fuel for machines or manure in their farms or feeds for their animals.

Cassava wholesalers

All wholesalers are involved in cassava related activities. The average quantity of cassava handled by a wholesaler is 44,667 kilograms per season (Table 4.28). Wholesalers sell each kilogram of cassava for an average price of 0.27 USD and incur costs worth 45% of their average income (8,065 USD). About 83% of wholesalers spend money on wholesale services and costs, averaging to 3,654 USD. Most wholesalers spend on services like storage facilities, transportation, labor, and communication.

Table 4.28. Wholesalers' selling price, incomes, and expenses per season

Quantities, incomes, and expenses	Average (kilograms / USD)
Quantity handled (kilograms)	44,667
Income	8,064.5
Price per kilogram	0.269
Expenses	3,653.8

Source: RUNRES FVC Context study for Rwanda, 2019

Quality of raw materials and products

All wholesalers (100%) agreed that the quality of the raw materials they are supplied with, and the product the wholesalers pass to the next actor in the chain is at least good. Moreover, 42% of wholesalers stated that the quality of raw material is excellent, while 58% stated that the quality of their final product is excellent. This may imply that wholesalers have confidence in cassava handled in the value chain.

Laws, policies and regulations

Only a quarter (25%) of wholesalers stated that they are affected by policies, laws and regulations. This further points to possible needs on policy awareness across the cassava value chain actor segments. Among the policies/laws/norms that wholesalers identified as enabling their business activities are those related to hygiene, certification of product quality, and personal commitments to agreements. Wholesalers identified failure of policies to tame price fluctuation as hampering to their business activities. Wholesalers however, consider themselves as the responsible party to make laws regulating their business.

Gender

All wholesalers use males in their business activities, and about 83% of wholesalers also engage females. On average, there are ten females in a business where females are engaged, while males are seven. Interestingly, the largest proportion of females involved in the cassava wholesale business (53%) are engaged as financiers/owners, and a sizeable proportion (27%) are engaged as shop attendants. Males are engaged in various cassava wholesale business activities, but mostly also as financiers/owners (38%), shop attendants (19%), brokers (10%), running machines (5%), and other activities (29%). However, the large proportions of financiers/owners could still point to existence of small-scale wholesale activities that are dominated by small companies whose activities are largely run by their owners. Therefore, innovations that could scale up operations to accommodate more youths or women as employees in the wholesale business would be helpful.

Markets and information

About 58% of wholesalers do not sell all their cassava (an average of 720 kilograms) due to heavy rains, bad storage facilities, quality going bad during transportation or storage, and sometimes lack of customers. Most wholesalers sell their cassava to retailers and consumers, and rarely to other wholesalers. About 53% of wholesalers sell their cassava as a flour product, while others (47%) sell it as dry pellets. This points to the need for innovations that can add and improve value of the final product sold by wholesalers to enhance returns to actors. All wholesalers (100%) share information with customers by phone calls, while about 83% use the person-to-person mechanism. Although there is no use of the internet, at least the radio/TVs are used by about 17% of wholesalers.

Most wholesalers exchanged information with their customers on product prices (75%), product performance (67%), and available product markets (50%). Wholesalers keep their customers committed by supplying genuine products (50%), offering good product prices (19%), and ensuring consistent supplies (17%). Most wholesalers described their relationship with their customers as (very) good.

Institutional support

Interestingly, nearly 75% of wholesalers could access financial support, 89% of which would be from formal financial institutions. Moreover, unlike other actors in the cassava value chain in Rwanda, 25% of wholesalers could access technical support. This may point to the sizeable capital investment of the wholesalers' businesses that attracts confidence for investment from both financial and technical institutions. However, innovations should also be in place to enable a secure financial and technical support access by other actors in the chain to improve business efficiency, and add better value addition to all products at each chain segment for better economic gains to the respective actors.

Moreover, all wholesalers (100%) that receive technical support, do so through government institutions and international NGO's. This could point to viable public-private partnerships that may be necessary in upscaling cassava wholesale businesses and that only need to be well facilitated to achieve their maximum potential.

Challenges, solutions, and opportunities

Only 17% of wholesalers stated that they face challenges in their business activities. Among the challenges are the lack of substantial financial capital for investments, limited means of product transportation, and delayed payment for supplied products to customers. Wholesalers also mentioned environmental related barriers, such as low quality of cassava during rainy seasons, lack of proper drying, and storage facilities during rainy seasons. Some of the solutions identified by wholesalers against these challenges include facilitated access to drying equipment, financial capital, and competitive markets. Wholesalers also emphasized the need for law enforcement towards payments of their supplied products, or innovations that could enhance efficient and timely delivery and payment systems for supplied products. Wholesalers also identified opportunities around the cassava wholesale businesses such as valorization of cassava peels, low cost and readily available raw materials, and high demand for cassava products.

Waste from wholesale activities

All wholesalers (100%) generate solid waste, while a smaller proportion (58%) generate liquid waste. Unfortunately, all liquid waste (100%) is dumped in open dumpsites without treatment or processing, thus exposing the environment to a toxic and acidic liquid waste. Also, 25% of the solid waste is simply dumped in open sites (Figure 4.76). However, some wholesalers instead recycle the solid waste to some other useable products. For instance, animal feeds (50%), and compost manure (25%). Therefore, innovations that could valorize this waste could help protect the environment from toxic residues, while also enhancing household incomes for wholesalers.

4.4 Msunduzi, South Africa

5 Waste Stream Mapping

Acronyms and abbreviations

ABM	Area Based Management
CMS	Content Matter Specialist
EDTEA	Economic Development, Tourism and Environmental Affairs
FGD	Focus Group Discussions
IDP	Integrated Development Plan
IP	Innovation plan
MDB	Municipal Demarcations Board
MRF	Materials recovery facility
MSWM	Municipal Solid Waste Management
NDP	National Development Plan
NERL	New England Landfill Site
NEMA	National Environmental Management Act
SSI	Semi Structured Interview
SMME	Small Medium and Micro Enterprise
VIP	Ventilated Improved Pit
UDM	uMgungundlovu District Municipality
WBMU	Waste Management Business Unit
WWTP	Wastewater Treatment Plant

5.1 Bukavu, Democratic Republic of the Congo

Data collection and methodology

Key persons or stakeholders involved in waste management was contacted for an interview. These include representatives from the municipality, those of the Ministry of the Environment, as well as the agents of National and international NGOs (Mercy Corps, FAO, etc.) working in the field of waste management. The emphasis was more on the partners of the RUNRES project with whom we conducted interviews (CMS) and focus groups. In addition, for each innovation plan (IP,) 4 focus groups were organized with the 4 member organizations of each IP. These include 2 organizations that collect / evacuate waste, 1 organization that recovers (transformation) waste, and a coffee cooperative whose members use the end product (compost) of waste processing in agricultural production. 6 to 10 people were selected by each organization to participate to the focus group discussion. The DRC RUNRES project coordinator. who has a good understanding of the actors involved in waste management in the city of Bukavu and whose position has facilitated access to the information necessary for this study, conducted this field work.

Solid waste management and collection

Waste management remains a very critical problem in the city of Bukavu. Despite many initiatives initiated by local authorities, civil society, and other organizations working in the field of management and recovery of waste, the problem continues to worsen. According to interviews conducted with municipal experts, 15 volunteer organizations are committed to collecting and transporting the waste produced in the city. These organizations together are capable of mobilizing only 23 trucks with a total capacity of 6 tons (Figure 5.1).

Figure 5.1: Municipal dump truck offloading solid waste at the Elakat/Bagira Dumpsite.

Best estimates indicate that, of the total amount of waste generated within the city-region, roughly 12.5% is collected and transported to the two officially recognized final dumps (Elakat and Bagira). Although some collection and valorization of the waste is done by scavengers at the dumpsite, most of the waste that does make it to the landfills is left to accumulate on site. Consequently, the official landfills are overburdened, and residents of the city region turn to a variety of informal dumping sites: roads, markets, trails, neighbors' plots, rivers, lakes, wells, abandoned buildings, the roofs of other people's homes. Of particular concern is the regular use of coastal areas as a dumping ground.

Officially, the Bukavu city has only two final dumps, Elakat and Bagira, that are supposed to receive all the waste generated in the city. However, in addition to these official dumps, there are dozens of other unofficial dumps (Figure 5.2 & Figure 5.4) located throughout the city where households that are not subscribed to waste collection and disposal services deposit their garbage at night. Furthermore, this phenomenon becomes more pronounced during the dry season because the rains during this period allow these individuals to unload their garbage cans and throw their waste in the canals (Figure 5.3) whose courses in the Ruzizi river and Lake Kivu.

Figure 5.2: unofficial dumpsite at the Mashinji market.

Figure 5.3: city canal used to transport wastes away from households

Generation and composition

Based on recent data, the city of Bukavu produces more than 600 tons of waste daily, from which around 70 tons comes from households (2.7kg per day per HH) and 530 tons from urban markets. From these 600 tons, 93% is biodegradable (Balagizi et al, 2011; Bisimwa et al, 2013). The main sources of waste are food markets, households, restaurants, and food depots, or shops.

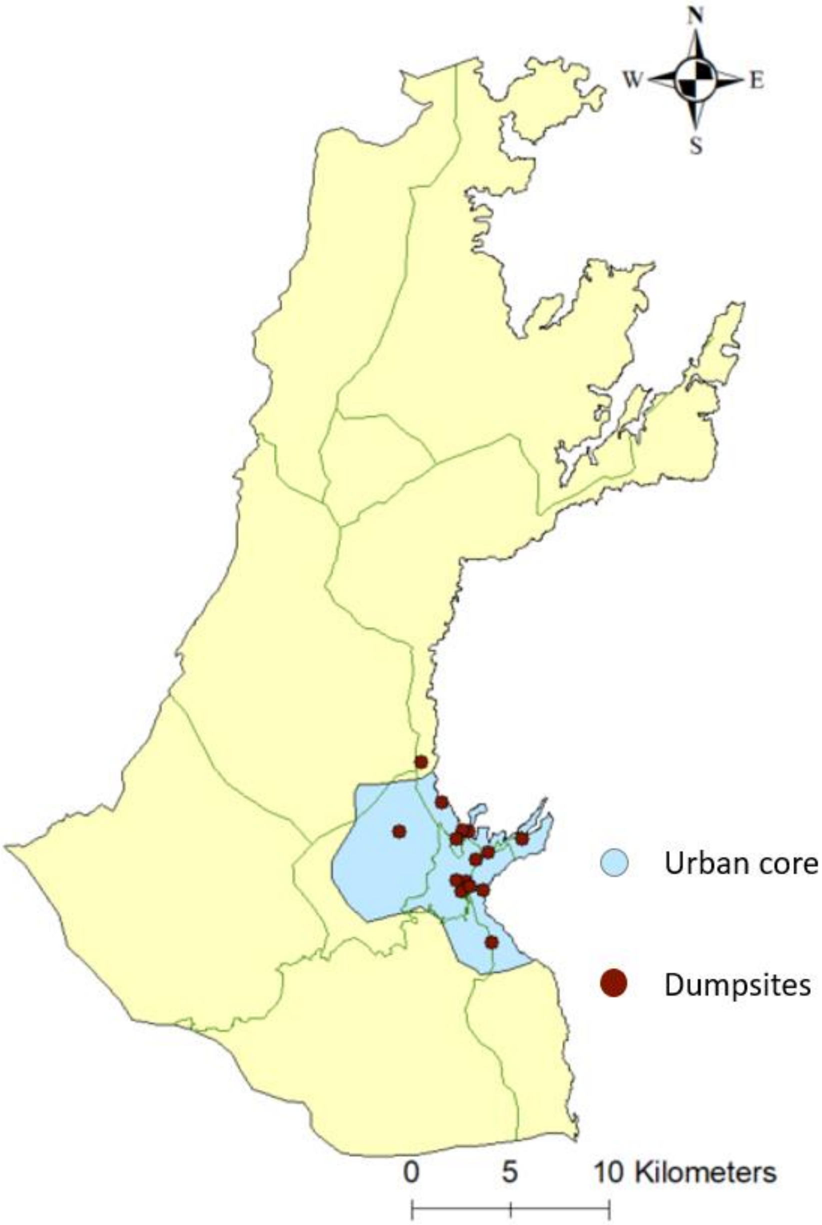

Figure 5.4: Informal and formal dumpsites located within the urban core of the Bukavu city-region.

Human waste management

Sanitation policies in Bukavu and the DRC

As said previously, laws regulating the management of human waste exist as well, but the problem is in the application of these laws.

Among these are:

Ordinance N 74-345 on public hygiene in urban areas at his art. 3 and 4

Art 3.

1 ° every dwelling, store, workshop, site, office or any other establishment must be provided with sanitary and suitable toilets. By dwelling is meant the premises occupied by a single family.

2 ° in towns and urban districts and near factories, construction sites, counters, workshops, offices, heads of industry or trading house must also establish latrines for the use of their servants and workers.

> *The latrines will be established under the conditions prescribed by the ordinances regulating the constructions in the cities and the urban districts.*
>
> *The emptying will be removed and buried or dumped under the conditions to be determined by the local territorial authority.*

Art 4 : When a water distribution network operates, only the use of flushing latrines connected to septic purification tanks, to the collectors of a purification station or to the public sewer network is authorized when the latter is was established according to the sewerage system.

> *Latrines, septic purification tanks and purification devices can only be built after approval of the plans and devices by the technical direction of hygiene works at the provincial capital or by the local public hygiene service.*

The current sanitation landscape

Human waste generation

Collection, treatment, disposal

Rural areas

Generally, traditional (pit) toilets are commonly used by more than 96% of households, the choice of this system is motivated by several factors including:

- Lack of an adequate water supply system to operate the modern toilet system
- Limited resources to buy and build modern toilets
- No space problem as is the case in urban areas
- Habit

We can point out the presence and use of some modern toilets in hotels and in the houses of certain executives and notable of the village as well. However, the proportion of residents in these areas that use waterborne sanitation is negligible.

Urban areas (Bukavu)

The situation is a bit complex, however, as can be seen in the figure below, three systems have been identified including:

- Modern toilets (septic tank) that are primarily used in the municipality of Ibanda (town center)
- Traditional toilets (pit) that are utilized in the communes of Kadutu and Bagira (the peripheries of Bukavu city).
- Toilets connected to the rivers and whose destination is Lake Kivu and the Ruzizi River. This last system is mostly used in the communes of Kadutu and Bagira, and dominates the two preceding systems (modern and traditional).

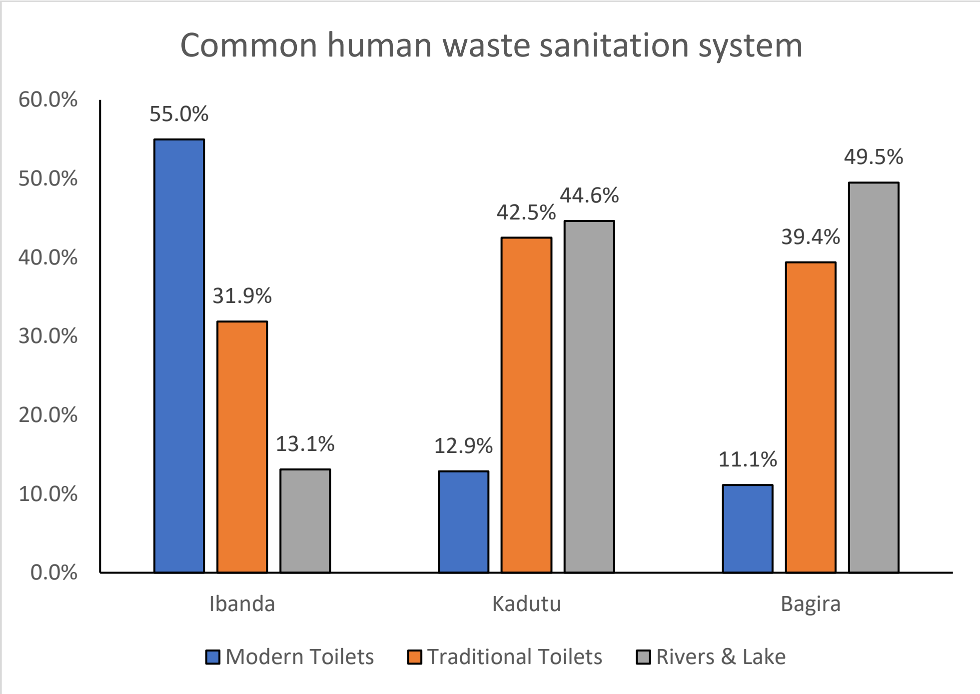

Figure 5.5: sanitation technologies utilized within the urban sectors of the Bukavu city-region.

When asked whether the system adopted by the users is adequate or not, more than 63% indicated no in the city (Bukavu), while 50% did so in the village (Kabare) (Figure 5.6). As for possible changes or improvements to the existing system, the respondents shared that between the people of the city and those of the rural environment (Kabare) they only wish to see a simple improvement of the construction (method and material), and improved maintenance of their traditional system (pit toilet), rather than to completely change the system as the people who live in the city (Bukavu) wish. The Kabare people's position on system change is more supported by the fact that the modern system is not suited to their socio-economic conditions (water and resources).

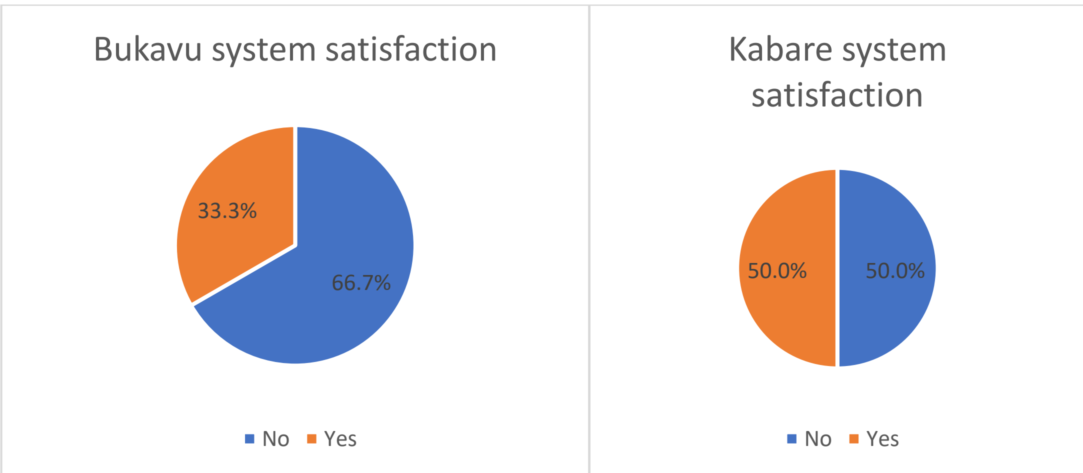

Figure 5.6: satisfaction with the existing sanitation systems utilized within the Bukavu city-region.

The respondents also noted that 95.8% of households are responsible for the maintenance of their toilets, and only 4% of the sanitation facilities are maintained by the municipality (emptying of septic tanks in town for example) intervention (Figure 5.7). Because of this lack of state support, there is a great deal of variability in how and when sanitation facilities are maintained. This not only exposes the environment to pollution, but also the human health of users and neighbors to disease. In towns and villages alike, environmental officers often pass to make sure that each household is maintaining well its toilet, but they have no enforcement capacity.

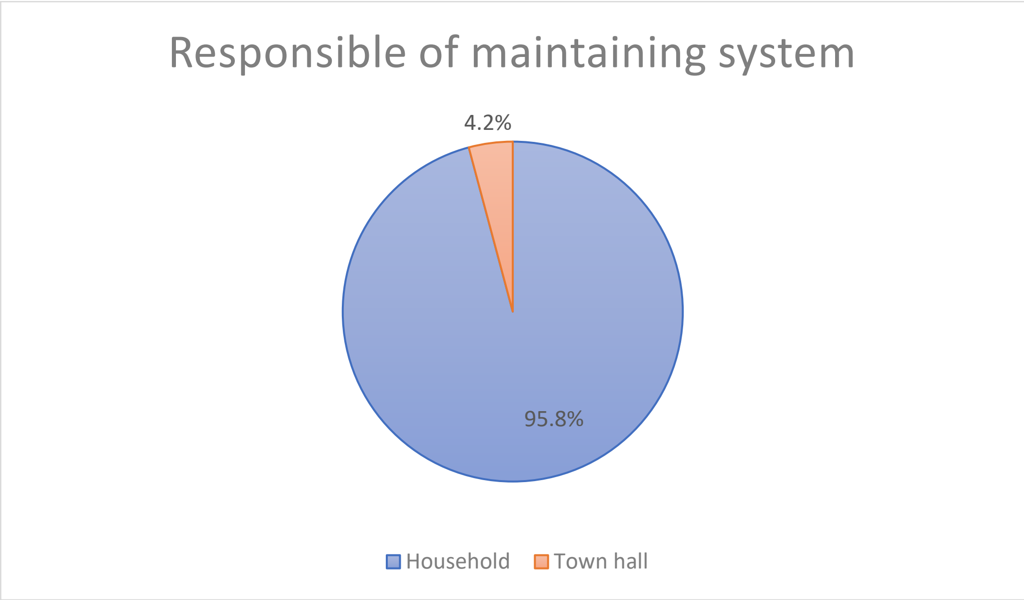

Figure 5.7: responsibility for sanitation system maintenance.

General conclusions

The following points represent the key takeaways of the WSM work:

- The municipality currently suffers from a lack of a coherent solid and liquid waste management policy.
- There is a lack of awareness by the public about the human and environmental health risks posed by the current sanitation system.
- The spreading of waste without any sanitation measures or initiatives to create jobs on waste does occur.
- Overpopulation affects the logical choice of habitable sites and worthy construction.
- Systematic deforestation for the creation of plots is very widespread.

- The density of households makes it difficult to create the internal capacity for waste and wastewater management.
- The occurrence of landslides, fires and erosions that wash away houses and their inhabitants occurs regularly, making investment difficult.
- Dumps located at the level of each household are irregularly emptied and refuse is dumped in pipes in public places, roads, streets, rivers. This practice is a violation of the legal texts in force in the country.
- Public dumpsites are almost non-existent, and those located in certain municipalities are neither maintained nor emptied. They thus become foul-smelling sites and sources of often serious diseases.
- Wastewater comes from broken or clogged sewers, non-emptied septic tanks, and full toilets not unloaded because of the small size of family plots. This water regularly spreads onto the streets and the roads.
- Drinking water supply points are insufficient or even non-existent in certain districts of the city.
- Latrines are typically not emptied and poorly constructed.
- Excrement litters the streets and the drains, the flies swarm everywhere, and bushes are often used as a location for defecation.
- Many locations exist for breeding grounds for mosquitoes, which are vectors of malaria

5.2 Arba Minch, Ethiopia

Methodology

Both qualitative primary and quantitative secondary data were collected from the Arba Minch city-region using protocols developed by RUNRES scientists. RUNRES scientists collected data in Ethiopia through community level focus group discussions (FGD), as well as with content matter specialist (CMS) interviews. Specifically, acommunity level FGD was held in an urban area (Sikela Sub-city), peri-urban area (Shara Kebele), and rural area (Lante Kebele) within the city-region. In addition, RUNRES team members interviewed six local content matter specialists to understand the waste management system (Table 5.1).

Table 5.1: List of waste management stakeholders and key informants identified and interviewed for this report.

Name and Surname	Organization	Expertise	Role along value chain
Mr. Endirias Olto (MSc)	Arba Minch Municipality office	Environmental health officer	Coordination of improved sanitation value chain activity implementation
Kinfe Kassa (PhD-Associate professor)	Arba Minch University	Environmental Engineer	Capacity building of experts and consultancy service
Mr. Tamirat Tadesse (BSc.)	Arba Minch city administration Sikela sub-city	Green area development and beautification	Monitoring solid waste management and sanitation improvement
Mr. Gedemu Shambel (BSc)	Arba Minch city administration Sikela sub-city	Green area development and beautification	Monitoring solid waste management and sanitation improvement
Ms. Brihane Girma (BSc)	Arba Minch city administration Sikela sub-city	Green area development and beautification	Monitoring solid waste management and sanitation improvement
Mr. Firew Ayele (MSc)	Arba Minch city Water supply and Sewerage Enterprise	Water supply and Sanitation engineer	Monitoring drinking water distribution and sewerage management of the city

Secondary data were also collected and utilized to support this study and municipal reports from the Arba Minch municipal office of water supply and sewerage were used to triangulate collected data. The collected data were analyzed using descriptive statistics.

Solid waste management and collection

Waste management actors

Municipal solid waste in Arba Minch town is generated primarily from residents (households) and commercial centers such as supermarkets, market places, shops, cafes, restaurants and hotels. Stakeholders in the local waste management sector range from single households to large institutions and each stakeholder performs different activities within the sector. Based on the results of the FGDs and CMS interviews, the key actors within the solid waste management chain in Arba Minch can be broken down as follows:

1. **Urban residents/individual households:** residents/households can be either single or multifamily dwellings. Solid waste generation at this scale encompasses those activities in which materials are identified as no longer being of value and are either thrown away or gathered for disposal. The most common sources of resident/household solid waste are waste generation through the handling and use of food waste, paper, cardboard, plastics, textiles, yard wastes, wood, glass, or ashes. Each household puts its generated waste in sacks outside the compound for collection.
2. **Commercial Enterprise:** In the case of Arba Minch, commercial centers range from small shops to large international hotels and lodges. They generate solid waste from a variety of sources: paper, cardboard, plastics, wood, food waste, glass, metals, special wastes, and hazardous waste. All of this is stored either in the municipal commercial center or in a common area arranged by the private sector and utilized for temporary solid waste collection. As with the households, all the waste is transported using sacks carried by donkey carts.
3. **Waste collectors:** in Arba Minch town there are eight waste collector associations (Table 5.2) that can best be characterized as micro and small scale enterprises organized by each sub-city's municipal office of Green Area Development and Beautification. These micro and small waste collector enterprises collect from each household door-to-door, clean roadsides where they are assigned, and also collect solid wastes from commercial centers like cafes, supermarkets, restaurants and hotels and transport this material to short term waste transfer sites.

Table 5.2: List of waste collection associations, their area of responsibility, and the population they serve.

Waste collection association	Sub-city	Total number of households per sub-city
Wubet le Arba Minch	Secha sub-city	
Fox	Secha sub-city	12,592
Endodi	Nechi Sari sub-city	
Lemlem	Nechi Sari sub-city	2,402
Getayalew	Sikela sub-city	
Enberta	Sikela sub-city	5,578
Tesfa	Abaya sub-city	
Lewut Lediget	Abaya sub-city	4,735

4. **Waste Separators:** In Arba Minch, waste separators are those scavengers who separate recyclable materials like metals and plastic materials from solid waste dumped in the short-term waste transfer sites of the four sub-cities, as well as at the Sira dumpsite. This scavenged waste is then sold to roaming waste buyers or "*korallew*." Once purchased from the scavengers, these buyers collect and arrange them separately based waste type. Once a large enough quantity of a specific material is collected, it is loaded onto trucks and transported to Addis Ababa and other big cities, where it is sold to industries for recycling and reuse.
5. **Municipal services:** The Arba Minch municipality office of infrastructure development and beautification has green area development and beautification work projects. Through these projects, the municipality office dump truck loads all solid waste stored at temporary waste transfer sites and transports this waste to the permitted solid waste dumping area, known as the Sira solid waste dumping site.
6. **Farmers/agricultural commodity producers**: Within the Arba Minch city region many agricultural commodity producers ranging in scale from small to large-scale producers exist. Through these activities, both marketable (useful/edible/marketable) and non-marketable (waste) products are created. Examples of agricultural solid waste generated within agricultural zones of the city region are animal manure, slaughterhouse waste, spoiled food waste, unused agricultural biomass (leaves, stems, etc.) and unused chemical wastes (pesticides, herbicides, fungicides). Typically, the organic waste generated by agricultural producers is either burned or used as a soil amendment.

Waste disposal regulatory framework

The primary objective of municipal solid waste management (MSWM) is to protect the health of the population, promote environmental quality, develop sustainability, and provide support to economic productivity. To meet these goals, sustainable solid waste management systems must be embraced fully by local authorities in collaboration with both the public and private sectors (Henry et al., 2006). While Federal Democratic Republic of Ethiopia Solid Waste Management Proclamation ensures decentralization of responsibilities among different levels of administrative bodies, Article 5 of Solid Waste Management Proclamation No.513 /2007 deals specifically with solid waste management planning. Sub-article 1 of Article 5 states that "urban administrations shall ensure the participation of the lowest administrative levels and their respective local communities in designing and implementing their respective solid waste management plans."

In addition, sub-article 4 states that the responsibilities of MSWM is the responsibility of the lowest administrative units. According to Article 5 of sub-article 4, the following responsibilities could be transferred to lowest administrative bodies: formulation and implementation of action plans on solid waste management; ensuring the installation of marked waste bins by streets and in other public places; ensuring the collection of solid wastes from waste bins with sufficient frequency to prevent overflow; planning and carrying out awareness raising activities; public and ensuring that measures are taken to prevent pollution arising from the mishandling of solid wastes.

In Arba Minch the authority and organizational structure of waste management responsibility fall within the following state offices: Urban Development and Construction Minister, Regional Office of Urban Development and Construction, Zonal Urban Development and Construction Department, Municipality office Sanitation, Beautification and Greenery development department, Sub-city Sanitation, beautification and greenery development work process.

Accordingly, Arba Minch city administration has four Sub-cities namely; Secha, Nechi sar, Sikela and Abaya, while each sub-city has their own municipality at the sub-city level. Under each sub-city there are sanitation, beautification and greenery development work processes. Therefore, sub-cities sanitation, beautification and greenery development work process is responsible for planning daily, monthly and quarterly activities stemming from Arba Minch Municipal office sanitation, beautification and greenery development department, monitoring routine waste management activities and reporting daily, monthly and quarterly activities to Arba Minch Municipality office Sanitation, beautification and greenery development department head. Also, the Arba Minch Municipality office sanitation, beautification, and greenery development office has the responsibility for capacity building training, supply waste management related input (like safety equipment and scheduling waste loading truck), preparing and paying street cleaning costs, and reporting to zonal Urban Development and Construction Department.

Waste Disposal

Dumpsite locations & transfer points

In Arba Minch solid municipal waste is collected from households and markets by donkey carts managed by waste collection associations. This waste is carted to temporary dumpsites located within the urban core, then collected and transported via municipal dump truck to the Sira dumpsite (Figure 5.8). A flowchart of the organizational framework that facilitates solid waste management in Arba Minch, as well as a diagram indicating the estimated volumes of waste collected across the city region on a yearly basis can be found in Figure 5.9 and Figure 5.10 below.

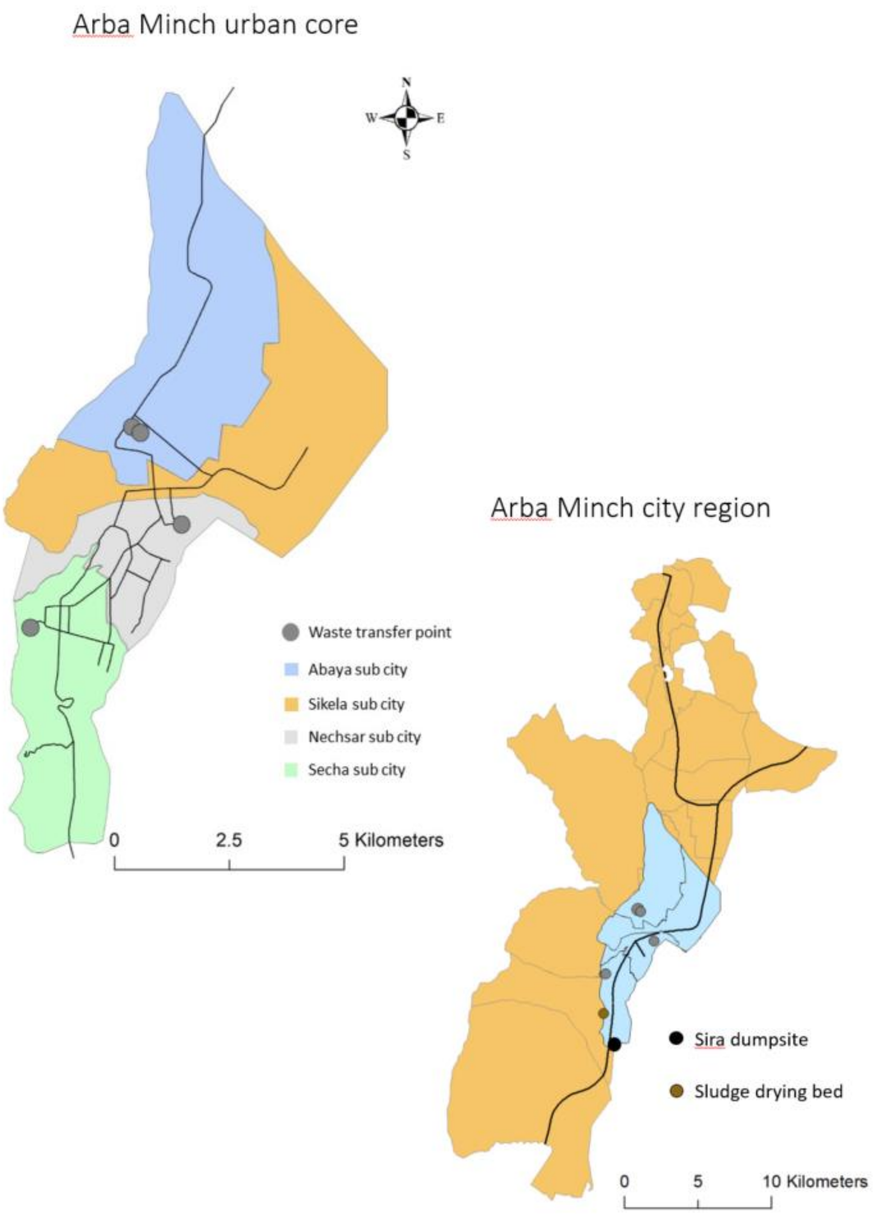

Figure 5.8: Key waste transfer points and management sites within the Arba Minch town. (GIS spatial data obtained from Arba Minch municipality.

Quantity and Composition of City -Region Waste

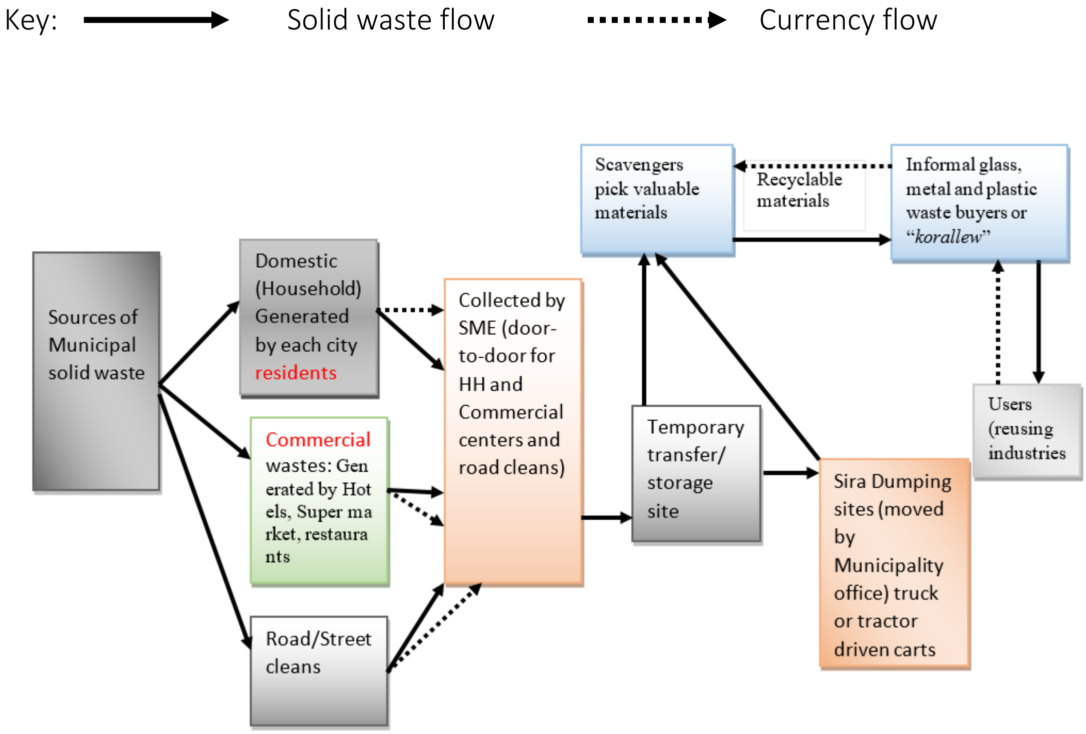

Figure 5.9: waste value chain stakeholder and commodity flow. Based on data collected from CMS and FGD participants 2020.

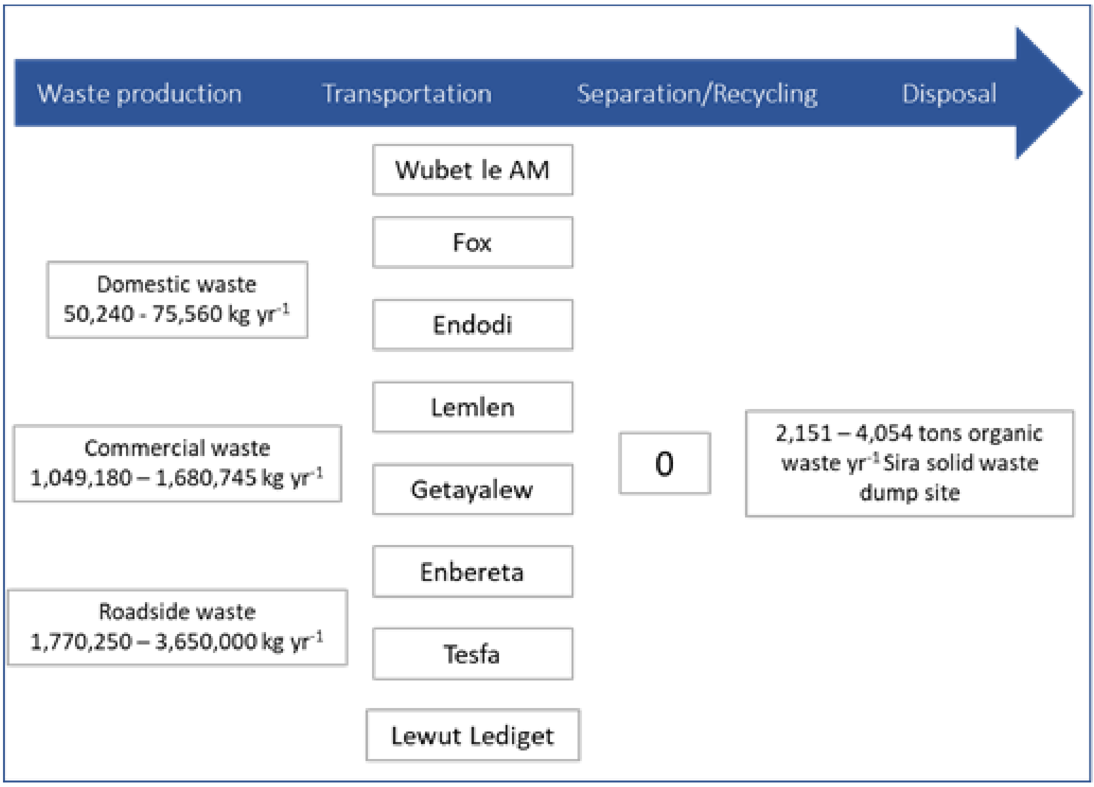

Figure 5.10: Solid waste flows across the Arba Minch city. Production volumes include inorganic and organic. The volumes given for organic waste disposal assume 75 % organic waste composition.

Constraints for Change

Collection and transportation

Poor collection rates associated with transportation of waste were the main problems identified by focus group discussion participants and waste collector SME. Focus group discussion participants said that waste collectors and transporters do not collect all residents' waste, therefore people resort to informal solutions such as throwing their waste in gorges, ditches and roadsides. Also, waste collectors agreed that this is the case because they use donkey carts to collect solid waste from door-to-door, therefore they are unable to meet current demand. Furthermore, they expressed that the municipal office waste transportation vehicle is old and unable to pick waste stored/collect in temporary transfer sites. In general, the municipal office also agreed that there are not enough vehicles and the vehicle that are available are not in good condition. Finally, payment (income earned) from waste collection is too small and those waste collector SME members do not earn enough for their basic needs.

Cultural barriers

During the interview period all waste collecting SME members identified three main problems as cultural barriers for effective waste management value chain performance. These are: (1) weak public awareness about the need to sort and properly store the waste before collecting it in appropriate containers (2) the absence of waste separation (organic vs. inorganic, hazardous, etc. waste) at the household storage level, and (3) poor waste disposal practice and systems, i.e. dumping on street sides, drainage lines/ditches, open spaces, river banks and other inappropriate locations.

Findings from the FGDs and SSIs indicate that a major challenge for waste valorization in Arba Minch stems from the lack of inorganic and organic waste separation. Mixing these waste streams at the source (household and commercial centers) makes it more difficult to isolate and collect the various waste streams. Previous attempts to valorize organic waste through composting processes found that the time necessary to separate inorganic waste to have quality inputs was ineffective and was a principle cause past failure. There is general agreement among local waste management exerts that a necessary step to support waste valorization is a waste collection system that supports the separation various waste streams before they are mixed.

In addition, the current reliance on donkey carts (Figure 5.11) to collect waste from households and commercial centers to intermediate transfer points is a constraint that was mentioned several times. These actors made it clear that investment in faster transportation would improve their capacity to collect waste generated across the city.

Figure 5.11: waste collected with donkeys and transported to an intermediate transfer point.

Human waste management

Water and sanitation overview

According to a report conducted by the Arba Minch town water supply and sewerage enterprise (Arba Minch Municipal Report, 2019), the source of the municipal water system comes from a combination of spring water and borehole water. The spring discharges 95 L s^{-1} and the boreholes discharge 75 L s^{-1}. The volume of daily water generation supplied from these sources is estimated at 9,875 m^3 day^{-1}.

Regarding sanitation, virtually the entire population in Arba Minch city region uses on-site sanitation facilities. According to the Arba Minch town Health office and Arba Minch town water supply and sewerage enterprise, the two most common toilet types are dry pit latrines and ventilated improved pit latrines (VIP). Taken together, these systems are utilized by ~99 % of the residents of Arba Minch (Table 5.3). In addition, a very small percentage (<1.0%) use either urine diversion dry toilets or flush toilets connected to onsite septic tanks.

Table 5.3: Toilet types and distribution in Arba Minch Town

Type of toilet	Population	%
Dry pit latrine	172320	86
Ventilated Improved Pit Latrine (VIP)	26849	13
Urine Diversion Dry Toilet	60	0.3
Flush toilet to septic	500	0.25
	199729	100

Source: Arba Minch Water Supply and Sewerage Service Enterprises, 2019

In urban and peri-urban areas of the city-region, pit-latrines are either used privately by single-family households or are shared among several households. In rural areas, most households have their own pit latrine or simply rely on open defecation. Focus group participants interviewed for this report indicated that the private pit-latrines are mostly clean and well maintained. Shared pit-latrines, however, are often in poor condition, over-used, and often impossible to clean. This type of facility is most common in government owned houses distributed for low income earning community groups. In these communities, 2-6 households typically use one latrine.

According to the focus group participants interviewed for this report, dry latrine toilet construction is cheaper and requires less maintenance costs than other alternatives. For the most part, the provision of sanitation facilities is up to the individual citizen/property owner. However, for low-income communities in the urban zones of the city-region, the municipality does directly support the construction of communal pit latrines. Populations with no facilities, such as the homeless, a large number of whom live along the Kulfo riverbank, typically resort to open defecation at river banks/edges, ditches, bushes, roadsides and corners.

Sanitation actors

Public Sector

In the Arba Minch city region sanitation services is provided by a mix of public and private sector actors. The Arba Minch City administration municipal office is responsible for solid waste management, while Arba Minch water supply and Sewerage office is responsible for drinking water supply and sewerage management. In addition to being responsible for the provision and maintenance of areas of the sanitation system, the public sector is responsible for ensuring that existing sanitation service standards are enforced.

Private sector

Although pit latrines are the dominant toilet type used in Arba Minch, flush toilets connected to onsite septic tanks do exist. These systems are supported primarily by the following private sector companies:

1) Tirig (Ezana Hotel)
2) Tourist hotel sanitation service
3) Décor liquid waste removal service
4) Tsidat liquid waste removal service
5) AMU vacuum truck service

With the exception of the AMU vacuum truck service, which maintains the University's sanitation system, septic tank emptying is conducted by private enterprise. Together, these agencies maintain a fleet of 19 vacuum trucks. For a private company to engage in this sector, it must be licensed through the Water Supply and Sewerage Enterprise Office. The capacity of these private vehicles ranges from 1,200- 10,000 liters per truck.

Quantity, composition, and disposal of city-region human waste

The sanitation demands and increased human excreta generation are driven by increasing population. In Africa the fecal matter generation rate is 128 grams person^{-1} day^{-1} while urine is 1.42 L person^{-1} day^{-1} (Rose, et al. 2015). Thus, in Arba Minch, a city-region with a population of 221,677, generates approximately 10,356 tons year^{-1} (fecal matter) and 115 Megaliters of urine year^{-1}. With roughly 99% of the residents of the city region utilizing some variation of pit latrines in the household, most of this waste is stored onsite in the pits. However, a small number of residents, as well as every major hotel and the University (Table 5.4), utilize flush toilets connected to septic tanks. Taken together, the volume of black water collected within the Arba Minch city region is roughly 32 megaliters year^{-1}. Of this total, 63% is produced by AMU, 23% by private households, and 14% is produced by the large hotels (Figure 5.13). This waste is transported daily to the Sira dumping site (Figure 5.12).

Table 5.4: septic tank companies, clients

Sanitation Company	Client Institution	Disposal site	Liters year^{-1}
Tirig	Paradise lodge	Farm use	1,728,000
Tirig	Haile resort	Sile waste disposal site	1,728,000
Tirig	Bekele Molla	Sile waste disposal site	4,800
Tirig	Mora heights lodge	Sile waste disposal site	576,000
Tirig	Ezana hotel	Sile waste disposal site	57,600
Tirig	Romi hotel	Sile waste disposal site	86,400
Tourist hotel sanitation service	Tourist hotel	Sile waste disposal site and Farm use	230,400
Tourist hotel sanitation service	Lamba dina hotel	Sile waste disposal site	115,200
Décor liquid waste removal service	Private residents	Sile waste disposal site	3,650,000
Tsidat liquid waste service	Private residents	Sile waste disposal site	3,650,000
AMU vaccum service	AMU campuses	Sile waste disposal site	20,160,000

Figure 5.12: Untreated effluent dumped by a vacuum trip at the Sira dumpsite (left). One of 19 vacuum trucks operating in the Arba Minch city region (right).

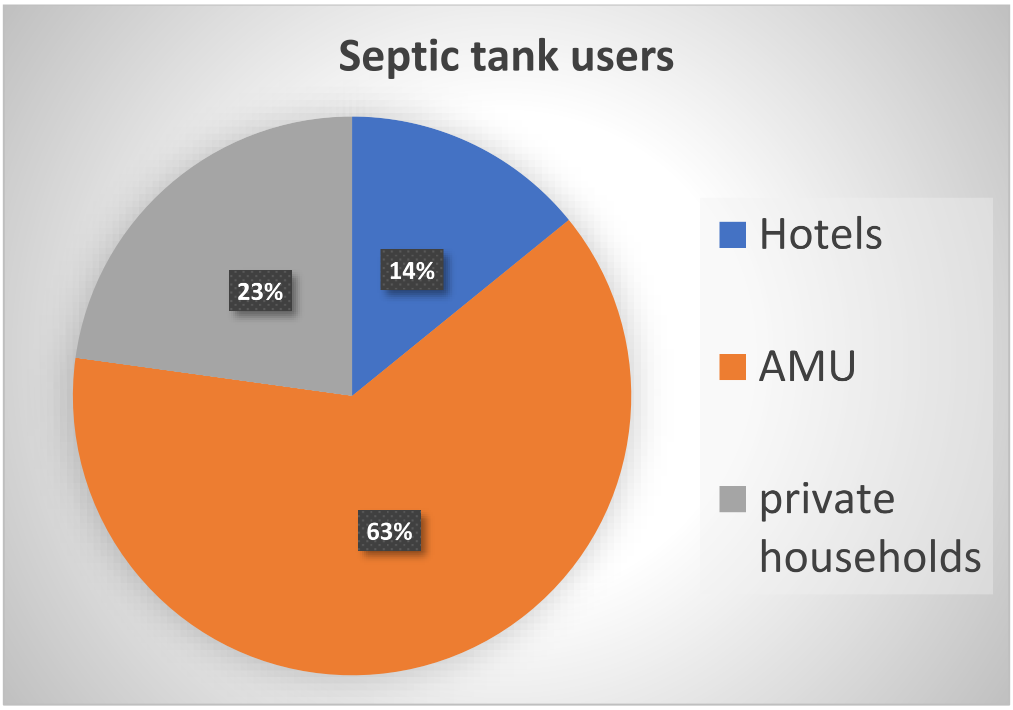

Figure 5.13: proportions of septic tank users within Arba Minch town.

Challenges in human waste management

As discussed above, blackwater collected and emptied from households and commercial organizations is dumped daily at Sira official dumping sites. This effluent is not treated and constitutes a major threat to human and environmental health. According to the Arba Minch Town water supply and sewerage enterprise secondary city project coordinator, Mr. Frew Ayele (Water supply and sewerage enterprise secondary project coordinator) and Mr. Endrias Olto (Municipality office improved sanitation value chain project coordinator) "dumping waste in an open/unprotected dumping area without treatment is considered as open defecation." Thus, none of the waste collected via septic tanks can be considered properly treated.

Focus group discussion participants of urban, peri-urban and rural zones stated that financial limitation is the main problem for the adoption and use of improved sanitation facilities, especially human waste/toilets. FGD participants of Lante and Shara Kebele said that "before three or four years ago government was supplied improved toilet house construction facilities and subsidized bio-gas construction and supplied facilities for bio-gas construction, but today both improved toilet house construction facility supply and bio-gas facilities are not supplied. Bio-gas type toilet house users complained that "there is no expert is sent from government to maintain our bio-gas facilities. Therefore, we are not using bio-gas technology, but obligated to pay all costs associated with the technology".

Also, urban FGD participants stated that sanitation technologies are not economical. Therefore, most low-income earning communities cannot afford it and use traditional sanitation management/treatment methods, specifically closing filled pits and digging new pit latrines. However, they worry about its suitability because there is insufficient land available to build new latrines.

5.3 Kamonyi, Rwanda

Introduction

Kamonyi is a district (akarere) situated in southern province of Rwanda. Its capital is Kamonyi, also sometimes known as Gihinga. It is divided into 12 sectors (imirenge): Gacurabwenge, Karama, Kayenzi, Kayumbu, Mugina, Musambira, Ngamba, Nyamiyaga, Nyarubaka, Rugalika, Rukoma and Runda. The total population, according to 2012 national census, is 340,501, with an average population density of 520/km^2. It covers a total area of 655 km^2.

Data collection and Methodology

The RUNRES team conducted twelve semi-structured interviews with content matter specialists (Table 5.5) that informed this report. In addition, nine focus group sessions were conducted across the city-region to gather community input on the state of waste management within the area. In addition to this primary qualitative data, the project scientists utilized a variety of peer reviewed scientific literature, government reports, and various other grey literature to help understand the current flows of waste within the city region boundary.

Table 5.5: List of waste management stakeholders and key informants identified by the RUNRES core team and attended the kick-off meeting.

Name	Sector	Organisation	Expertise
Charlres Niyonizeye	Karama	Public sector	Social affairs
Uwineza Zam zam	Kayenzi	Public sector	Social affairs
Clementine Gahongayire	Nyamiyaga	Public sector	Social affairs
Andrew Mudagiri	Musambira	Public sector	Social affairs
Alfred Rushirabwoba	Gacurabwenge	Public sector	Social affairs
Mudahemuka Jean Damascene	Nyarubaka	Public sector	Executive secretary
Mukamana Pacifique	Kayumbu	Public sector	Social affairs
Obed Ntayubuhungiro	Ngamba	Public sector	Executive secretary
Pauline Mpazimaka	Mugina	Public sector	Social affairs

Solid waste management and collection

Solid waste management in the Kamonyi city-region is comprised primarily of many informal actors operating autonomously to maintain a clean and healthy environment. Households, businesses, and market vendors organize together to dispose of solid waste that accumulates throughout the built environment. Although some recycling and valorization of inorganic waste (valuable metals and glass) does occur, little to no valorization of organic waste is currently done. The landfills utilized by the residents within the city-region are a mix of official and unofficial landfills (Figure 5.14). In addition to ad hoc transport of waste to these landfills, some farmers do currently collect animal waste, and in some instances market waste, from around the area and use it to fertilize local agricultural fields.

However, in addition to these largely informal waste management activities, there is a larger solid waste management company, COPED that does operate in the area. COPED transports the waste it collects to the formal landfill at Nduba, in Kigali. However, according to a report conducted by the International growth center (IGC), this facility is an "open air dumping site that suffers from numerous environmental challenge such as leachate, vermin, and spontaneous combustions". In addition to disposing of waste at Nduba, COPED does also maintain a waste valorization facility at Runda (Figure 5.15) where glass, metal, and organic waste are all separated and valorized.

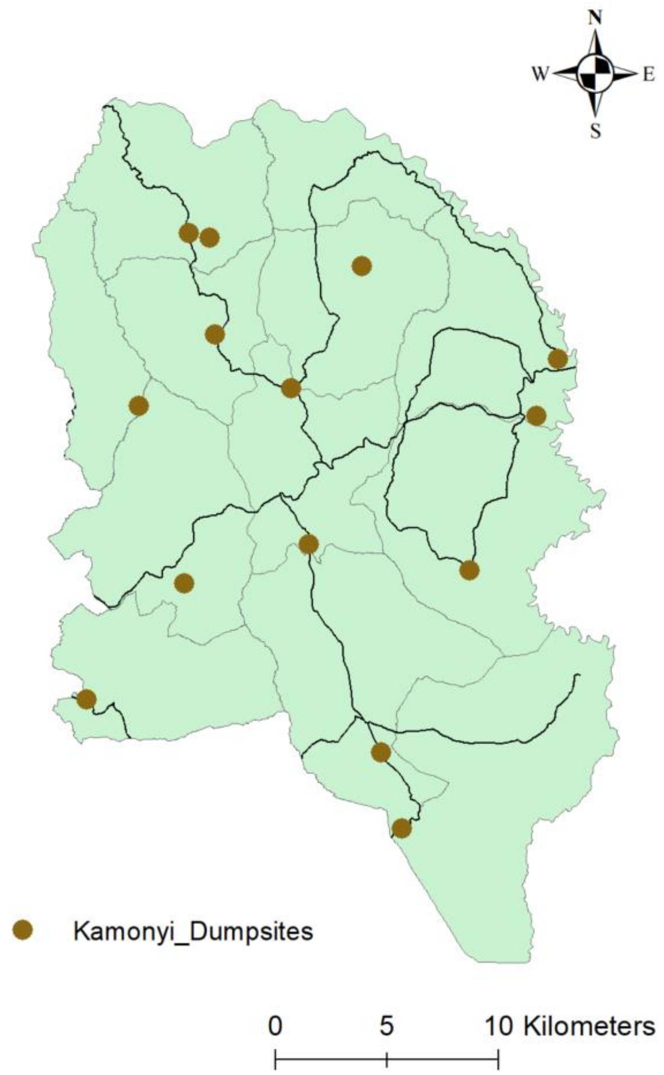

Figure 5.14: Locations of Kamonyi dumpsites.

Figure 5.15: Image of the largest dumpsite in the Kamonyi city-region (COPED Runda).

Private sector solid waste management actors

COPED is the major private sector waste management actor that operates within the Kamonyi region. In addition, two actors that specialize in waste valorization, ECOMAKE and Mukunguri Rice Promotion Cooperative, are also engaged in recycling activities that exist within the city-region. In addition, a variety of small-scale waste collection efforts are undertaken by a variety of ad hoc organizations and societal actors. For example, several farmers currently collect animal waste from around the area and use it to fertilize local agricultural fields. At households and markets, small contracts are given to cleaners that maintain the cleanliness of these areas. A significant portion of this waste is organic and is typically transported to local fields and left to decompose on site.

Generation and Composition

According to experts within the Kamonyi city-region, roughly 3,917 tons of waste are collected per year within the Kamonyi city-region. Of this, the majority is collected by COPED and disposed of either at the landfill in Kigali or valorized at Runda. In addition to waste transported to Runda, the sectors of Gacurabwenge and Mugina also collect significant volumes of waste (Figure 5.16). Furthermore, solid waste management experts interviewed for this report estimate that of the total waste generated within the city-region 83% (± 15% sd) is organic.

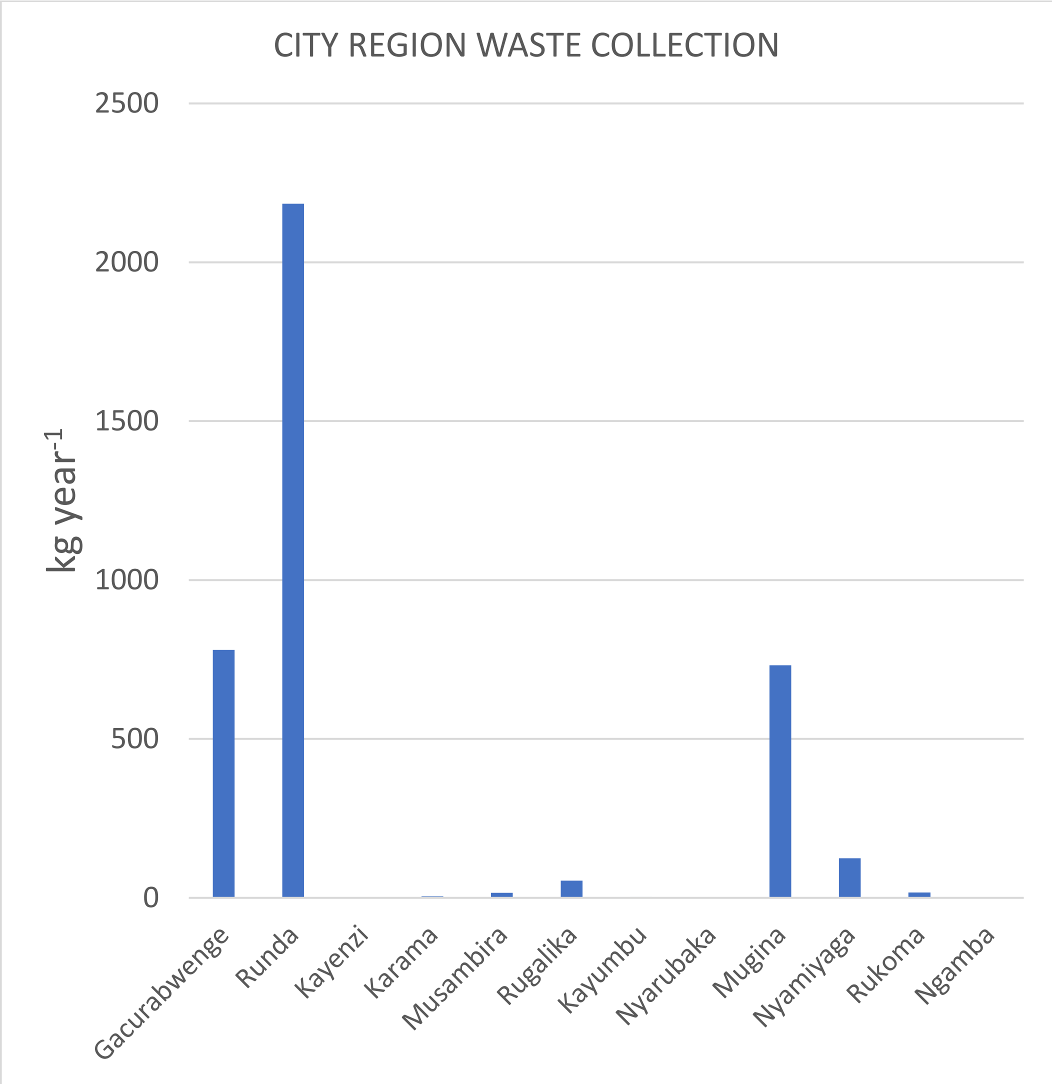

Figure 5.16: amount of waste collected and transported to sector dumpsites within the Kamonyi city-region.

Challenges with solid waste management

Content matter specialists raised the following points when explaining the major challenges that exist with solid waste management in the Kamonyi region.

- *"A majority of residents know that most wastes if collected, they have to be burnt after disposal. Only a few are aware that they are recyclable."*
- *"Some market venues have no dumping site, all trash collected after the market day are disposed at nearby yards which consequently impose a hazardous effect."*
- *Not enough facilities (finance and infrastructures) on limited recycling plants are available and under operation as they recycle some recyclables and put others in the trash that are supposed to be reused.*

- *Respondents conceal some crucial information required in the survey as they fear that the local government levels would base on that to put them in social categories as were done before and this left recurring fear in their hearts.*
- *Refusal of giving out information from respondents after failure an enumerator to present organization working card (ikarita y'akazi).This classifies him/her as a stranger in an area.*
- *Lack of trained personnel to prohibit littering of streets, promote waste segregation, organize house to house waste collection, conduct awareness programs to disseminate information to public, and to promote public participation.*
- *Limited community waste storage facilities.*
- *No Transport of wastes in covered vehicles.*
- *Existing dump sites and disposal of inert wastes in sanitary landfills are not upgraded*

Opportunities for RUNRES

Despite the challenges that face solid waste management efforts in Kamonyi, there are several clear opportunities. For example, the government of Rwanda is committed to improving solid waste management across the country. This focus goes beyond mere legal or regulatory pronouncements; the government of Rwanda is mobilizing significant financial and technical resources to upgrade the landfill in Kigali (Nduba), which COPED utilizes (IGC, 2019). In addition, the government of Rwanda is increasingly focused on promoting a circular bioeconomy predicated on the recycling and valorization of waste.

Human waste management

Sanitation policies in Kigali, Rwanda

The government of Rwanda is clearly focused on improving sanitation and solid waste management. For example, Vision 2020 (MINECOFIN, 2002), a guiding document developed to improve water and sanitation provision states that*:*

Water: All Rwandans will have access to safe drinking water; water resource management will be rationalized, integrated and in harmony with the national land-use master plans in all water dependent domains."

Waste Management: At least 80% of the Rwandan population will have easy access to adequate waste management systems and will have mastered individual and community hygiene practices. By 2020, the rural and urban areas will have sufficient sewerage and disposal *systems; each town will be endowed with an adequate unit for treating and compressing solid wastes for disposal. Households will have mastered and be practicing measures of hygiene and waste disposal".*

Furthermore, this document makes explicit the link between poor sanitation and reduced environmental and human health. Additional policy documents such as the Economic Development and Poverty Reduction Strategy (EDPRS) and the National Water and Sanitation Policy make clear the importance the government of Rwanda places on sanitation improvement (Tsinda, 2011)

The current sanitation landscape

Human waste generation

The sanitation demands and increased human excreta generation are driven by a growing population. In Africa, faecal matter production is roughly 128 grams person^{-1} day^{-1}, while urine is 1.42 L person^{-1} day^{-1} (Rose, et al., 2015). Thus, Kamonyi, with a population of 340,501, generates approximately 15,690 tons year^{-1} (faecal matter) and 176 Megalitres of urine year^{-1}. This waste is environmentally hazardous and must be safely contained, transported, treated and disposed/reused.

Collection, treatment, and disposal

According to qualitative data collected by the RUNRES Rwanda team Table 5.6 represents the waste management solutions utilized within the city region. Furthermore, a shit flow diagram developed for the city-region indicates that of the total amount of human excreta produced across the city-region, roughly 55% is treated safely. It must be noted that this is a preliminary shit flow diagram, and large uncertainties still exist regarding the construction quality and maintenance of pit latrines in the region.

Table 5.6: the range of sanitation solutions that are currently utilized within the city region boundary.

Current Kamonyi sanitation solutions						
Community	**Dwelling type**	**Open defecation %**	**Pit latrine**	**UDDT**	**Septic tank**	**Municipal sewage**
Rural	Rural-Traditional	0	100	0	0	0
	Rural-formal	0	100	0	0	0
Peri-urban	Shack	0	100	0	0	0
	Formal House	0	100	0	0	0
	Apartment	0	100	0	0	0
Urban	Shack	0	100	0	0	0
	Formal House	0	100	0	0	0
	Apartment	0	100	0	0	0

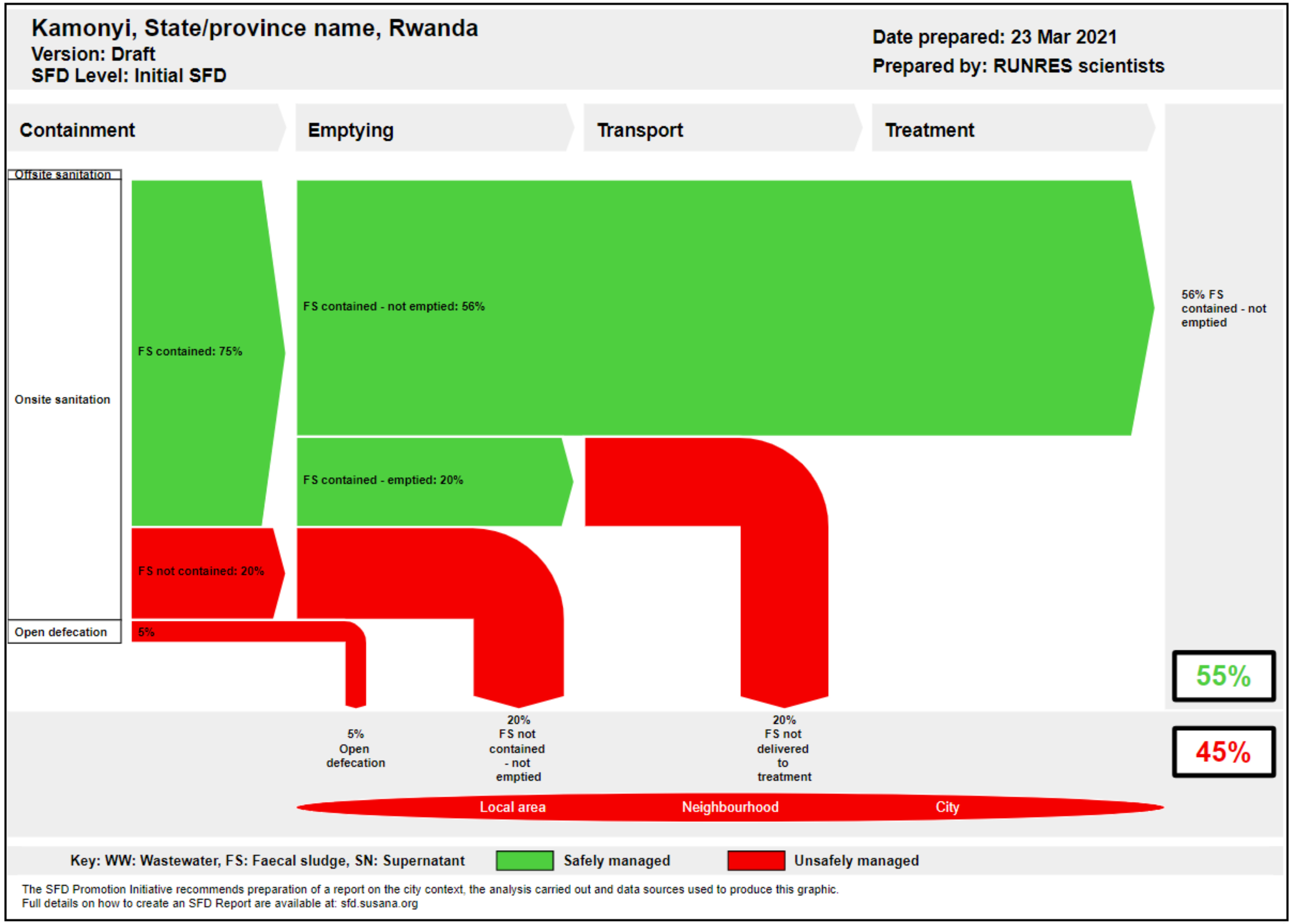

Figure 5.17: Initial shit flow diagram, Kamonyi, Rwanda.

Local perspectives

Content matter specialists

Semi-structured interviews were conducted with twelve Kamonyi sector representatives in order to understand the sanitation landscape within the city-region. Very little variation in the sanitation system was expressed by the interviewed experts. Across the entire city-region, much of the population utilizes pit latrines, with $<1\%$ of the population utilizing waterborne sanitation. Very little municipal or state assistance is given to citizens to support the construction of household pit latrines; the members of each house are responsible for financing the construction and maintenance of their latrines. Local materials, primarily logs harvested from nearby forests, are almost universally used in the construction of the superstructure as well as to cover the pit itself. Almost all the interviewed CMS expressed that this reliance on local forests is contributing to unsustainable deforestation and that alternative construction materials must be utilized.

In addition, the local experts stated that the logs used to cover the pits does not adequately cover the latrine, which allows both water and flies to enter into the pit. This risks flooding of the effluent in the latrine, as well as a public health risk associated with the flies. Interestingly, every interviewed expert stated that the fecal sludge, when collected from a full pit latrine, is often deposited on nearby agricultural fields. The community does this both because it provides a likely method to deposit the sludge, but also because the community is aware of the fertilizing potential of fecal sludge to support agricultural production.

According to the interviewed experts, there are aspirations from the community to improve the current sanitation landscape. This desire primarily expresses itself as a desire to optimize the pit latrines. However, due to a lack of state support and low availability to capital, achieving these aspirations has proven difficult. Lastly, the experts interviewed stated that open defecation is not at all common within the city region. According to these interviewees, this practice is frowned upon and those community members that are incapable of installing a latrine in their own household are supported by their neighbors to ensure that the necessary infrastructure is installed.

Community members

The RUNRES Rwanda team conducted nine focus group discussions (FGD) across the city region in order to understand the community's perspective regarding the current sanitation landscape. In general, the opinions articulated by the content matter specialists aligned quite well with the results of the FGDs. Overall, the participants of the focus group session indicate that the reliance on pit latrines is not problematic. However, the concerns articulated by the community members focus on the quality of the construction and challenges presented by maintenance of the deployed solution. In every focus group session, the participants identified several issues presented when constructing a safe latrine. First, achieving sufficient pit depth with the resources available at the household level was regularly cited as a major challenge. This problem forces household to dig new pits more frequently, which is a challenge in higher density communities and increases the risk of effluent overflow during periods of heavy rain, which result in the uncontrolled release of fecal sludge into the environment. In addition, most of the households in the city region stated that they rely largely on lumber sourced from the local forests to construct both the superstructure and the pit cover. The participants regularly stated that reliance on this material for pit latrine construction results in a low-quality latrine and exacerbates deforestation rates.

In almost every FGD, the participants expressed the desire to improve the construction materials used in the construction of the latrines. In particular, replacing wooden latrine covers with concrete slabs was stated as a major aspiration by most of the community participants. As with the interviewed experts, the community members articulated that households receive little support from the state for sanitation provision. The burdens associated with construction, maintenance, and emptying of the latrines is born by the households.

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5.4 Msunduzi, South Africa

Data Collection

Both qualitative primary and quantitative secondary data were collected from Msunduzi city region using protocols developed by RUNRES project Postdocs. Qualitative data related to waste streams within the city region boundary were collected through a series of focus group discussions (FGD) and semi structured interviews (SSI) with content matter specialists (CMS). Table 5.7 provides details regarding the FGDs and SSIs conducted for this report:

Table 5.7: List of waste management stakeholders and key informants identified by the RUNRES core team and attended the kick-off meeting.

Name	Organisation	Expertise	Role in value chain
Mike Greatwood	Msunduzi Municipality	Water Services Authority Manager	Sanitation management
Royal Nzuza	UMDM	Water and sanitation	Sanitation management
Debbie Trollip	Umgeni water	Wastewater management	Wastewater management
Mluleki Mnguni	Umgeni water	Wastewater management	Wastewater treatment
Riaz Jogiat	UMDM	Manager Solid Waste	Solid waste management

Secondary data were collected from the municipal office and water supply and sewerage enterprises. Finally, collected data were analysed using descriptive data methods.

Waste Collection and Management

Municipal solid waste consists of non-biodegradable inorganic waste and biodegradable organic waste (food and green waste). RUNRES intends to capture the organic waste stream component. The following description of the city-region's solid waste collection and management system was accomplished through a literature review of secondary, published grey literature, government and municipal reports, and stakeholder interviews. The locations of waste treatment and disposal hubs were identified through a participatory exercise conducted during the kick-off meeting, information which was then georeferenced and overlaid onto existing municipal shapefiles.

The New England Landfill site (NERL) in uMgungundlovu district (Msunduzi Municipality, 2018) is the primary facility for solid waste disposal in the municipality. It covers an area of 44 hectares, 29 of which are already fully utilized. The landfill is classified as G: L: B+, meaning that it accepts non-hazardous wastes emanating from households, industries, commercial activities and builder's rubble. The facility has the capacity to accept 500 tons of waste day^{-1} and is equipped to manage the liquid balance through a leachate management system. It is licenced under the permit number 16/2/7U203/D3/P64, which was issued in 1998 by the Department of Water Affairs and is equipped with vehicle access control, a weighbridge, site security, site office, and ancillary supporting infrastructure. The licence allows the municipality to carry out the following activities enlisted under the National Environmental Management: Waste Act 59 (2008):

(i) Sorting, shredding, grinding, crushing, screening or bailing of general waste at a facility exceeding an area of 1000m^2 and,

(ii) The disposal of general waste to area exceeding 200m^2 and with a total capacity exceeding 25,000 tons.

The landfill is permitted to operate until it reaches a height of 652 m above sea level and is currently sitting at 5% of that level.

Waste management actors

Public sector solid waste management actors

Each local municipality in the uMgungundlovu district has its own unique organization to manage solid waste. The Waste Management Business Unit (WBMU) of the Msunduzi municipality is responsible for refuse management as per the National Environmental Management Act: Waste Act No. 59 (2008) policy (RSA, 2009). The WBMU collects refuse once a week from various sectors of the local municipality (households, hospitals, businesses, residential complexes, commercial zones). Furthermore, this organization also manages and maintains the landfill and eight garden refuse sites across Msunduzi (Msunduzi Municipality, 2020).

Census data for Msunduzi local municipality shows a decline in weekly refuse collection services from 59.5% of households (2001) to 53.2% of households (2011), and the recent 2016 community survey data shows a further decline to 48.5% (Statistics South Africa, 2016). This is attributed to an increase in the number of households, which is imposing more pressure on service delivery capacity. To counter this trend, the municipality developed an integrated development plan (IDP), which considers planning and implementation strategies to ensure provision of basic services such as refuse collection (RSA, 2000). Based on the data reported from Statistics South Africa (2016), approximately 120,000 households in Msunduzi receive refuse collection services. However, this service is very minimal in Vulindlela (Figure 2).

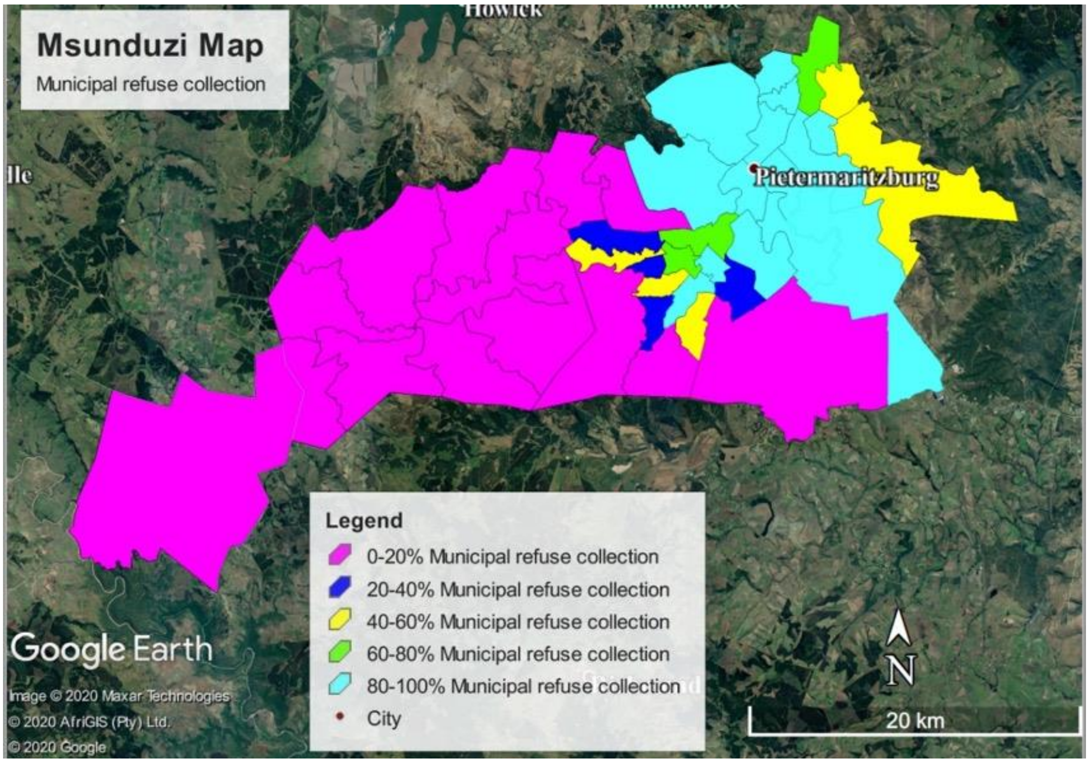

Figure 5.18: Percentage of households receiving municipal refuse collection service in different wards of Msunduzi local municipality (Statistics South Africa, 2016).

Private sector solid waste management actors

There are several private companies, including Small Medium and Micro Enterprises (SMMEs) dealing in collection and recycling of inorganic materials (plastic, bottles and other non-biodegradable materials) from Msunduzi. These private companies include Central waste, E-waste and KVM recycling. Central waste is a Pietermaritzburg based recycling company trading as Ellis Wastepaper. It started as a family business in 1994 and the company currently collects paper, cardboard and various inorganic recyclable materials (plastic and steel). The company employs 61 people directly and provides an income for a further 500 informal traders and hawkers around Pietermaritzburg. E-waste is a private company situated in Mkhondeni, Pietermaritzburg with other plants around South Africa (Cape town, Pretoria and Johannesburg). They provide services for onsite storage, collection and recycling of light bulbs. KVM recyclers is a company located in Mkhondeni, Pietermaritzburg as well. They deal with various kinds of glass waste and cans.

International organizations & NGOs

Wildlands conservation trust is an environmental conservation non-governmental organization (NGO). Its mission is to nurture the development of waste recycling through initiatives such as waste-preneurship (Recycling for life projects), tree-preneurship (Indigenous trees for life projects) and food-preneurship (food for life projects). They are involved in providing environment enabling partnerships for effective waste recycling, restoration of community ecosystems, and support for climate change mitigation strategies. Therefore, they are crucial in spearheading recycling initiatives related to minimisation of waste entering the landfills.

COWI holdings is a Danish non-governmental organization belonging to COWI foundation. The organization is active in numerous global environmental management projects including African countries such as South Africa. It has partnered with research organizations such as the Centre for Scientific and Industrial Research (CSIR) on solid waste management projects. They were also part of the group working with uMgungundlovu local municipality, private sectors (Gromor Pty Ltd and Farmyard organics) and government (Department of Environmental Affairs; DEA, and Economic Development, Trade and Environmental Affairs; EDTEA) to promote advanced integrated solid waste management in uMgungundlovu, with a special focus on organic waste (R. Jogiat, 2020).

GroundWork is one of the non-profit environmental justice organisations working in Southern Africa. It protects vulnerable groups by promoting the right to a clean environment, conservation, maximum sustainable and use of natural resources, and justifiable economic and social development.

There are some people's national movements such as the South African Waste Pickers Association (SAWPA). The SAWPA works with waste pickers from waste dumps and the streets. The organization has many affiliates all over South African provinces except in North Cape.

Organic waste value chain mapping

Dumpsites for organic and green waste: management structure, payment schemes

There are eight garden refuse dumpsites across local Msunduzi municipality that are managed and maintained by the WMBU. These are situated in Link Road, Prestbury, Richie Road in Pelham, the Grange, Sobantu, Eastwood, and South Road in Northdale and Woodlands (Msunduzi Municipality, 2018). The WMBU allows a free single bakkie load per day of garden refuse on the designated dumpsites. However, the exact amounts of garden waste disposed at each garden waste dumpsite is not known since there is no record keeping. Since there is no security and supervision at night the dumpsites are often abused. Illegal dumping on the green waste sites is a common practice; the public dumps inorganic materials including building rubble which are not supposed to be there (Pillay, 2017). As a result, the green waste is mixed inorganic materials (R. Jogiat, 2020). Inorganic materials are estimated to constitute about 20-25% of the total waste in dumpsites. Therefore, intensive sorting, must be done if the green waste is to be used for composting. The green waste from the eight dumpsites is collected by the WMBU and disposed at the New England Landfill Site (NERL) in Pietermaritzburg (Figure 5.19). There is need for increased security and public education on handling different types of waste before disposal onto the dumpsite.

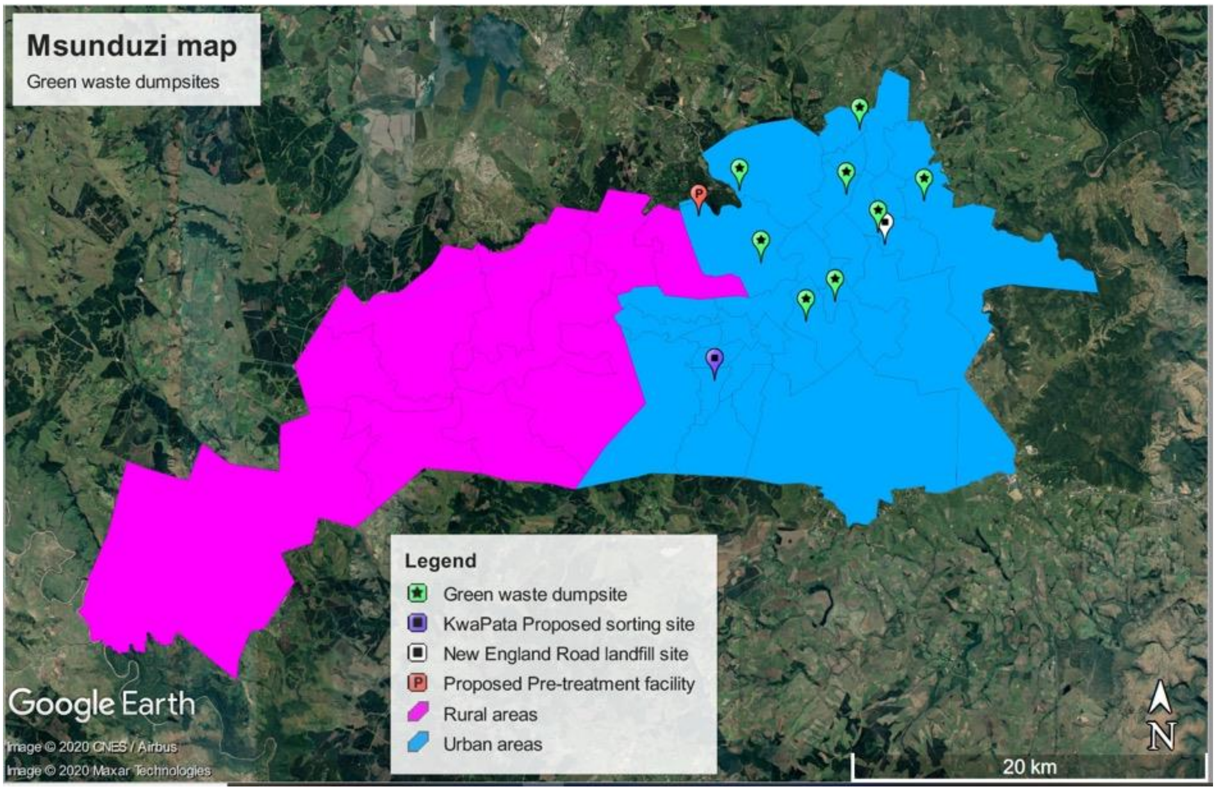

Figure 5.19: Locations for eight green waste site and the New England Road Landfill (NERL) site where garden waste in disposed (Msunduzi Municipality, 2020).

Valorization centers

Most of the organic waste recycling companies identified are located outside the city-region boundary; Amberglo (Howick), Gromor (Camperdown) and Maggie Stretcher (Curries' post) commercially produce various agricultural inputs from organic and garden waste. These companies produce compost from animal manure such as chicken, cow, pig and/or horse manure mixed with mill saw dust.

Gromor (Pty) Ltd is a private company located 30 km from Pietermaritzburg city, within the uMkhambathini local municipality of the uMgungundlovu district municipality. The company was formed to valorise chicken waste coming from a nearby farm (Rainbow chickens). Recently, the company merged with TWK international and is operating as its subsidiary. In addition, Farmyard organics (Pty Ltd) is also a subsidiary of Gromor. Gromor uses chicken litter, saw dust, horse and cattle manure to produce organic fertilisers. Some of the products available on the market include Gromor Accelerator ™ (made from pelleted chicken manure, costing R120 per 20kg), Gromor Compost ™ (chicken litter, horse manure, straw and kraal manure and costing R32 per dm^3), Gromor Potting Mix ™ (Pine bark costing R32 per dm^3) and Gromor Seedling Mix ™ (Pine bark R32 per dm^3). The company also has a range of inorganic fertilisers for sale. Most of their target markets include nurseries such as Blackwood in Msunduzi. Gromor has been exploring avenues for the use of green waste from municipal garden refuse sites because their production is limited by feedstock rather than market base (Personal communication with the manager).

Amberglo Pty Ltd produces organic fertilisers (nutri-mixes) from a mixture of animal manure (horse manure and chicken litter), biochar and topsoil. Their products are used for ornamental crops (lawns and flowers), planting and trees. A large bag ($70dm^3$) costs about R70 and has a market base in nurseries around Pietermaritzburg, Hilton and Howick. Margie Scratcher, Drumnadrochit Farm, is a family run business situated in KwaZulu-Natal, which keeps chickens for egg production and they employ around 30 people. They produce organic fertilisers using chicken litter mixed with other farm green waste through a Rapid Thermophilic Digestive System from Biomax Technologies, Singapore.

Currently, the organic waste collected in Msunduzi is not being valorised except for the inorganic recyclables (plastic, glass, paper and cardboard), which are collected from curbside sorting areas, city streets and the landfill. Inorganic recyclables are commonly collected by residents living in informal settlements such as Jika Joe, Pietermaritzburg (Mbulelo, 2009). Despite having established formal and informal systems dealing with recyclables, the major concern is on biogenic wastes (household food waste, green waste and animal waste) generated within the Msunduzi region that end up at NERL, shortening the lifespan of the landfill. The South African Department of Environmental Affairs, under the National Environmental Management: Waste Act of 1998 (NEMA) and in agreement with the National Organic Waste Composting strategy presented at the Waste Summit in 2015, state that the wastes entering landfills must be minimised through integrated waste management practices (reduction, reusing, recycling, treatment and disposal). According to R. Jogiat (2020), the Msunduzi municipality spends ~R855 per ton on solid waste management, of which R122 per ton (R20 million per year) is directed toward disposal costs. In response, the Msunduzi municipality is investigating ways to collect, treat and valorise green and organic wastes as an initiative to reduce landfill disposal costs and respective environmental consequences.

Currently, green waste collected from the eight garden refuse sites is transported in intermediate storage containers to the landfill. As part of municipal development plans for integrated waste management, Msunduzi local municipality, in conjunction with the uMgungundlovu district municipality solid waste management unit, have been planning the construction of a pre-treatment facility for green waste. Several potential sites have been proposed and some of these include NERL (access road to Darvill Wastewater treatment site) and Curry's post (uMgeni local municipality) drop off site.

However, after assessing different factors to balance between environmental compliance and centrality, the proposed site is at Dorpspruit road, undeveloped land with an area of 7.5 ha (Figure 5.20). The facility was expected to pre-treat garden waste through activities such as sorting the organic waste by removing inorganic materials and non-compostable material such as wood, which can be used as firewood or pyrolyzed to biochar. The remaining green waste was to be shredded and sold to private sector actors such as composting companies and others seeking to use organic waste. The facility was expected to treat 50-90 tonnes of waste per day and experienced composting companies such as Gromor (Pty) Ltd were expected to be tendered for marketing and operations.

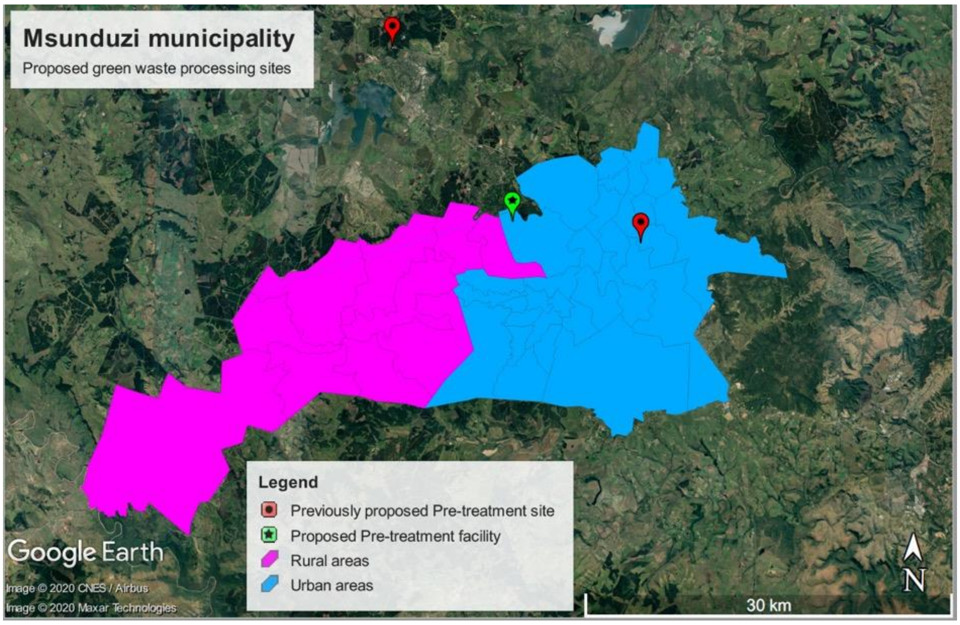

Figure 5.20: The proposed green waste pre-treatment facility in Msunduzi local municipality and other proposed sites (Msunduzi Municipality, 2020).

Proposed organic waste valorisation initiatives linked to this facility included simple and complex composting facilities, onsite composting, vermiculture, mechanical biological treatment (MBT) for energy production and a demonstration community garden (R. Jogiat, 2020 personal communication). The MBT was supposed to use animal waste for energy production, and the residue from this process was a potential feedstock for organic fertilisers. The MBT residue is odourless and sterile and can produce a commercially valuable organic fertiliser.

Apart from animal manure, food wastes may be used as feedstocks for MBT. Thermophilic anaerobic digestion of animal excreta waste has been demonstrated via various case studies conducted outside Msunduzi local municipality, in areas such as Kamberg, Thornville (pig and cattle manure), and Albert Falls (poultry manure). However, some of these activities may not be applicable to Msunduzi municipality due to unavailability of animal feed stock due to minimal livestock production within Msunduzi (R. Jogiat, 2014).

Generation and composition

The proportion of waste generated within the Msunduzi local municipality, emanating from households and industries/commercial sectors has been quantified and is presented below (Figure 5.8). Results show a significant variation in domestic waste generation across socio-economic groups, high volumes being generated in low income groups than high income, and in urban areas than rural. This shows that the low-income group is larger in the Msunduzi region. Industry (including commercial sectors) generate about 38% of the total solid waste within the city region.

Further waste stream quantification, based on 2013 data, was conducted to understand the quantities and composition of various organic waste streams generated from various socio-economic groups within the city boundary (Table 5.8). The organic food waste (actual recognisable food waste), garden refuse waste and the residual biogenic waste (mixture of food wastes and other waste types) are presented. Larger quantities of total organic waste emanate from high density areas than low density areas, with the largest values produced within urban high-density areas.

Garden refuse was not reported in rural high and low densities, and low values were found in rural medium and low densities. Very low quantities of green waste from rural areas are attributed to absence of landscaping activities. Landscaping and home gardening activities are usually prominent in low density areas such as Montrose. However, less amounts of garden waste in general household waste reported in low density areas is attributed to garden waste separation. In such residents garden waste is separated from domestic waste and efficient transportation to respective dumpsites, as a result the proportion of garden waste in general domestic waste is low. More food waste is generated in rural commercial and industrial areas compared to urban counterparts because people in rural areas rarely consume fast foods and their purchasing power is very low as a result more food is wasted from fast foods. The resulting residual biogenic and garden refuse wastes are generally low in rural low densities due to source separation of organic waste stream.

Table 5.8: Quantities of various organic waste streams generated in various areas of the Msunduzi local municipality excluding garden refuse from dumpsites (2013).

Source	Organic food waste (tons/yr)	Garden refuse (tons/yr)	Residual biogenic (tons/yr)	Total (tons/yr)
Urban high density	5,324	765	8,960	15,050
Urban medium density	714	116	1,266	2,094
Urban low density	0.4	6	399	405
Rural high density	1,227	0	3,094	4,320
Rural medium density	259	6	462	726
Rural low density	36	0	109	146
Commercial industrial urban areas	2,367	79	3,516	5,961
Commercial and industrial rural areas	4,056	49	2,306	6,411
Total	13,982	1,020	20,112	35,115

Waste collection & transportation

Different types of waste collected by the Msunduzi municipality business unit between the year 2015-2018 is reported Table 5.9. There was a general decline in garden waste refuse from the year 2015 to 2018, with the least amount being reported in 2017 (8,175 tons per year), giving a mean value of 14,199 tons per year. Generally, the bulk food waste collected is very small, making up 0.25% of the total municipal waste collected.

Table 5.9: The composition of various waste streams (tons year-1) collected by the Msunduzi municipality in 2018 (Msunduzi Municipality, 2018).

Description	2015	2016	2017	2018	Mean	Stdev	SE	Composition
Builders rubble	63,777	45,239	66,448	42,854	54,579	12,250	6,125	31.54%
Bulk food waste	417	547	476	321	440	96	48	0.25%
Garden refuse	19,839	18,025	8,175	10,759	14,199	5,615	2,807	8.21%
Domestic waste	33,502	36,600	26,702	28,138	31,236	4,621	2,310	18.05%
Industrial waste	35,208	33,287	33,219	35,423	34,284	1,194	597	19.81%
Sawdust	148	66	0	125	85	66	33	0.05%
Cover material	46,134	33,316	16,554	55,352	37,839	16,822	8,411	21.87%
Wood waste	3,743	5,302	97	70	2,303	2,641	1,320	1.33%

Total	202,768	172,382	151,671	173,042	174,965	21,024	10,511	100%

Organic waste valorization challenges

There have been some initiatives to collect and valorise organic waste from Msunduzi region. These have been hindered by several challenges ranging from financial, institutional, and administrative issues within the municipality. The Msunduzi has been facing a lot of challenges and in 2019 the municipality was placed under provincial administration because of poor service delivery, financial systems, institutional capacity and performance. Therefore, the expected integrated waste management plans could not materialise.

There have been a lot of pilot projects to promote waste management in Msunduzi and one of them is named “Siyazenzela”, which means “we do for ourselves” in Isizulu Zulu. The project was initiated in 2008 by the Msunduzi municipality aiming to empower residents living in Jika Joe informal settlement (Mbulelo, 2009). The project activities involve promoting the collection of recyclable inorganic waste in low income communities and the beneficiaries were paid food vouchers. In addition, the project envisioned to engage on other activities such as teaching the residents innovative waste management practices such as valorisation of organic waste through compost production. If successful the project was supposed to be outscaled. However, the project failed to materialise due to budget constraints within the municipality and lack of external funding.

Organic gold is another company that seeked to sort and compost organic waste from the NERL into organic fertilisers. Initially, the project was approved by the technical and engineering services of Msunduzi municipality. However, final approval from the city council was not successful. Later on, another company (Shoretech) received a tender to compost organic matter from NEL but this plan was abandoned as the company failed to secure an environmental assessment licence from the provincial Department of Environmental Affairs.

Despite the municipal vision of creating a safe environment at NERL through formalisation and recognition of waste pickers by constructing the Material Recovery Facility (MRF), this hasn’t yet been achieved. The fertiliser company Gromor was in a process of establishing access to green waste feedstock from the Msunduzi municipality, but this was halted by informal waste pickers (Personal communication with the Gromor manager) because they felt their livelihoods were threatened by this process. This illustrates that competing interests between waste management actors does exist.

Despite several challenges encountered by the municipality in the past, integrated waste management continues to be a focus in their integrated development plan, with a special focus on minimising organic waste entering the landfill site. The construction of a material recovery facility (MRF) for waste pickers, establishment of energy plants and/or composting facility near the NERL have been clearly stated as the municipal vision (Msunduzi Municipality, 2020).

Waste disposal

The Msunduzi municipality waste collection data above does not show the actual proportions of various waste streams that reach the municipal landfill. This informationn was generated using data from a study done by uMgungundlovu district municipality in conjunction with Msunduzi municipality, which shows the characteristics of waste disposed at the NERL site (Table 5.10). The information was based on projections done by uMgungundlovu during their feasibility study on the potential for recovering organic waste within the district boundary. The projections were done because of the inconsistences in monitoring weighbridge data, which resulted in a lack of reliable information on the actual volumes disposed at the NERL. Actual data collected in 2013 was used for projections of waste quantities to be delivered to NERL over the next 20 years, with an assumption that waste quantities will increase by 1.0% per year.

The largest proportion of waste entering the NERL (presumed to be generated within the city region) is biodegradable (garden refuse + organic waste) and is about 59,001 tons year^{-1}. Based on results reported in the previous section, the mean value of garden refuse waste generated and transported from garden dumpsites in Msunduzi is ~14,999 tons year^{-1}, while the value reported in below is 20,472 tons year^{-1}. This discrepancy is due to the fact that the study conducted by uMgungundlovu municipality included green wastes emanating from other municipalities. According to Riaz Jogiat, about 15,000 tons year^{-1} of garden waste comes from Msunduzi garden sites while an additional 5,000 is transported from other municipalities (R. Jogiat, 2020).

In addition, about 440 tons year^{-1} of food waste is transported to NERL. Much of this food waste is mixed up with inorganic domestic waste, a fact that makes organic waste valorisation efforts difficult. Taken all together, the Msunduzi city-region produces ~55,000 tons biodegradable waste year^{-1} (Figure 5.21), virtually none of which is currently captured, processed, and valorized.

Table 5.10: The composition of various waste streams (tons year^{-1}) disposed at NERL based on current characterisation data projected for the year 2020.

Waste type	Volume (tons/yr)	Percentage
Paper and cardboard	24,396	15%
Plastic	11,310	7%
Glass	6,336	4%
Metal	4,407	3%
Organic	38,529	23%
Other	29,991	18%
Inerts	31,056	19%
Garden refuse	20,472	12%
Total	166,497	100%

** Plastic (low and high density polyethylene, polyethylene-terephthalate, polypropylene, polyvinyl chloride), Paper and cardboard (heavy letter 1, common mixed waste, newspaper, scrap boxes and cardboards and Tetra Pak), glass (green, brown and clear glass bottles and containers), organic (putrescibles), garden refuse (green and woody waste) and other (tyres, wood waste, textiles, cloths, batteries and e-waste).*

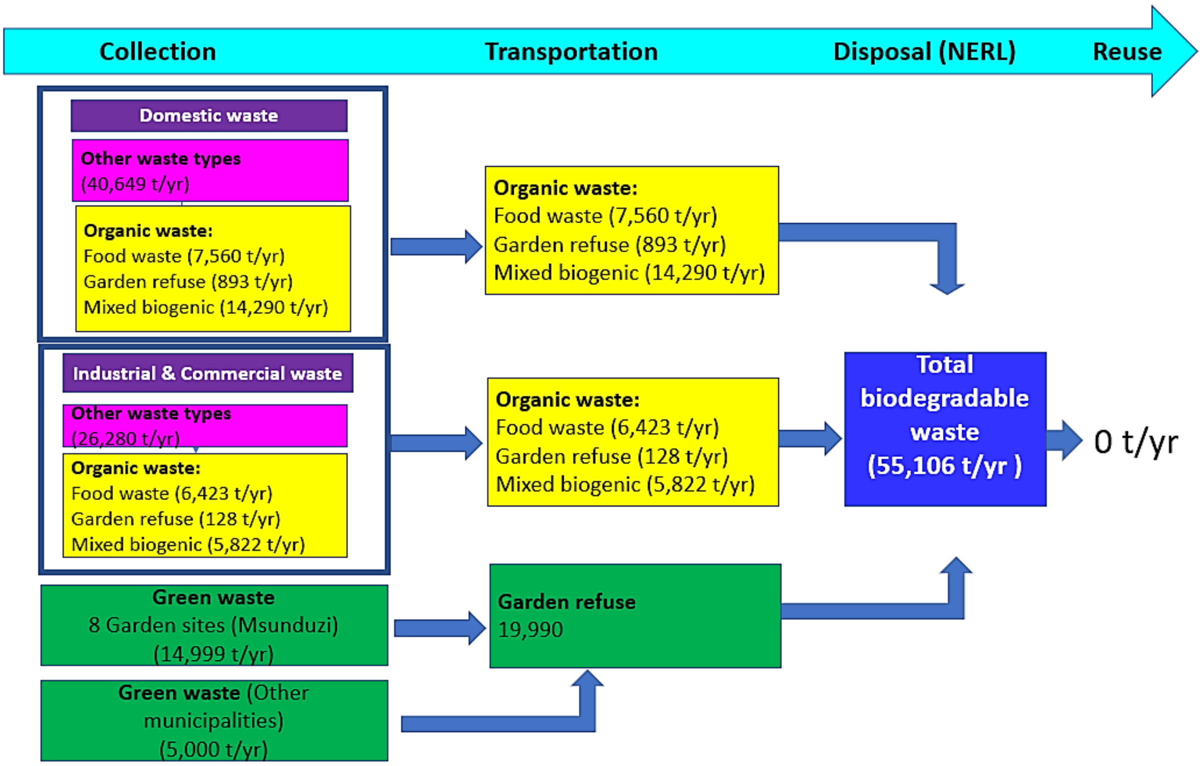

Figure 5.21: Organic waste stream flows from collection, transportation, disposal and end use in Msunduzi local municipality.

Conclusion

The waste management system in Msunduzi is run by various actors; public, private, informal and non-governmental organisations. The public sector (Waste Management Business Unit of Msunduzi municipality) is responsible for the collection, transportation and disposal of general household, industrial and commercial waste as well as the management of eight garden refuse sites and the landfill. Most of the inorganic recyclables are collected by private companies in Msunduzi, with no focus on organic waste.

Msunduzi has a strong institutional and legal framework for promoting a circular economy through organic waste valorisation. South Africa Waste Pickers Association and Groundwork empowers informal waste pickers are active in collection of recyclables and can potentially play a role in organic waste recycling activities. The Wildlands trust, through various initiatives to promote green activities, provides an environment for these low-income groups to earn a living through eco-friendly businesses. There are eight garden sites around Msunduzi from which garden refuse can be obtained from, however, these dumpsites are abused through illegal dumping so much work must be done to influence behaviour change and solidify security in the respective sites. Furthermore, the food waste generated in Msunduzi is higher than the amounts being effectively separated and eventually dumped at the landfill hence source separation of food waste, especially in high density areas, is crucial.

A successful organic waste recycling program in Msunduzi must take a transdisciplinary approach involving public institutions, private sector, non-governmental organisation and the community (informal waste picker, small medium microenterprises and/or even small holder farmers or cooperatives) to establish a common understanding and goal. Furthermore, the municipality is crucial in driving up a conducive environment through speeding up establishment of a material recovery facility and a green waste pre-treatment facility.

Human waste management

Sanitation policy in South Africa

In 2015 nations around the world developed the Sustainable Development Goals. One of these goals (6) focused on clean water and sanitation for everyone. Recent data shows that despite a 10% increase in access to clean water between 2000-2017, roughly 785 million people are still deprived of this essential resource. The provision of basic sanitation services increased from 28% to 45% during this period as well. However, 709 million people continue to practice open defecation and the lack of adequate sanitation remains a major public health crisis (WHO & UNICEF, 2019).

Currently, South African sanitation provision is governed by three policy documents (Cape Town City, 2008; Msunduzi Municipality, 2018). These documents include the White Paper on Water Supply and Sanitation Policy (1994), the White Paper on a National Water Policy of South Africa (1997), and the White Paper on Basic Household Sanitation (2001). The White Paper on Water Supply and Sanitation Policy was established by the South African Department of Water Affairs and Forestry (currently the Department of Water and Sanitation) to improve equity in water and sanitation provision for all users, regardless of race, gender, or income. The White Paper on Water Supply and Sanitation Policy (1994) was established with a vision to enhance the provision of adequate sanitation services in order to protect public health, protect the environment, eradicate the ‘’bucket system’’, stimulate employment opportunities, and ensure consistency in urban and rural housing policies.

In addition, the National Development Plan Policy (Vision 2030) was instituted to eliminate poverty and reduce inequality. Part of the policy focused on sanitation infrastructure that is poorly located, inadequate, and under- maintained (National Planning Commission, 2011). Currently, the National Sanitation Policy (2016) assesses the positions of various sanitation policies across the entire sanitation value chain: collection, removal, and disposal or treatment of human excreta and domestic and industrial wastewater (Republic of South Africa, 2016). Additional policies governing water and sanitation provision in Msunduzi municipality are summarised in Table 1 (chapter appendix).

Inequality

South Africa is a country that has faced significant inequalities in terms of spatial planning and the distribution of infrastructure. According to N. B. Mkhize (2018), the link between spatial planning and infrastructure planning must be considered to eliminate inequalities; a critical component of which involves the equitable provision of sanitation (Msunduzi Municipality, 2020). Currently, about 6% of households don’t have access to any form of sanitation, while 30% have pit latrines, 62% use toilets treated by the waterborne system (46% having flush toilets in their households). Use of waterborne flush toilets is highly correlated with both race and socio-economic status in South Africa. This is contradictory to the National Development Plan (Vision 2030) policy, which speaks in favour of equitable sanitation (Msunduzi Municipality, 2020).

In addition to spatial inequalities of sanitation provision, socio-economic factors are also very important. Low income residents often struggle to afford access to safe and dignified sanitation. To counter this challenge, city council customers who earn less than R4,000 month^{-1} qualify to receive assistance. A program, subsidized by the national government, subsidizes sanitation costs for this group, officially categorized as indigent. As of 2016, there were 4,473 households receiving free basic sanitation. This number dropped to about 1,255 households by the end of 2018 (Msunduzi Municipality, 2018), because the indigent status is not permanent, hence it is forfeited as the living standard improves.

Institutional roles

Sanitation policies developed at the national level are diffused to the provincial, district, and local municipality levels. The Department of Water and Sanitation (DWS) is responsible for framing and applying policy governing the sector at both the national and provincial level. The DWS developed the national sanitation policy (2016) to provide integrated sanitation services, coordinate institutional arrangements, ensure participatory sanitation planning, and ensure sound regulatory supervision.

The Water Research Commission (WRC) is a National Research and Development centre that was established through the Water Research Act (Act No 34 of 1971) following a period of water shortage. The institution tackles water quality issues associated with water scarcity, pollution resulting from anthropogenic activities, and the sustainable management of water resources. The key activities of the WRC are thus summarised below:

i. Promote coordination, cooperation and communication in water research areas
ii. Establish water research needs and priorities
iii. Stimulate and fund research according to water priorities
iv. Promote effective information and technology transfer
v. Enhance knowledge and capacity building.

Another critical institution is The KwaZulu-Natal Department of Co-operative Governance and Traditional Affairs (COGTA). COGTA is a provincial governing board that regulates the Local Government through the Municipal Systems Act (Act 32 of 2000) and Municipal Structures Act (Act 117 of 1998). COGTA is involved in the integrated aspects of municipal services provision, including governance, administration, municipal finance and integrated planning at a provincial level. Therefore, COGTA plays a role in ensuring that municipalities meet service provision standards.

Msunduzi Municipality is another key institution. The municipality, with authority stemming from section 98 of the Local Government: Municipal Systems Act, is a governance entity responsible for water and sanitation provision. The municipal by laws allows the city council to provide certain levels of sanitation provision at its own discretion. The municipality has total control over water resources and sanitation infrastructure within its jurisdiction, for example. The general functions of the municipality are summarised in an organogram (Figure 1, chapter appendix). The water and sanitation infrastructural development activities are performed by the infrastructure services of Msunduzi. The unit is responsible for the establishment and maintenance of sanitation infrastructure including off site and onsite waterborne or waterless systems.

Umgeni water authority is responsible for the bulk supply of water and wastewater treatment and is an additional key institution. Umgeni operates the Darvill WWTP and the small package treatment, Lynnfield Park WWTP. Umgeni water is a state-owned entity that is mandated to provide water services through water supply and sanitation provision to other water services institutions within its operation area. The entity was started in 1974 and is housed within the Government Business Entities, operating according to the Water Services Act (Act 108 of 1997) and the Public Finance Management Act (Act 1 of 1999). Its activities include:

I. Management services, training and other support services to other water services institutions, in order to promote co-operation in the provision of water services;
II. Supplying non-potable water to end-users who do not use it for household purposes;
III. Providing catchment management services on behalf of the relevant authority;
IV. Supplying water directly for industrial use, accepting industrial effluent and acting as a water services provider to consumers, which is done through approval from Water Services Authority.

The environmental health unit within Msunduzi municipality is responsible for the monitoring, effective wastewater treatment and water pollution control. Activities include collection, treatment and disposal of sewage, and control of the quality of surface water (including the sea) and ground water. They support proper and safe water and wastewater consumption. This is done through sampling and analysis of sewage wastewater.

Service provision

South African law recognises sanitation as a basic human right (Gounden, Pfaff, Macleod, & Buckley, 2018). Poor sanitation is one of the major contributors to water borne disease outbreaks such as cholera, which was evidenced in Kwazulu-Natal, South Africa in 1982 and 2001 (Nojiyeza & Amisi, 2008). Therefore, water and sanitation authorities must provide sanitation to every household within its jurisdiction areas.

Sanitation provision is categorized into different classes: (1) no sanitation, (2) essential sanitation, (3) basic sanitation and (4) full sanitation. In a “no sanitation” scenario, residents share unimproved facilities with neighbors or resort to other unhygienic practices such as the “black bucket system,” whereby a 20 liter bucket is used for defecation and subsequently collected for emptying on a weekly basis. The second level of sanitation, categorized as “essential” by Cape Town City (2008), is characterised by more than five people per household sharing a toilet. Basic sanitation involves the provision of at least a shared toilet, which serves a family of at least 5 people per household and this is deemed safe, reliable, hygienic, dignified, healthy, and environmentally safe. A ventilated improved pit latrine (VIP) is an example of a basic sanitation technology. The highest level of sanitation, termed “full sanitation,’’ involves a water borne sewerage system which can be either onsite or offsite waterborne (conservancy tanks, septic tanks, municipal sewage), or hygienic waterless technologies (Cape Town City, 2008).

Msunduzi municipality, as a water and sanitation services provider, has established Msunduzi municipality by-laws on sanitation (Msunduzi Municipality, 2020), which control the construction, management, and compliance of any sanitation technology within its jurisdiction to ensure that the system is not hazardous to human and environmental health. The Municipality Water and Sanitation Business Unit is responsible for establishment, replacement, and maintenance of sewerage infrastructure. In non- sewered rural areas, this agency provides sanitation in the form of VIP toilets. However, in some informal settlements, sanitation is also provided in the form of chemical toilets on interim basis (Greatwood, 2020).

The collection of excreta waste from conservancy tanks, septic tanks, and VIP toilets lies within the responsibility of the Msunduzi municipality on a pay as you go basis. The tariffs for the removal of conservancy tank contents and the emptying of pits is based on the volume removed by vacuum tanker (Table 5.11). There are several private companies involved in vacuum tank emptying business around the Msunduzi, however they must provide the service directly to consumers upon approval from the City Council (Msunduzi Municipality, 2014b).

Table 5.11: tariff rates of onsite waste removal or maintenance (Msunduzi Municipality, 2020). Costs based on either a per load or per septic tank basis.

Municipal service	Cost
Clearing of septic tanks within Council jurisdiction zone	R2283.0
Clearing of conservancy tanks during normal working hours for non-residential property (per load)	R720.98
Clearing of conservancy tanks during normal working hours for residential property (per load)	R360.49

Clearing of a VIP	R360.49
Clearing of a VIP (monthly tariff)	R56.08

The Msunduzi municipality tankers empty waste from conservancy tanks and septic tanks into the interceptor sewer (manhole) located in Plessislaer, Pietermaritzburg. The contents are then transported via the main sewer system to the Darvill wastewater treatment plant (WWTP). Legally, VIP contents must be directly transported to the nearest WWTP when they are emptied (Msunduzi Municipality, 2014b). However, some operators attempt to discharge contaminated VIP contents into the interceptor sewer, which overload the system. Detritus, illegal connections, and stormwater intrusion also contribute to the system overload. At the moment, the municipal sewer system is operating at almost 200% of its original design capacity. (Greatwood, 2020).

In rural areas such as Vulindlela, where VIP toilets are prominent pit emptying is a challenge due to inaccessibility. In addition to accessing homesteads on narrow, steep, and unimproved roads, long distances to the WWTP are prohibitive. As such, some private companies are considering deep row entrenchment as an alternative disposal practice. Onsite sludge burial followed by planting trees is also a promising alternative, however space for new VIPs is often limited.

All human excreta waste must be treated prior to final disposal as per the local municipal sanitation by-laws and the National Environmental Management Act. 59 (2008) (RSA, 2009). The Darvill WWTP is authorised and responsible for treating all the sewage emanating from the Msunduzi local municipality.

Service standards

All the sanitation service standards are governed by the legal framework in the specific study area (Tayler, 2018). The legal framework that regulates necessary standards for toilet design, collection services, treatment, and disposal are governed by various policies explained in Table 1 of the appendices. These standards must ensure that every sanitation facility has minimal negative effects on health, reduces vector transmission and odour, preserves human dignity, reduces exposure against harsh weather, and protects vulnerable groups such as women and children (Msunduzi Municipality, 2018). Therefore, all the conservancy tanks, chemical toilets, pit latrines, and septic tanks used in Msunduzi were designed according to standards accredited by the South African Bureau of Standards and the International Standards Organisation (ISO) (CSIR Boutek, 2005). Maintenance of these systems is regulated by the

Msunduzi tariff plan that covers activities such as sewer connection, clearing of drainage pipes, septic tanks, and pit latrines (Msunduzi Municipality, 2014b).

The VIP toilet constructed in Msunduzi, which is commonly used across the city-region, is classified as a basic sanitation technology as per the White Paper on basic water and sanitation. The design for VIPs in South Africa was done by Bester and Austin (1997), and accredited by the South African Board of Standards (SABS) (CSIR Boutek, 2005).

Msunduzi municipality has established standards for managing its waterborne sewerage system within its jurisdiction area. The municipality has structures in place to ensure optimum service provision for sewer collection. Therefore, the sewer master plan was established to address current and future challenges in the functioning of the sewer system (Msunduzi Municipality, 2016a). In addition, the connection of new households to the sewer system is regulated by the municipal by laws. The safe emptying of conservancy tanks, chemical toilets and VIP latrines is done via a tariff system approved by the Msunduzi city council. Msunduzi is unique to other countries such as Tanzania, where pit emptying is done manually in a risky manner but this is not socially acceptable by most people.

As per the DWA (2013) the faecal sludge must be treated before being released into the environment. Therefore, Msunduzi municipality has standards set in place for transportation, treatment and disposal of faecal matter. The contents emanating from VIP toilets must be delivered to the nearest WWTP. Any private company found discharging VIP sludge into the interceptor sewer is liable to a fine as per the Msunduzi Municipality (2014b) by laws. This is also applicable to industries discharging their effluent into the sewer system, which must obtain compliance licences to ensure that other hazardous chemicals are not being discharged. However, there are still some challenges with illegal dumping of sludge into the public drains.

The Msunduzi municipality wastewater treatment is controlled by the Umgeni water, a state owned entity. Umgeni water internationally recognised analytical laboratories accredited by the ISO board and other local authorities for monitoring wastewater. Key monitoring competencies for wastewater quality compliance and water sludge treatment residue disposal, which are reported on a monthly basis to the relevant regulatory bodies have been developed. The discharge of effluent into water bodies is done in accordance with the Water Act of 1998. Umgeni has been awarded a green drop status, implying its capability to treat wastewater is in compliance with the National Water Act of 1998 (Umgeni Water, 2019). The green drop standard requires 80% treatment efficiency of wastewater.

Sanitation planning and goals

Service targets

The NDP, established to fight poverty and inequality, developed a framework to achieve equitable economic infrastructure development, with a special focus on regional water and wastewater provision. This effort has improved service provision from 84% (2013) to 90% (2018). In addition, the NDP identified 18 strategic integrated projects (SIPs) to expand provision of basic water supply to 1.4 million households and sanitation to 2.1 million households (Msunduzi Municipality, 2018). As part of these targets, Msunduzi has detailed water and sanitation infrastructure development plans in Vulindlela, Pietermaritzburg, Edendale and the broader Msunduzi Municipality (Msunduzi Municipality, 2020). Specifically, municipal sanitation objectives are to provide 100% of households with water, 70% with water borne sewerage, 30% basic minimum VIPs, reduce no revenue water losses, reduce water service interruptions, and to respond to 100% of service interruptions within 8 hours (Msunduzi Municipality, 2020).

The Strategic Framework for Water Services (2003) gives a provision for a 10-year roadmap to address sanitation service delivery. As part of this framework Msunduzi, aims to eliminate all vestiges of the Apartheid era “bucket system”, open defecation, and to provide a minimum of basic sanitation to every household. Although the municipality has succeeded in eliminating the “bucket system”, work continues to achieve the other service targets. The struggle for the municipality to achieve these targets is driven by population dynamics; high rates of urbanisation, industrialisation and the uncontrolled emergence of informal settlements (Msunduzi Municipality, 2018), which is not only a challenge to Msunduzi but most South African municipalities (Ashipala and Armitage, 2011).

Special attention must also be given to sanitation in the school system. As per the National Sanitation Policy Draft (2016), basic sanitation is safe and dignified, and special care is taken to highlight the vulnerability of certain groups such as women and children. Recently, a child tragically drowned in a pit latrine in Eastern cape province, an incident that spurred government to call for emergency intervention in auditing unsafe infrastructure in schools, which should comply with the South African Schools Act of 1996.

The Department of Education has a mandate to improve undignified sanitation structures in schools by the year 2019/2020 (DWS, 2018). In alignment with the government call, Msunduzi municipality responded by identifying about 4,000 schools that need attention, with plans in place to eradicate unsafe sanitation by the year 2022 (Msunduzi Municipality, 2020). Although

VIP toilets are considered as an acceptable minimum standard as per the South African Schools Act of 1996, this system is hazardous, particularly for small children (Louton et al., 2015). Thus, the WRC has recommended that alternative water borne toilets such as pour flush toilets be considered for schools.

Public investments

Significant investments have been made by the Msunduzi municipality in order to achieve the proposed sanitation service delivery targets. The municipality has reserved funds for capital investments in the water and sanitation sector (Table 5.12) through various funding sources such as Municipal Infrastructural Grants (MIG), Department of Human Settlements funding (DOHS), Municipal Water Infrastructural Grants (MWIG) and City Council (CNL) funding (Msunduzi Municipality, 2020). The funds aim to provide at least 70% water borne sanitation and 30% provision of non sewered sanitation within Msunduzi in the near future.

Table 5.12: The Sanitation service delivery budget for Msunduzi municipality in from 2019 - 2022.

Msunduzi sanitation service delivery budget		
2019-2020	2020-2021	2021-2022
R79,018,000	R107,329,000	R135,486,000

Expansion of service

The Msunduzi municipality in accordance with the Municipal Systems Act (No. 32 of 2000) and the National Sanitation Policy Draft (2016) aims to provide basic sanitation to all citizens including the indigent group.

The municipality continue to provide sanitation services to both the affluent and the indigent groups. As the population continue to rise the pressure is imposed on the existing sewerage systems. The municipality has set up a master plan to upgrade the sewerage system in the urban, which has been completed and incorporated into the Water Services and Development Plans (WSDP) (Msunduzi Municipality, 2018). The Umgeni Water Authority has been upgrading the Darvill WWTP and the Lynnfield WWTP to increase the treatment capacity to contain the growing populations. Currently the Darvill WWTP upgrades are 95% complete.

The municipality sanitation backlog is 100% complete, there is no “bucket system”, however the challenge remains with the uncontrolled urbanisation. Due to industrialisation most rural people are migrating to urban areas in search of greener pastures. Most people end up staying in informal settlements where municipalities can hardly provide them with basic services. Therefore, total eradication of sanitation backlog is impossible.

The municipality continue to provide minimum basic sanitation in the form of VIPs in rural areas to cope with population increase. Furthermore, there are no current emptying plans hence filled up toilets are replaced with new ones. The collection, transportation, treatment and disposal of faecal waste to protect human health and the environment, in accordance with the National Sanitation Policy of 2016, is still not well established in rural areas.

Monitoring and reporting of service access

The monitoring and reporting process in Msunduzi is done as per the legislative requirements through the Annual Performance Report (APR). The report is divided into two different sections. Section A is the functional service delivery reporting, and section B is the annual report of the service delivery budget implementation plan (SDBIP) and annual report of the operational plan. The municipality implements an Organisation Performance Management System (OPMS) as a monitoring and evaluation tool. The OPS involves municipal business unit managers, councillors, and community representatives in order to monitor services delivered in a way to increase transparency and accountability of the municipality. In accordance with the national and provincial regulations, the municipality sets up and monitors key performance indicators which have been included in the SDIBP.

Monitoring of sanitation services levels are done across the value chain. This involves sanitation infrastructure development, and service delivery in terms of collection, transportation, treatment and disposal or reuse. The Msunduzi municipality has been granted a green drop status. The green drop program was established by the Department of Water and Sanitation with an aim to identify and develop the core competencies required to improve the level of wastewater management in South `Africa (Brouckaert et al., 2016). According to Ntombela et al., (2016), the green drop certification is granted when the following parameters achieve a minimum score of 90%:

- Human resources in terms of process control, maintenance and management skills;
- Wastewater quality monitoring;
- Credibility of wastewater sampling and analysis methods;
- Submission of wastewater quality results;
- Wastewater quality compliance;
- Management of wastewater quality failures;
- Stormwater and water demand management;
- By-laws;
- Capacity and facility to reticulate and treat wastewater;

- Publication of wastewater quality performance;
- Wastewater asset management.

The Darvill WWTP is struggling to meet the established 80% treatment compliance for a long period. This has been due to illegal connections to the main sewer, growing population, industrialisation and dumping of illegal stuff into interceptor sewer, coupled with stormwater ingress during high rainfall periods. This has therefore forced Umgeni to upgrade the Darvill WWTP from the current capacity of 75Ml per day to a maximum figure of about 120Ml per day (Msunduzi Municipality, 2016a). The similar challenge is being faced by Lynnfield WWTP, which is currently operating at 0.2Ml per day and Umgeni has prospects to upgrade it to 1Ml per day (Umgeni Water, 2019).

In terms of the section 46 of the Municipality Systems Act measures are taken to improve overall municipal performance. The performance of each business unit is audited by the office of the city manager who decides on which action take as per outcomes reported.

Current sanitation landscape

Overview

At the moment in Msunduzi municipality, 6% of the households don’t have access to any form of sanitation, 30% utilize pit latrines, and 62% use some form of water borne sanitation. At the same time, the municipality recognizes the Constitutional clause 108 of 1996 (Bill of Rights), which asserts the right of all South African citizens to dignity and access to an environment that is not harmful to their wellbeing (RSA, 1996). Thus, the municipality thrives to provide, at a minimum, basic sanitation to all residents, and waterborne sewerage wherever possible. As stated above, the municipality is striving to achieve this goal. Several strategic approaches have been put in place to improve the sanitation landscape within the municipality. The sanitation master plan seeks to address sanitation coverage within the urban core by expanding the size of the sewer system, and to provide interim solutions such as chemical toilets in informal settlements such as Jika Joe (Greatwood, 2020).

The scenario is different in rural zones such as Vulindlela, which is outside the municipal centralised sewerage zone. In this area basic sanitation is provided in the form of VIPs. The critical challenge facing residents that utilize VIPs deals with maintenance; no solution is in place that allows for the removal of fecal sludge when a pit is full. Hundreds of pit latrines across these wards are now full and present a risk to human and environmental health. To ensure sanitation equity the local municipality is searching for solutions that will allow for a sustainable and safe solution to this growing crisis.

Human waste generation

The sanitation demands and increased human excreta generation are driven by a growing population. In Africa, faecal matter production is roughly 128 grams person^{-1} day^{-1}, while urine is 1.42 L person^{-1} day^{-1} (Rose, Parker, Jefferson, & Cartmell, 2015). Thus, in Msunduzi local municipality, a population of 679,038, generates approximately 31,800 tons year^{-1} (faecal matter) and 352 Megalitres of urine year^{-1}. This waste is environmentally hazardous and must be safely contained, transported, treated and disposed/reused. The methods and extent to which human excreta is managed properly differ within various households. As reported, 30% of human excreta is contained using VIP toilets, 18% using chemical toilets, conservancy tanks or septic tanks, 46% via the municipal sewerage system, and 6% is via open defaecation. VIP toilets are commonly utilized in rural areas of the municipality such as Vulindlela, while conservancy and septic tanks are found in Greater Edendale and most rural schools. The municipal sewer system is located only within wards 10-38 (Figure 5.22). Most of the temporary sanitation solutions such as chemical toilets are provided in informal settlements.

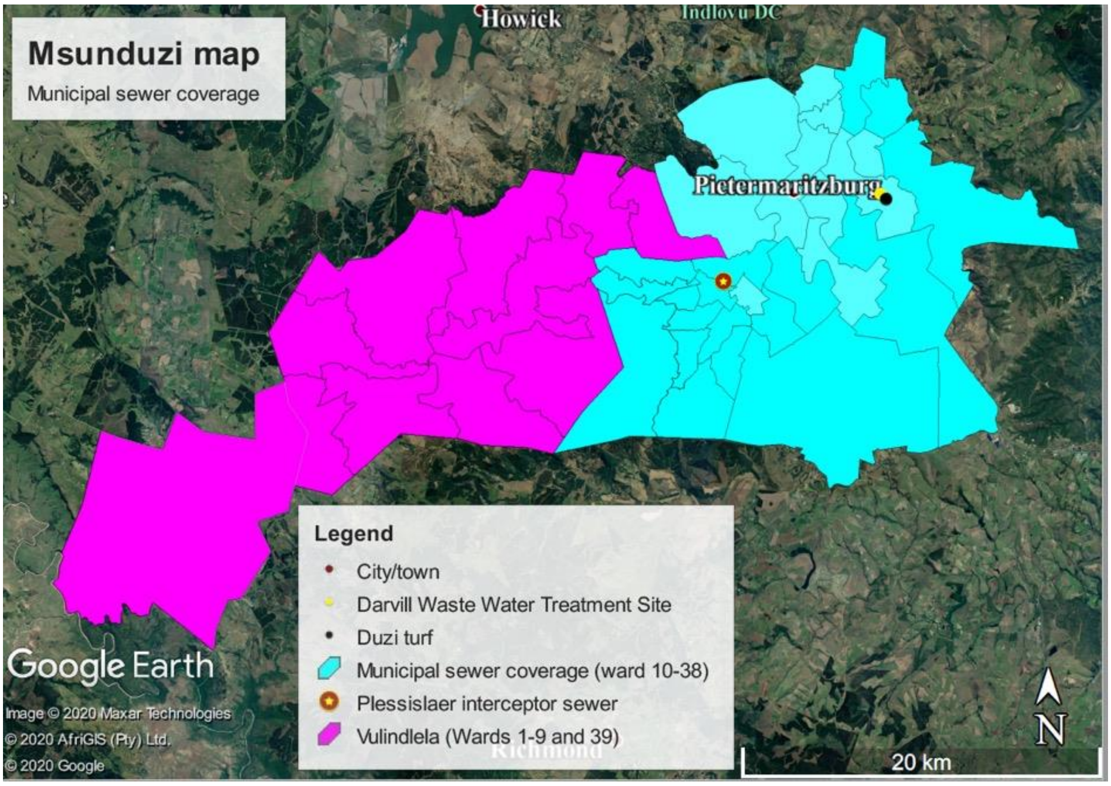

Figure 5.22: The areas under the Msunduzi sewerage system (ward 10-38), showing the location of the interceptor sewer (Plessislaer), rural areas (Vulindlela), Darvill Wastewater Treatment Plant and the Duzi turf.

Collection, treatment, and disposal

From the existing sanitation infrastructure in Msunduzi (**Error! Reference source not found.**), there are no ecological toilets (such as urine diversion toilets; UDDTs) and "bucket toilets", despite being reported by Statistics South Africa (2016). According to Mr. Mike Greatwood (in personal communication), the ecological toilets might have been erroneously reported by enumerators from Statistics South Africa who did not understand differences amongst different sanitation systems they surveyed. Furthermore, the information reported by Msunduzi Municipality (2018) does not show any presence of bucket and ecological toilets within the local municipality, an indication that the municipal road to achieve its target is on course.

The current VIP toilets do not separate urine from faeces, the superstructures are collapsing, and emptying of the contents is difficult. The eThekwini municipality has recognised the urine diversion toilet as the minimum standard for basic sanitation, and rolled out programs to replace all VIP toilets in its area of jurisdiction (Gounden et al., 2018). Msunduzi still recognises VIP as the minimum basic toilet, which constitutes about 30% of the total toilets in the municipality (Figure 5.23). The municipality is continually rolling out VIPs in non sewered rural areas. Considering, the environmental impacts of VIP toilets on groundwater resources, their continuous use is contradictory to the sustainable development goal number 6.6, which encourages the protection of water resources from pollution.

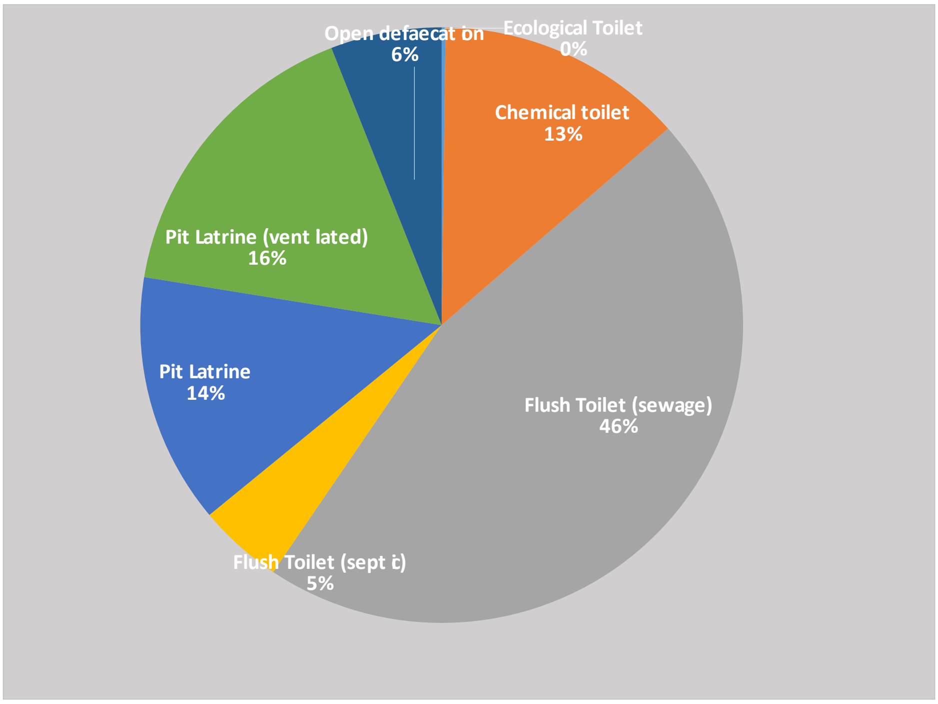

Figure 5.23: The provision of toilet types across Msunduzi (Statistics South Africa, 2016).

As a Water Services Authority, the Msunduzi municipality water and sanitation unit is responsible for the management of sanitation services within the local municipality (Greatwood, 2020). About 64% of the total human excreta is safely collected by the municipality via municipal tankers “honey suckers” or is deposited directly into the municipal sewer system. Of this total, 18% of residents use conservancy tanks, chemical toilets and septic tanks and 46% are connected to the central municipal sewerage. Mr. Mike Greatwood confirmed that there are no contracted private emptying companies, although other companies such as Sanitech and Partners in Development (PID) offer the service. The municipal collection of septic tanks is less frequent and in some instances the service is constrained by the unavailability of adequate fleet, leaving the responsibility to the residents who must ensure that their septic tanks are serviced when full. In sewered areas, Msunduzi municipality is responsible for the management and maintenance of the sewerage system. The scenario is different for rural residents living in Vulindlela, a non sewered region where VIP latrines are prominently used. Due to the rugged terrain in Vulindlela, accessibility of honey suckers is a challenge and most VIPs are not being emptied. In addition, the municipality did not initially have plans to empty pit latrines, VIPs where constructed as part of basic sanitation program and dealing with full toilets was the owner’s responsibility. The old structure was supposed to be abandoned and the owner has to construct a new one (Msunduzi Municipality, 2016b). Some households pay private companies to empty their pits, but the nature of the latrine contents prohibits the use of vacuum tankers hence manual emptying can be a practical option as being done in most Asian countries such as India.

The Darvil WWTP has an average treatment efficiency of 83.7%, which is above the legal standard of 80%, meaning that about 17% of the waste delivered to the site is lost through other processes such as burst pipes and stormwater intrusion. However, during the last three years the plant has operated operating below 75% treatment efficiency (Umgeni Water, 2019). Wastewater is treated through conventional methods, including mechanical screening, sedimentation, and activated sludge processes to produce thickened sludge. The treated wastewater is not used for potable purposes, but rather is discharged into the river. However, there are prospects for portable wastewater recycling and the infrastructure has already been established and is awaiting respective protocols (Umgeni Water, 2019). Currently there are four anaerobic reactors to produce energy used to heat the treatment system (Personal communication with Mluleki Mnguni during a site tour). The primary sludge from pre-fermentation process and the secondary sludge from the activated sludge reactor are mixed together, stabilised and transported to a facility operated by Duzi Turf (Pty Ltd). However, disposal of sewage sludge in general is a challenge for Umgeni (Mluleki Mnguni, personal communication).

Current challenges

Currently, many of the VIP latrines are filled up and efforts to empty them have proven unsuccessful due to the inaccessibility of rural areas such as Vulindlela (Msunduzi Municipality, 2016b). Consequently, faecal sludge is contained but not emptied, which is contradictory to the National Water Act (1998).

In addition to filled up toilets, some of the toilet superstructures are damaged, forcing other residents to dig new pit latrines next to the old structure. The VIPs sludge is mixed up with various inorganic wastes due to lack of proper education on handling such sanitation systems. This inappropriate debris from VIP sludge damages vacuum tankers, making emptying by municipal vehicles impossible (Partners in Development, 2019).

However, Darvill WWTP has struggled to meet wastewater treatment standards for the past three years. This could be attributed to frequent power outages, over straining of the system through illegal dumping of sludge in the municipal sewer system, stormwater intrusion, and growing waste flows resulting from urbanization.

Msunduzi is one of the 21 municipalities that has been operating below the minimum standards so they were placed under administration. Therefore, they are reporting on a monthly basis to back to basics. This improves municipal governance and administration so that it can achieve its service targets. They have, furthermore, implemented operational and maintenance plans for various services including sanitation.

The second concern lies within the conveyance of excreta waste from households to treatment plants. Based on the current municipal literature there are no plans for improving collection of VIP contents in areas such as Vulindlela. However, the budget plans to cater for infrastructural development through construction of VIP toilets. Some of the municipal plan is to improve water borne sewerage system in Msunduzi urban area, for example, part of Edendale is served with conservative tanks and the contents are discharged into the interceptor sewer in Plessislaer. Edendale was allocated R185 million in the 2016 sewer master plan.

The municipality is taking sanitation environment compliance seriously. Sewage spills resulting from blockages and aged pipes during containment and transportation of raw sewage to the WWTP is a source of environmental pollution. According to Msunduzi Municipality (2020) the number of reported blockages increased from 2,000 (2011/2012) to more than 3,500

(2017/2018). Due to these blockages the municipality has incurred a lot of operational expenses. Therefore, approximately R977 million have been allocated to upgrade Darvil WWTP by the Umgeni Water Authority (Umgeni Water, 2019). The Umgeni Water Authority has also invested in product quality for customer satisfaction; R213 million (2018) was invested for infrastructural maintenance. It is worth nothing that Umgeni Water Authority is cognisant of the community dynamics. The company seeks to contract, wherever possible, with black owned companies and supports female owned enterprises (Umgeni Water, 2019).

Shit Flow Diagram (SFD)

Containment technologies in Msunduzi

Faecal sludge containment technologies in Msunduzi are reported in Table 5.13. The containment of faecal sludge is primarily accomplished with either flush toilets (45.9% of population) connected to municipal sewage, or onsite solutions such as VIPs, septic/conservancy tanks, or chemical toilets (49% of population). There is one offsite decentralised wastewater treatment package serving a small population in Lynnfield park, Msunduzi local municipality, which makes an insignificant proportion of total faecal matter contained (0.1%).

Table 5.13: The description of sanitation containment with special reference to Msunduzi local municipality context.

SFD variable	Description of sanitation containment	Population using it	Proportion	Msunduzi description
F2	FS contained on site	203,973	30%	VIP toilets
		30,980	5%	Septic tanks
		91,858	14%	Chemical toilets and conservancy tanks
OD9	Open Defecation	40,477	6%	Informal pits, people in unserved areas
W2	WW contained centralised (offsite)	310,985	45.9%	Waterborne flush toilets connected to the centralised wastewater treatment plant.
W3	WW contained (decentralised)	764	0.1%	Waterborne flush toilets connected to decentralised package plants.

The distribution of sanitation systems across different residential areas of Msunduzi shows that rural traditional areas and informal settlement (shacks) are the least served as shown by largest population practicing open defaecation (Table 5.14). People in rural traditional areas of Msunduzi are using VIPs toilets which are rarely maintained; sometimes the superstructures break or the toilet fills up without emptying (Msunduzi Municipality, 2016b). As a result, people end up practicing open defaecation. There are no UDDT toilets in the Msunduzi municipality. The flush toilets are predominantly used in formal houses of the peri-urban and urban areas. About 5% of the Msunduzi total population, residing in Ashburton area, are using septic tanks due to availability of enough land for such sanitation systems. Conservancy tanks and chemical toilets are found within the urban informal settlements.

Table 5.14: Population proportion per containment type per dwelling type.

	Dwelling Type	Open defecation	VIP Toilets	UDDT *	Chemical toilets and conservancy tanks	Flush toilets connected to WWTP	Septic tanks	Total
Rural	Rural- traditional	16,865	44,994					61,859
	Rural- formal house		59,992					59,992
Peri-urban	Shacks	16,865	44,994					61,859
	Formal house					78,329		78,329
	Apartment building					78,329		78,329
Urban	Shacks	6,746	53,993		91,858			183,577
	Formal house					76,762	30,980	76,762
	Apartment building					78,329		78,329
	TOTAL	40,477	203,973	0	91,858	311,749	30,980	679,037
	PERCENTAGE	6%	30%	0%	14%	46%	5%	100%

*UDDT is the Urine Diversion Dehydrated Toilets

Transportation of faecal sludge

The SFD matrix showing inputs for containment technologies, proportion transported and treated is reported in Table 2 of the appendices. The flush toilets (46%) are connected to the centralised sewerage system where wastewater is conveyed to the Darvill WWTP. Flush toilets in Lynnfield park are connected to the package WWTP and they contribute to only 0.1% of the total faecal sludge conveyed within Msunduzi.

Septic tanks found in Ashburton (5%) are generally connected to the sock pit. The Ashburton area allows the use of septic tanks since a large portion of the area is categorised as ‘’garden lot zone 1 and 2’’, meaning areas with lot sizes 1 and 2 hectares respectively. The septic tank effluent drains into soakaways because the soil permeability allows this with no problems reported by the time when this was reported (Msunduzi Municipality, 2014a). Some septic tanks found in Lynnfield drain into soakaways and discharge into Lynnfield WWTP. The remaining faecal sludge emptied from the septic tanks is discharged into the interceptor sewer, according to Greatwood (2020) 99% of the contents are estimated to eventually reach the Darvill WWTP, when giving a room of 1% losses through burst pipes.

The conservancy tanks and chemical toilets are fully lined, and they don’t have any outlet or overflow. Their contents are regularly emptied and discharged into the interceptor sewer and subsequently conveyed to the Darvill WWTP. The VIP toilets are generally semi-permeable and the bottom is open (Bester & Austin, 1997). The faecal sludge contained in the VIP toilets is not emptied therefore remained buried in the pits; there is no overflow or outlet. Since there is no borehole water consumption in Msunduzi this has no risks on groundwater quality.

Groundwater contamination risk

Groundwater constitutes about 97% of total freshwater potentially available for human consumption (Lawrence et al., 2001). The groundwater is vulnerable to pollution from various anthropogenic activities such as agriculture and sanitation systems. Agricultural systems release nutrients such as nitrates into the groundwater. Excessive nitrate levels in drinking water can cause methemoglobinemia, a condition in which oxygen uptake by red blood cells is impaired (Fewtrell, 2004). Just like agriculture, sanitation systems may also contaminate groundwater resources with either nutrients or water borne pathogens such as typhoid, cholera and helminths.

According to Lawrence et al. (2001) different factors that can cause groundwater pollution include soil type, groundwater table depth, location of the sanitation system and the source of drinking water. According to the SFD parameters for Msunduzi municipality there are low groundwater risks due to inexistence of borehole water for drinking purposes (Msunduzi Municipality, 2019; Ntuli, 2020; Statistics South Africa, 2016). Since the municipality is looking forward to install boreholes in underserved communities such as Vulindlela (Ntuli, 2020), groundwater risks with regards to soil type and lateral spacing needs to be assessed.

Data quality

The shit flow diagram graphics shows faecal sludge generation, containment, transportation, treatment and disposal/reuse (**Error! Reference source not found.**). Faecal sludge from 46% of the total population in Msunduzi is contained by flush toilets connected to the centralised sewerage system. About 1% of the total sewage wastewater conveyed to the WWTP is not delivered. According to Greatwood (2020) an estimated 1% of the wastewater conveyed to the WWTP is lost through burst pipes. According to Mr Mluleki during a site visit at Darvill WWTP, stormwater overflows are common during the rainy season, contributing to some extent of sewage spills as the WWTP inlet floods (Umgeni Water, 2019). Perforated steel manholes installed to allow stormwater flushing during rainy periods are subject to theft as a result debris enter the systems thereby causing blockages (Msunduzi Municipality, 2016a). Stormwater monitoring has been planned for through various pump stations around Msunduzi, meaning that the issue is being addressed in the municipality therefore 1% wastewater losses are somehow validated.

Onsite sanitation technologies reported in **Error! Reference source not found.** are comprised of conservancy tanks, chemical toilets, septic tanks and VIP toilets. The 33% of faecal sludge contained but not emptied emanates from VIP toilets. This is the sludge that is not delivered to the treatment plant but remains in the pits. According to Greatwood (2020), most of the VIP toilets are located in Vulindlela where they were constructed to provide basic sanitation. Pit emptying service is available on a pay as you go basis, but people are not willing to pay for the service. Furthermore, the areas are inaccessible making it difficult for municipal tankers to reach for emptying. As a result, people abandon the toilet and construct the new one after filling up. Despite having some alternatives such as emptying faecal sludge and disposing in into deep row entrenchment, followed by growing trees, the practice is not yet being done in Msunduzi (D. A. Still, Lorentz, & Adhanom, 2014).

There was no conclusive information on the numbers of septic tanks that are not being emptied in Msunduzi since the practice is being done by various private companies and the municipality. The billing information could not be obtained since some municipal officers were not working during the Covid 19 lockdown. However, based on the information provided by Greatwood (2020), the practice is being done by the municipality on pay as you go basis as well. The proportion of population using septic tanks is very small, about 5% (***Table 5.14***), predominantly in Ashburton area which is highly accessible. Furthermore, septic tank emptying service is less frequent and can be done over a period of 5 years depending on the size of the tank (Norris, 2000). Therefore, based on this information, it was assumed that all the faecal sludge (100%) from the septic tanks was being emptied.

The average treatment efficiency of Darvill WWTP is 83.7% whereby the treatment plant has been struggling to operate above 80% for the past 3 years due to stormwater intrusion and upgrade works taking place at the site (Umgeni Water, 2019). Therefore, 83.7% of all the faecal sludge emanating directly from flush toilets and indirectly from containment technologies (conservancy tanks, chemical toilets and septic tanks sludge) discharging into interceptor sewer is safely treated. The Darvill WWTP upgrades were expected to complete by 2020, however the progress was hindered by the contractor who underwent business rescue, therefore completion of the upgrade will improve the plant treatment efficiency.

About 6% of the faecal sludge coming from Msunduzi is unsafely managed through open defaecation. A report by Msunduzi Municipality (2018) shows that there are no bucket toilets and residents in informal settlements are served by chemical toilets. This open defaecation is probably being done in informal pits and by people with no sanitation access in rural areas. In addition, uncontrolled urbanisation is making it difficult for the municipality to eliminate sanitation backlogs (Msunduzi Municipality, 2018), since most of the people coming to towns and cities are living in informal settlements. These people do not have immediate access to sanitation as a result they practice open defaecation.

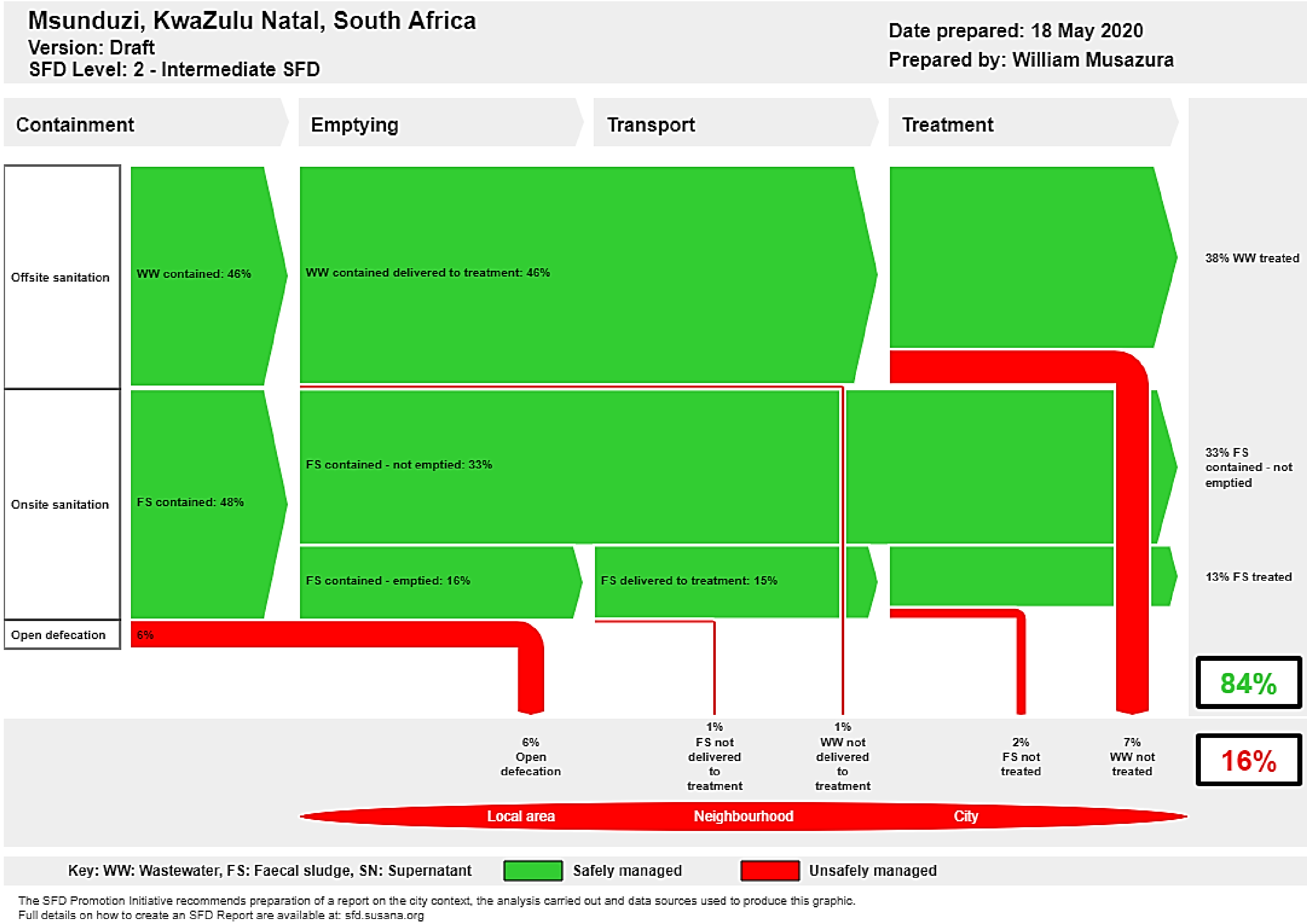

Figure 5.24: The Msunduzi municipality shit flow diagram graphic.

Local perspectives

Content matter specialists- Offsite sanitation

The range of sanitation service chains, extent to which sanitation services are effective, reliable, achieve performance standards and targets, respond to existing demand services, and address future demands were assessed.

About 62% of the residents in Msunduzi was estimated to be using the offsite sanitation, except Lynnfield which is served by a package decentralised WWTP. However, this figure was including chemical tanks and conservancy tanks which are disposed into the main sewer system. The offsite sewerage system serves residents in urban areas of Msunduzi local municipality.

According to an interview with Mr. Greatwood approximately all the wastewater emanating from the city reaches the WWTP. However, there is a room for some losses through burst pipes, which were marked negligible. Therefore, 99% eventually reaches the WWTP. This was almost in agreement with the figure of 96-97% estimated by Mr. Royal Nzuza. This shows that the sewerage system is very efficient in safe transportation of wastewater to treatment plants, despite having challenges in illegal discharge of some sewage sludge into the main sewer system by bogus private pit emptying companies.

The wastewater treatment in Msunduzi is done at Darvill WWTP, a facility that is operated by the Umgeni Water Authority. According to Mr. Mluleki, the wastewater treatment is done following a conventional method which involve stormwater diversion, mechanical screening, primary sedimentation, activated sludge processes, phosphate precipitation using aluminium, secondary clarification to separate and return activated sludge, chlorination of final effluent and prethickening for primary sludge.

According to Mr. Royal Nzuza and Mr. Greatwood, wastewater treatment compliance was estimated to be between 95-100%. They attributed this to Umgeni being an entity that has a green drop status with a water use licence issued by the Department of Water and Sanitation. However, the interviewed specialists recommended further confirmation in the Umgeni final report after highlighting that the entity was having some challenges. Further confirmation in Umgeni Water (2019), wastewater treatment compliance is one of the major issues faced by Umgeni water. The entity was reported to achieve an average of 84% wastewater treatment efficiency; however, the treatment efficiency has been operating below 80% for the past three years. This has been attributed to ongoing upgrades, power failure and excessive stormwater intrusion as the plant is operating above its potential capacity. However, this is expected to normalise soon after the completion of the upgrade activities.

As the urban population continues to grow the Msunduzi municipality is expected to handle wastewater generation. Current challenges being faced include aged infrastructure which was made to cater for small populations. Secondly the WWTP is under pressure as increased flows from stormwater intrusion and illegal connections are burdening the treatment plant capacity. Two entities involved in wastewater management will play pivotal roles; the Umgeni Water Authority is responsible for wastewater treatment plant operations and Msunduzi municipality is responsible for sewerage infrastructure management. The Msunduzi municipality has a sewer master plan in place aiming to increase wastewater transportation capacity to WWTP. The municipality have plans to replace aged pipes to minimise bursts. In addition, Umgeni Water Authority has been working on upgrading the WWTP from 75 Ml day^{-1} to 120 Ml day^{-1}. According to Mr. Royal Nzuza and Mr. Greatwood, initially the municipality planned to construct a new WWTP, however this was deemed expensive, therefore, upgrading the existing one was taken as a viable option.

The treated wastewater is currently not used for any purpose, according to Mr. Royal Nzuza and Mr. Greatwood, the water is discharge into the river. Indirect water use might be happening along the river course. During a site visit at Darvill WWTP, according to Mr. Mluleki, the Umgeni Water Authority has established a pilot facility to assess the feasibility for direct portable water use of treated wastewater. The wastewater sludge produced, and treatment residues are being used to produce turf by Duzi Turf (Pty) Ltd. According to Mr. Mluleki during the site visit, there have been some farmers who were interested in obtaining the wastewater sludge, but they were collecting it inconsistently. Therefore, the accumulation of sewage sludge was one of the challenges the entity was facing as it must be safely disposed.

Onsite sanitation

The VIP toilets constitutes 30% of the total sanitation containment technologies in Msunduzi, with no UDDTs available. According to Mr. Greatwood there are not many septic tanks in use; those that are utilized are primarily found in Ashburton. The septic tanks are connected to the French drain soakaway system (Nzuza, 2020). There is also a small proportion of conservancy tanks and most of them are found in schools; 50% being concentrated in rural schools. However, the department of education have been planning to eradicate them so these are no longer installed in new schools, which should have sewer systems (Greatwood, 2020).

Vacuum tankers owned by the Msunduzi municipality Water and Sanitation business unit are used for emptying toilets on a pay as you go basis (Greatwood, 2020; Nzuza, 2020). However, most VIPs are not emptied since some of the sludge emanating from these toilets contains a lot of trash which damage vacuum pipes (Greatwood, 2020; Nzuza, 2020). In addition, accessibility to these toilets is a challenge due to settlement patterns and terrain. Therefore, manual emptying is the best option as done in other countries such as India and Tanzania, followed by onsite burial in deep row entrenchments (Greatwood, 2020). This cannot be applied to South Africa due to negative perceptions toward handling human excreta waste (Greatwood, 2020). As a result when the VIP toilet is full the superstructure is moved, leaving the pit behind (Nzuza, 2020). Emptying septic tank sludge is not a challenge since it contains less debris.

Open defaecation is not common in Msunduzi. Mr. Royal Nzuza estimated it to be about 3%, which is not far from 5.5% confirmed by Mr. Greatwood. According to Mr. Greatwood, everyone has access to sanitation, including people in informal settlements. This value could open defaecation value could be attributed to other unserved people in farms (Nzuza, 2020) or even informal pits (Greatwood, 2020).

Treatment and disposal of onsite sanitation faecal sludge is being done mostly in areas served by septic tanks, conservancy tanks and chemical toilets (Greatwood, 2020). The sludge from septic tanks has no debris making it easier to empty using vacuum tanks. As for chemical toilets and conservancy tanks the contents are easily collected by municipal vehicles and sometimes private emptying companies. The collected stuff is disposed into the interceptor sewer near Plessislaer police station. This is transported through the municipal sewer system and eventually reach the Darvill WWTP, where treatment is done. According to the municipal by laws sludge collected from VIP toilets must be transported to the nearest WWTP (Nzuza, 2020), however some bogus emptying companies end up discharging faecal sludge into the interceptor sewer causing some blockages in the system. However, the proportion of VIP sludge that is being emptied is negligible, therefore most of it is not being collected, treated and disposed/valorised (Nzuza, 2020).

Effectiveness and reliability of existing services

The effectiveness and reliability of sanitations depends on how the value chains are managed in a dignified, environmentally sound, equitable, sustainable and safe way.

Umgeni Water Authority which runs the Darvill WWTP is responsible for wastewater treatment, quality monitoring and reporting in compliance with the DWA (2013) general authorisation for wastewater discharge into water bodies. The Umgeni Water Authority has been awarded a green drop status by the Department of Water and Sanitation, meaning it has the capacity (resources, human capacity and reliable operating procedures) to treat wastewater to the Department of Water Affairs satisfaction (Nzuza, 2020). Despite having the capacity to treat wastewater to the general national standards, there are some times when the plant does not comply with the recommended standards, like currently the treatment capacity is relatively lower (Greatwood, 2020).

The demand for sanitation services is increasing due to increasing population, industrialisation and urbanisation (Greatwood, 2020; Nzuza, 2020). Therefore, upgrade of the existing sewerage system is required to meet the demand. However, the Darvill WWTP upgrade is being put in place.

There were mixed views on community perceptions towards waterborne and onsite dry sanitation systems. According to Mr. Greatwood resentment towards onsite sanitation systems exists. Most people prefer water borne sanitation to dry onsite systems as people perceive them to be prestigious. However, Mr. Nzuza had another view on water borne sanitation; although people aspire to have more advanced sanitation systems in their homes, they appreciate available onsite sanitation as they are most possible available options.

There are different payment structures for sanitation services in Msunduzi. Sewage charges are based on water consumption through meter readings (Greatwood, 2020). People using septic tanks and VIP toilets pay for emptying (Greatwood, 2020).

There is minimal maintenance of onsite sanitation technologies from the municipality. Therefore, the owner is responsible for emptying the pits. People are not willing to pay for emptying tariffs, a problem common in rural communities since they rely on government support for everything. As a result, toilets are not being emptied so when they are full the old superstructure is abandoned. Sometimes other people dig up pits next to the old toilet, which is risky (Greatwood, 2020).

The municipality is responsible for the disposal of faecal sludge. The collected sludge must be disposal at the nearest WWTP. However, there are no enough vehicles to ferry sludge to nearest WWTP, hence the service is not frequent (Greatwood, 2020). Some private emptying companies discharge VIP sludge into the interceptor sewer where it causes blockages in the sewerage system.

Currently the faecal sludge is not being valorised in Msunduzi (Greatwood, 2020; Nzuza, 2020). This is an opportunity for RUNRES project to explores ways in which sludge can be collected, treated and reused. Much information is still needed especially the feasibility of valorising faecal sludge. Mr. Greatwood warned about political dynamics when piloting in communities, residents in various wards might build resentment when studies are not being done in their area. Furthermore, Mr. Nzuza stressed out about understanding sludge quality for reuse due to presence of industries illegally discharging wastewater in certain WWTP. He gave an example of Mpofana WWTP; where the sludge is high in heavy metals due to textile companies operating in the area. Currently, the only reuse option available for faecal sludge at Darvil WWTP is application to the land where Duzi Turf is using it for turf production (Mr. Mluleki, personal communication).

Community members

The community perspectives on the sanitation service provision, quality, investments and policies were thus conducted in three various residential areas of Msunduzi, which are the urban, peri-urban and rural areas. Findings for the Focus Group Discussion (FGD) are discussed in the following sections.

Urban zones

The residents in urban areas of Msunduzi region use flush toilets connected to the centralised wastewater treatment system. Although it has been reported that there is a certain proportion of residents in Ashburton are using septic tanks however none of the participants confirmed using it. This could have been due to a very small group (5%) using septic tanks (***Table 5.14***) and no one participated from Ashburton in the exercise. According to Greatwood (2020) some residents in informal settlements of Msunduzi are using chemical toilets but this could not be confirmed, therefore high proportion is connected to the main sewer. The residents were satisfied with their existing sanitation system and pointed out it was enough and no improvements they expect to see.

Msunduzi municipality water and sanitation department is responsible for managing sewerage systems in the urban areas. The division is responsible for repairing burst pipes and anything related to toilets remains the owner’s responsibility.

The residents felt that the sanitation system protect the human and environmental health since burst pipes are attended on time. On the hand there are no unmanaged pit latrines, the available sewerage system conveys wastewater to the treatment plant where it is safely treated and disposed.

Despite experiencing high quality sanitation service, residents feel that there are no opportunities for them to express their views on improvements they might want to see in their sanitation systems.

Peri-urban areas

The participated residents from Sobantu a peri-urban area in Msunduzi local municipality highlighted that they are using flush toilets connected to centralised sewer system. However, one of the members mentioned the use of informal pits and other form of sanitation in ward 35 of Sobantu, which is an informal settlement. However, this confirms that there are fewer flushing toilets in peri urban areas compared to urban areas (Msunduzi Municipality, 2020).

The residents were happy with the sanitation system despite issues related to aged pipes. It was raised that the sewerage system was established as far as 60 years back. As a result, the pipes are continuously bursting as the population continuously increase. This has been confirmed by the Msunduzi municipality and incorporated in their master plan, which aims to replace the aged pipes and upgrade the wastewater treatment plant (Msunduzi Municipality, 2020).

Msunduzi municipality was singled out as responsible for the maintenance of the sewerage system. As explained earlier, the user is responsible for managing the toilet. According to one of the participants, people are happy with municipality work on sanitation, but the maintenance is minimum. The participant even dated back the last maintenance work to as far as 1999, however it was not clear which type of work was being mentioned. According to Msunduzi municipality the response time to burst pipes is 8 hours or less (Msunduzi Municipality, 2020) and one participant stated that the municipality responds to burst pipes outside the yard and this takes 2 to 3 days. However, considering points raised in the previous focus group session it can be concluded that the municipality response to burst pipes differs in peri-urban and urban areas.

The impacts of the sewerage system on human and environmental health was not an issue as the participants did not report any water borne diseases. Basing on points raised by residents the human and environmental health risks can be attributed to continuous bursting of aged pipes. This is further exacerbated by slow response to burst pipes as mentioned in the previous paragraph.

Awareness on good sanitation management practices was suggested by one of the participants. Non-biodegradable objects are thrown into the toilets causing serious blockages. Therefore, this ca be minimised through community awareness programs. The National Development plan (Vision 2030) includes the back to basics policy which engages the community in all service delivery activities such as sanitation provision and management. The FGD showed that Msunduzi municipality should use the back to basics approach in sanitation awareness campaigns.

Rural zones

In rural areas of Msunduzi local municipality participants confirmed to use pit latrines (mostly ventilated improved pit latrines). There are no other forms of toilets in use.

The community feels that the toilets are adequate for them since they provide them with at least basic sanitation and they are generally odour free. However, there are aspirations for flushing toilets but the community understand the water crisis in rural areas, and this was raised during an interview with Mr. Greatwood. One challenge mentioned by one of the participants was filling up of toilets, unavailability of emptying services and safe methods collecting, treating and reusing faecal sludge. Solid waste disposal is another challenge mentioned; one participant feels that nappies may be disposed in the pit latrine, and this should be emptied. This clearly shows that more education on best maintenance practices of VIP toilets is needed.

The Msunduzi municipality installed VIP toilets some years ago and the user is responsible for maintaining and emptying the toilets. According to one of the participants, people were educated on how to use them but some families dispose nappies and other solid waste materials in pit latrines. Currently a number of toilets are full and the filling rate differs with family.

The participants did not provide a clear understanding of how the sanitation impacts human and environmental health. The concern was associated with the use of biochemicals, which contaminates the groundwater.

Material flow analysis

Material flow analysis (MFA) quantifies the “fluxes of resources used and transformed as they flow through a region” (Montangero, 2007). This analysis comprises the construction of a MFA model and will allow for the quantification and mapping of the three most critical nutrients for agricultural production: nitrogen (N), phosphorus (P), potassium (K). It will focus within the city-region boundary of each RUNRES site identified during the KOMs. This model will be built to accommodate the existing waste stream landscape of every RUNRES city-region as well as the full suite of innovations under consideration. Constructing the MFA models in this way will allow for two outputs: 1.) the ability to compare the waste stream landscapes across the study sites; 2.) the ability to simulate alternative sanitation scenarios, which will allow for predictions of specific innovation’s agricultural potent.

6 Socio-Economic Context

6.1 Introduction

Socio-economic aspects play a major role when it comes to transitions towards a more sustainable society. These aspects play a major role, since the use of new technologies or the application of new practices are embedded in the social setting where these new practices and settings are applied. Aiming to provide a preliminary screening of the socio-economic context in the RUNRES countries, we look at the existing context of the socio-economic system through the lenses of five different concepts: i. social capital, ii. cultural theory, iii. acceptance, iv. taboos, and v. different perspectives on sustainable development. While stand-alone, in this study we do not claim to have a comprehensive perspective on the RUNRES countries through these concepts, but rather to be complementary to the others context studies that are related to society and economy: the food value-chain (FVC), the policy context (PC) and the social-network analysis (SNA).

The concepts used in this study provide a generic approach to evaluate the social-economic context of the different RUNRES areas of concern. The generic approach described in this document has been adapted to the local context in the different RUNRES areas. This report entails four main sections: (1) a section describing the theory rationales behind the evaluation of the socio-economic context; (2) a method-section with a qualitative interview guide that has been used and applied in the different RUNRES regions (in annex); (3) a results section, where we show the main results according to the five concepts used in this study; (4) a short discussion-section on the meaning of these results for the RUNRES project.

6.2 Theory Rationales behind the social context evaluation

Socio-economic context refers to a broad array of different perspectives that one may take on the embedment of an individual actor in an environment. In this guideline document, we operationalize some of the concepts found in the scientific literature to get a comprehensive picture of the socio-economic environment of the regions addressed by the RUNRES Project.

Social Capital

Many perspectives are available to frame the social context of actors, and most of them are used to potentially predict different variables, ranging from the effectiveness of environmental protection, to more abstract notions like well-being. The more straightforward approach has been put forward by Robert Putnam with social capital, who goes deeper in gathering demographic data beyond those gathered through regular censuses. While there are several approaches to social capital (Woodcock & Narayan, 2000), Putnam takes a communitarian focus on the social embedment of actors, for instance membership in communities and associations, or trust in different institutions (Helliwell & Putnam, 2004). An evaluation of these additional indicators can then predict social capital as the way a person is embedded in their social environment. This approach is most appropriate for quantitative surveys, making it possible to reach a broad number of respondents.

Cultural Theory

Another perspective on social embedment has been proposed by Thompson et al. (1990) as Cultural Theory, which has been used in the past to predict environmental outcomes. Thompson postulates that solutions to sustainability issues have to cross-cut four different perspectives that might have to be viable on the long term: Fatalism, Hierarchy, Individualism, and Egalitarianism (Figure 6.1). According to Cultural Theory, actors can see issues differently according to their perception of their embedment in a social structure. In addition, actors can also see the issues differently according to their commitment in groups, the group, describing the degree in which their commitment to the group determines their actions. These concepts can be operationalizable in quantitative surveys (Kahan, 2012), as well as through qualitative surveys.

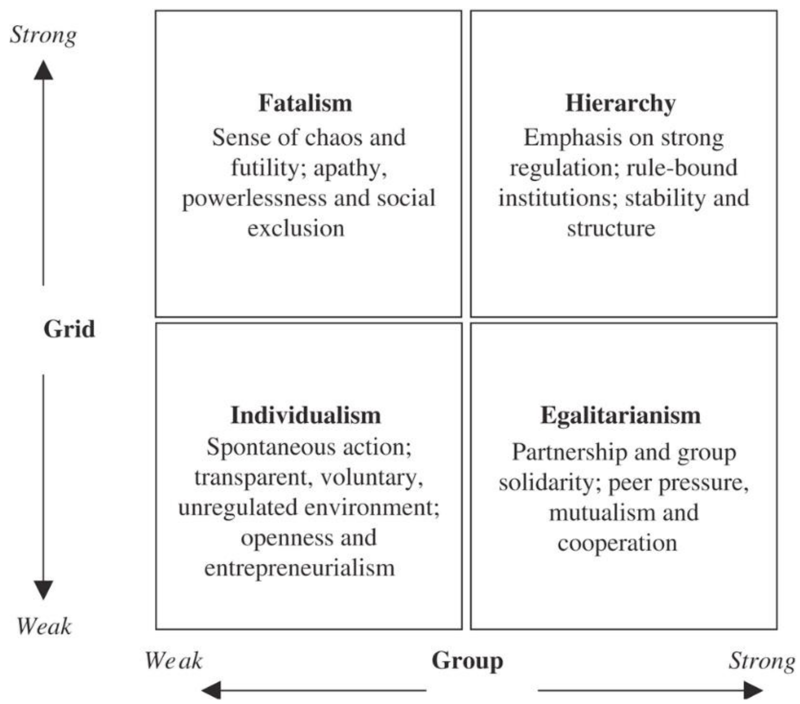

Figure 6.1: Schematized view of the two dimensions of cultural theory: grid and group and the general attributes of actors (picture from Stoltz, 2014).

Acceptance

When it comes to the aims of RUNRES, especially regarding the re-use of human waste, the question of acceptance is critical for the effective implementation of the different innovation that the project foresees. Some scholars decompose the concept of acceptance as a part of a larger structure around two sub-concepts: action and appraisal (Rau et al., 2012, see Figure 6.2). Appraisal is linked to the perception of an actor on a given technology and can be either positive or negative. Action is linked to the response of the given author, which can be either active or passive. While a negative appraisal of a technology can cause rejection (passive) or resistance (active), a positive appraisal of a technology can generate either acceptance (passive) or support (active). These two dimensions and their four possible cases can be operationalized as well through quantitative or qualitative surveys. However, qualitative surveys have the advantage to easily open up the reasons actors may have to accept or reject a given technology. In addition to the two sub-concepts related to acceptance, other scholars define three types of acceptance: community acceptance, socio-political acceptance and market acceptance (Wüstenhagen et al., 2007). This report focuses mainly on community and market acceptance, and partially socio-political acceptance. The value-chain mapping and policy context studies complement the analyses of these three types of acceptance.

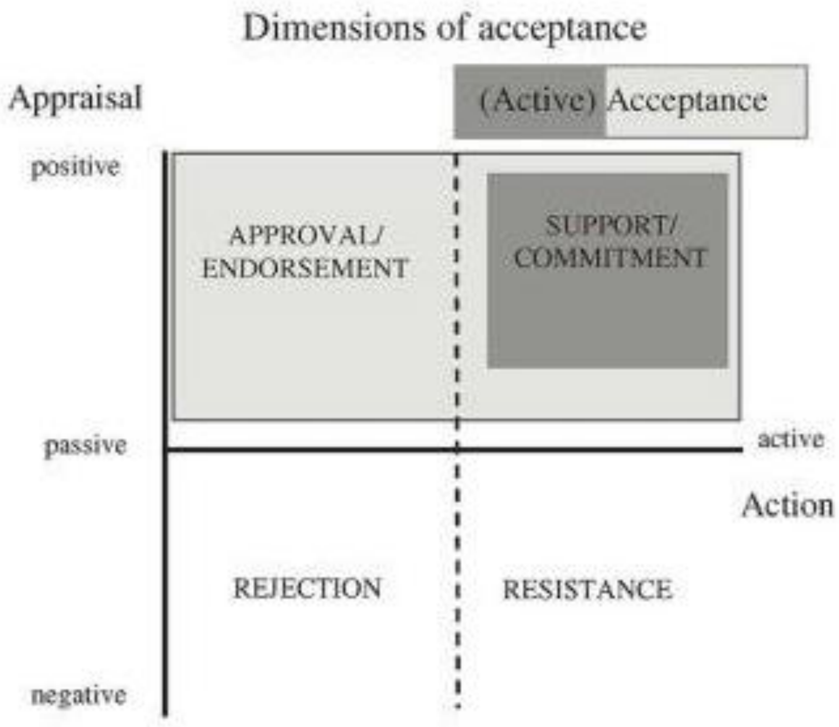

Figure 6.2: The two main dimensions surrounding the concept of acceptance (Rau et al., 2012).

Taboos

The primary characteristic of social taboos is that they are not easily visible. Taboos govern the behavior of people in an unformal way, beyond rules and laws, and they also affect the potential adoption of technologies supported through the RUNRES project. Colding and Folke (2001) describe several types of taboos in the field of nature conservations and the following categories of taboos can exist in the challenges addressed through RUNRES:

- Segment taboos: regulate what kind of waste can be recovered
- Time taboos: regulate when waste can be recovered
- Method taboo: regulate how waste can be recovered
- Group taboo: regulates who can recover the waste

These four categories can be operationalized through qualitative interviews. In addition to this, gender and age (youth), covered by the ongoing study of Kareem Buyana, as well as policies (legislation and ordinances) can be seen as part of the wider spectrum of socio-economic context in RUNRES. We separate them here due to different operationalization paths.

Economic perspectives and development

The implementation of the different innovations considered in RUNRES are directly dependent on financial aspects among stakeholders. In this report, we take a broader view on the economic issues surrounding the stakeholders involved in the project, as the micro-economic issues are already covered through the baseline-study Value Chain Mapping. However, when it comes to a broader perspective on economy, society, and environment, there are different perspectives that could come in conflict when it comes to what should be sustained, developed and maximized. The current paradigm regarding sustainable development is a perfect substitutability of capital, between economic and natural capital (natural resources), mostly through economic choice, also called Weak Sustainability (Solow, 1993). An alternative perspective, Strong Sustainability, considers economic and natural as not mutually substitutable, relying therefore on political choices (Daly, 1991). Finally, a last perspective, Human Development, considers economic issues secondary. This perspective emphasizes the need to sustain and to develop human capital and freedom as a social choice, and considers economy only as a means to reach these goals (Sen, 1999). While these three paradigms are not sharply delimited, different actors may share different perspectives on what is to be sustained and developed, and reality that can sometimes lead to conflict. Knowing how far these three perspectives on development are shared among the actors in the different RUNRES-regions can help to formulate solutions to address local issues in accordance with the perspectives of the actors.

6.3 Procedures

The interviews entailed two parts: a quantitative part and a qualitative part. The former was administered first (see the interview guide in annex), and the latter expanded on the first, according to the rationale that the respondents should explain and expand on the reasons they answered one question in a way or another. The full interview typically averaged 90 minutes. We therefore recommended a relatively small sample of about 20-30 people for each RUNRES country.

The collected qualitative data has been treated through basic statistic methods, mainly averages, sorted by countries. In the case of more complex quantitative concepts, we aggregated the data through different dimensions, mainly through averages of given batteries of items (e.g. Kahan, 2012). We processed the quantitative data through a spreadsheet.

The qualitative data went through a two-stage process. First, the different interviews were summarized by the local RUNRES staff. Second, we coded these notes according to the different concepts envisioned in the interview guide. On top of this, we used elements of grounded theory (Bryman, 2009) for the conceptual elements reported by the respondents that we did not foresee in the interview guide. We carried out the coding of the different statements through a color-code in a word-processor.

6.4 Results

Looking at the situation in the four RUNRES countries makes it possible to provide a relatively general picture of the current situation. In this section, we present the main results of the socio-economic context study. These results must be considered in perspective with the other RUNRES context studies, especially the *Food-Value-Chain study* and the *Policy Context study*. The coming sections are sorted according to the different theory concepts utilized, first through the lenses of quantitative data, and then through the lenses of qualitative data.

Aiming for an exploratory sample of about 20 to 30 respondents per countries, we have 66 respondents in total, with an average age of 42 years, where 24% were women. The educational level of the sample was skewed towards more educated people, since the study was about key people active in the rural-urban food-waste nexus of the RUNRES regions. 51% of the respondent had a university degree, 5% a vocational or college degree, 20% a secondary school degree and 24% a primary school degree.

Appraisal, Acceptance and Support

To evaluate appraisal, we used four items related to the circular economy, as we envisioned in RUNRES. We operationalized these items in a questionnaire through four Likert-scales (see the questions in Annex). The results show that reported appraisal of compost for food, urine as a fertilizer, fecal material as a fertilizer and UDDT was overall very high in all RUNRES countries (Table 6.1). The data show only a very slight lower appraisal of UDDT compared to the other elements, although still very positive (Figure 6.3).

Table 6.1: Summary of the variables used to evaluate the appraisal of the respondents on different aspects of the circular economy, as envisioned in RUNRES. The respondents answered on a 4-level Likert-scale ranging from 1: "negative", 2: "somewhat negative", 3: "somewhat positive", to 4 "positive". The detailed questionnaire is in Annex.

Var. number	Appraisal of...	Scale
1	...using composted organic waste to grow food	Negative to positive
2	...using safe treated-urine as a fertilizer	Negative to positive
3	...using safe treated-fecal material as a fertilizer	Negative to positive
4	...using toilets that sort urine and feces	Negative to positive

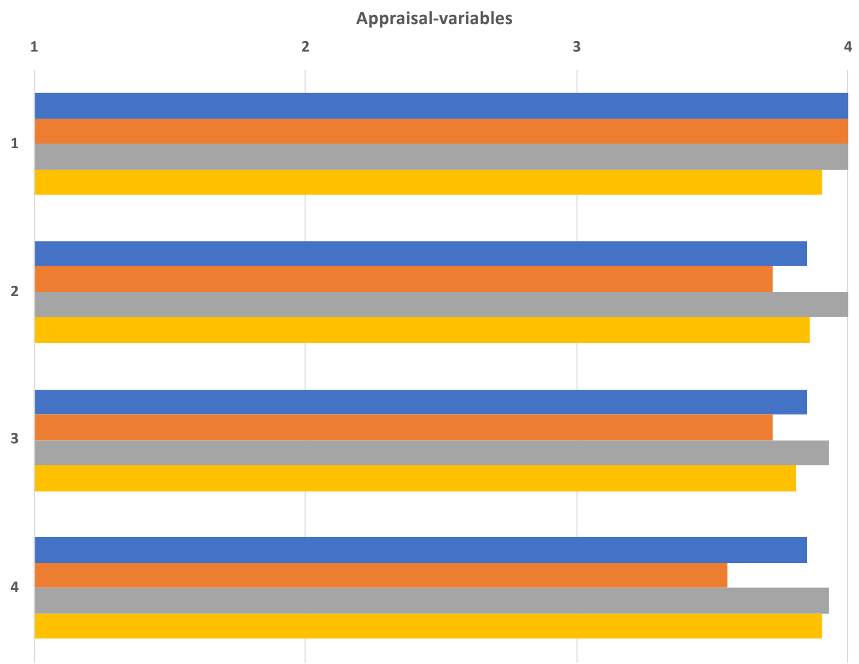

Figure 6.3: Results of the reported appraisal of the respondents (n = 66), on four different aspects of a circular economy, as envisioned by RUNRES with 1: composted organic waste, 2: safe treated urine, 3: treated fecal matter, and 4: UDDT. The respondents answered on a 4-level Likert-scale ranging from 1: "negative", 2: "somewhat negative", 3: "somewhat positive", to 4 "positive". The different colors are for the average in different countries, with blue for DRC, orange for Rwanda, grey for Ethiopia, and yellow for South Africa. The detailed questionnaire is in Annex.

To evaluate the potential acceptance of the main aspects of RUNRES in term of recirculation of nutrients, we used four items where the respondents reported on their potential acceptance for compost for food, urine as a fertilizer, fecal material as a fertilizer and UDDT (Table 6.2). The reported potential acceptance for these main elements of a circular economy was overall very high, except for Rwanda where the respondents reported a lower, but still positive potential acceptance of the use of treated fecal material for growing food ().

Table 6.2: Summary of the variables used to evaluate the acceptance of the respondents of different aspects of the circular economy, as envisioned in RUNRES. The respondents answered to the four items on a 4-level Likert-scale ranging from 1: "not agree at all", 2: "somewhat disagree", 3: "somewhat agree", to 4 "fully agree" on four given statements. The detailed questionnaire is in Annex.

Var. number	Acceptance of...	Scale
1	...consuming food that has been cultivated using organic compost	Low to high
2	...consuming food that has been cultivated by using safe treated-urine as a fertilizer	Low to high
3	...consuming food that has been cultivated using safe fecal-material	Low to high
4	...eating meat that has been fed with flies' larvae, a safe product, which have been fed with human feeces	Low to high

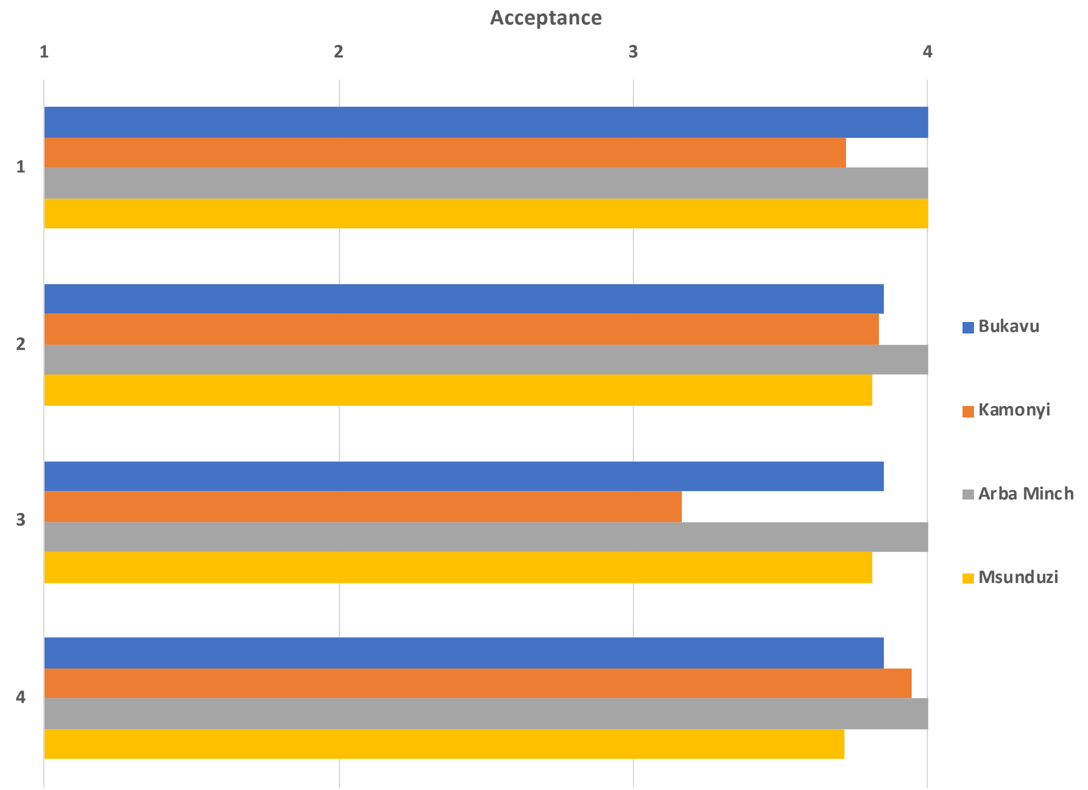

Figure 6.4: Results of the reported acceptance of the respondents (n = 66), of four different aspects of a circular economy, as envisioned by RUNRES with 1: consuming food that has been cultivated using organic compost, 2: consuming food that has been cultivated by using safe treated-urine as a fertilizer, 3: consuming food that has been cultivated using safe fecal-material, and 4: eating meat that has been fed with flies' larvae, a safe product, which have been fed with human feeces. The respondents answered to the four items on a 4-level Likert-scale ranging from 1: "not agree at all" (lowest acceptance), 2: "somewhat disagree", 3: "somewhat agree", to 4 "fully agree" (highest acceptance). The different colors are for the average in different countries, with blue for DRC, orange for Rwanda, grey for Ethiopia, and yellow for South Africa. The detailed questionnaire is in Annex.

On top of appraisal and acceptance, we evaluated the potential support of the respondents through an eight-items batters, covering several aspects of the RUNRES project (see Table 6.3). The reported potential support of support showed very high levels in all the countries (Figure 6.5). We only noted a slight lower level of reported potential support for using fecal material to grow food for Ethiopia, but still at a very high level.

Table 6.3: Summary of the variables used to evaluate the support of the respondents of different aspects of the circular economy, as envisioned in RUNRES. The respondents answered to the eight items on a 4-level Likert-scale ranging from 1: "not agree at all", 2: "somewhat disagree", 3: "somewhat agree", to 4 "fully agree" on eight given statements. The detailed questionnaire is in Annex.

Var. number	Support of community in...	Scale
1	...using organic compost to fertilize crops	Low to high
2	...using safe treated-urine to fertilize crops	Low to high
3	...using safe treated-fecal material to fertilize crops	Low to high
4	...using toilets that sort urine and feeces (UDDT)	Low to high
5	...eating food that has been grown with compost	Low to high
6	...eating food that has been grown with treated-urine, which is safe	Low to high
7	...eating food that has been grown with treated fecal material, which is safe	Low to high
8	...eating meat that has been fed with flies' larvae, a safe product, which have been fed with human feeces	Low to high

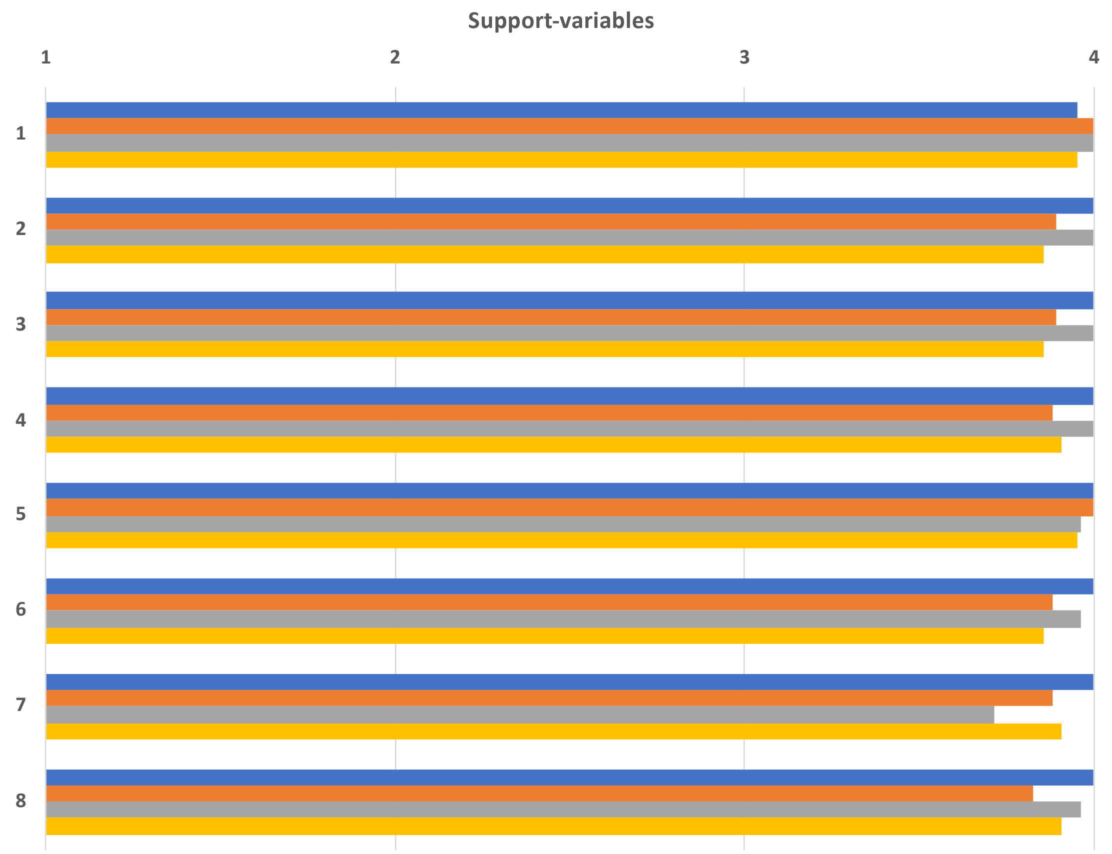

Figure 6.5: Results of the reported support of the respondents (n = 66), of eight different aspects of a circular economy, as envisioned by RUNRES with 1: using organic compost to fertilize crops, 2: using safe treated-urine to fertilize crops, 3: using safe treated-fecal material to fertilize crops, 4: using UDDT, 5: eating food that has been grown with compost, 6: eating food that has been grown with treated-urine, 7: eating food that has been grown with treated fecal material, and 8: eating meat that has been fed with flies' larvae, which have been fed with human feeces. The respondents answered to the four items on a 4-level Likert-scale ranging from 1: "not agree at all" (lowest support), 2: "somewhat disagree", 3: "somewhat agree", to 4 "fully agree" (highest support). The different colors are for the average in different countries, with blue for DRC, orange for Rwanda, and grey for Ethiopia. The detailed questionnaire is in Annex.

Social capital

Social capital can be operationalized through the number of interactions and the contribution of the respondents to the community. On top of this, trust can also be directly used as a proxy for social capital. Since we evaluate relatively small samples across four different countries, the data on community are hardly comparable between the different RUNRES countries. Nevertheless, these data can be used for a subsequent impact evaluation. However, the levels of trust are directly comparable between the different countries.

The results on social capital through trust show relatively low levels trust, directly reported as well as aggregated (Figure 6.6). In additional, the data from Ethiopia and South Africa are missing, making a general overall evaluation of social capital through trust for all the RUNRES countries difficult.

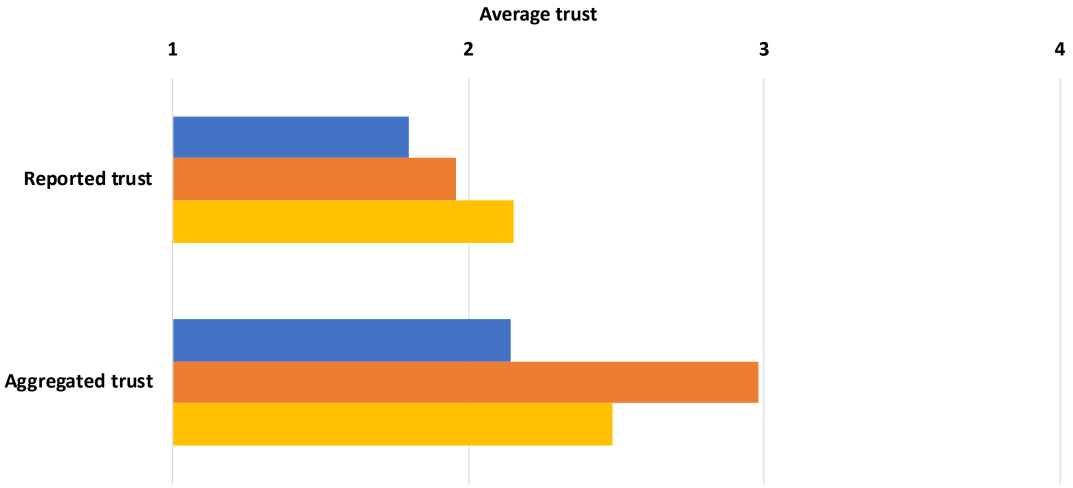

Figure 6.6: Results of the reported general trust (n = 38), once in directly reported form, and in aggregated form. The aggregated form is the average of five sub-variables related to trust. The reported trust has been collected through a 0-10 scale and has been normalized to a 1-4 scale to be compared to the aggregated trust results. The respondents reported trust levels on five variables forming the aggregated trust through a 4-level Likert-scale ranging from 1: "[trust] not at all", 2: "[trust] only a little", 3: "[trust] some", to 4: "[trust] lot". The different colors are for the average in different countries, with blue for DRC, orange for Rwanda, and yellow for South Africa. The detailed questionnaire is in Annex.

Cultural theory

Looking at our respondents through the lenses of cultural theory makes it possible to see to what type of social organization the respondents tend to lean. The four perspectives described in cultural theory are not meant to be interpreted as if one would be better than the other, rather, to reflect the different ways people behave. The respondents of this study show a general tendency to lean to low-grid modes, mainly individualism and egalitarianism (Figure 6.7)

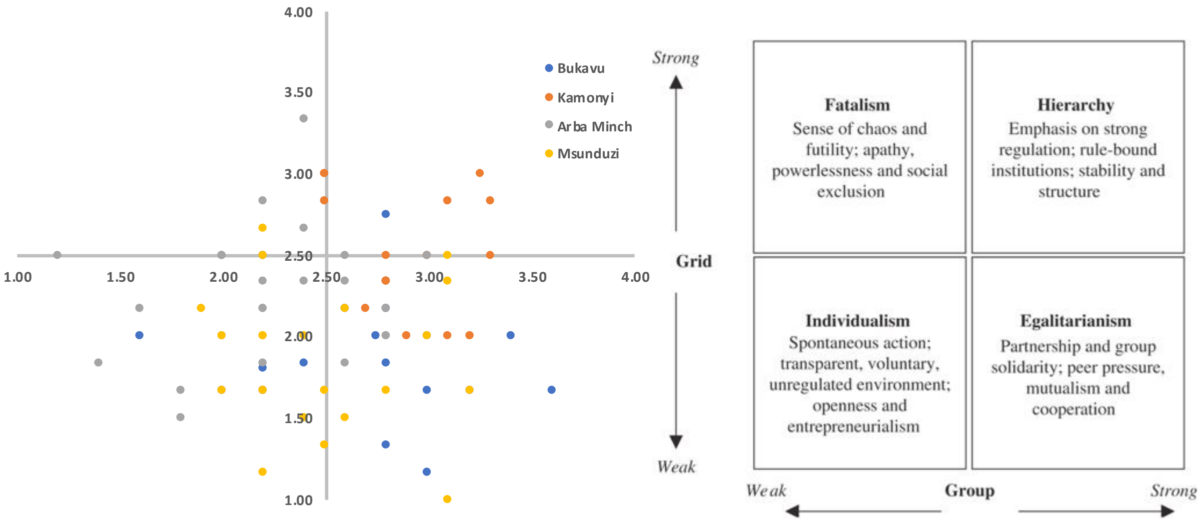

Figure 6.7: The position the respondents (left, n = 66), according to the cultural theory scheme (right; Kahan, 2012; picture from Stoltz, 2014). The horizontal axis is the affinity to group of the respondents, rated in averaged scores from 1 to 4 (N = 6), and the vertical is the propensity to the group do structure, grid, rated in averaged

scores from 1 to 4 (N = 5). The positioning of the respondent is colored according to the country, with blue for DRC, orange for Rwanda, grey for Ethiopia, and Yellow for South Africa. The detailed questionnaire is in Annex.

By disaggregating the different countries, we can see different tendencies regarding cultural theory among the different RUNRES countries. All of the evaluated countries, where data are available, show different directions (Figure 6.8). While the reported data from the DRC show a tendency toward egalitarianism, the respondents from Ethiopia show a tendency towards individualism. Finally, the reported values of the respondents from Rwanda are between hierarchy and egalitarianism. These values do not inform on the cultural perception of a given population, but rather the potential behavior of a given sample. The important aspect to keep in mind is that the way activities are run are strongly influenced by cultural theory, and the solutions developed through RUNRES should be perceived as compliant to the different points of view that the respondents expressed.

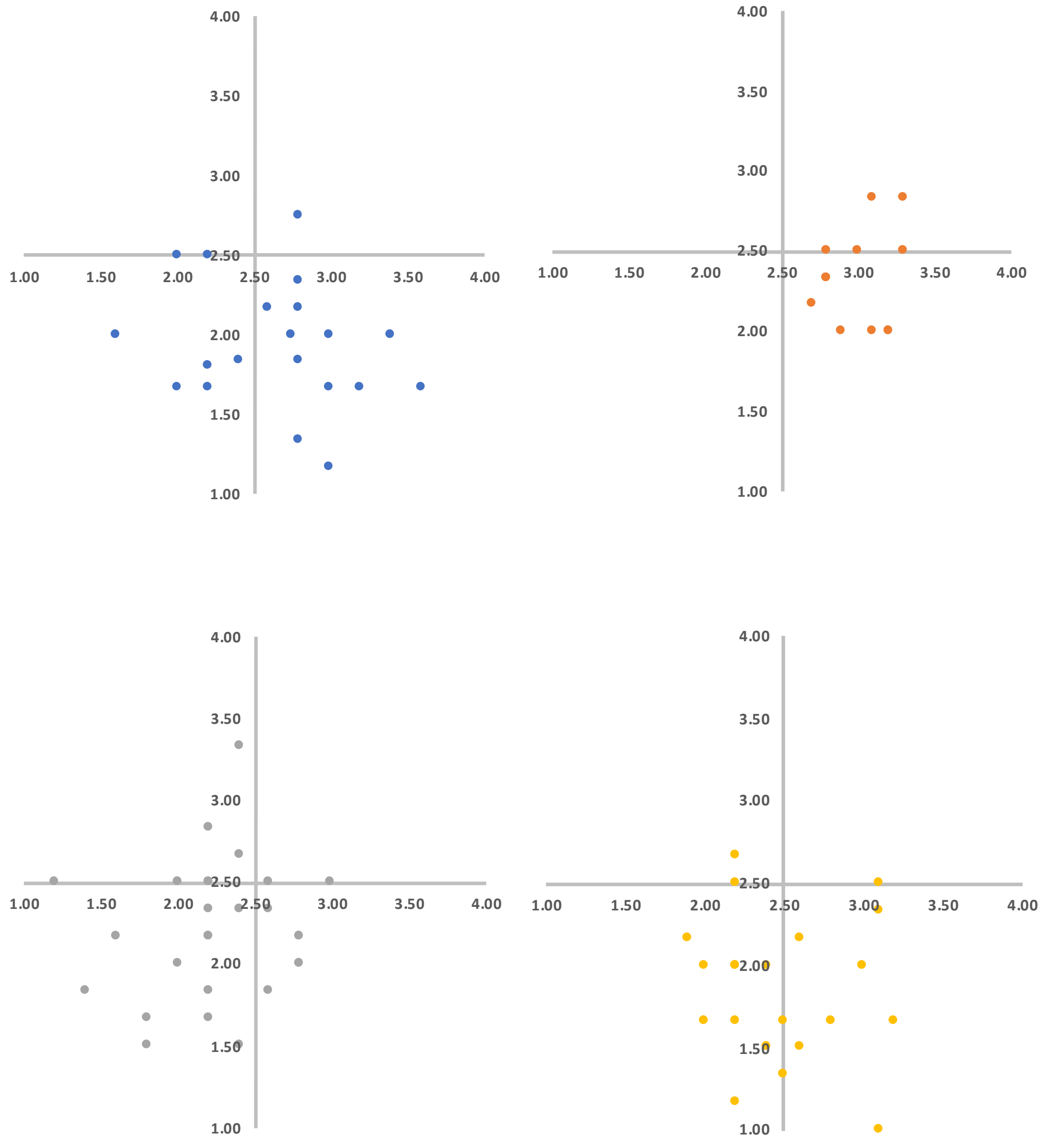

Figure 6.8: The position the respondents (n = 66), according to the cultural theory scheme, separated for each country, blue for DRC (upper-left), orange for Rwanda (upper-right), grey for Ethiopia (bottom-left), and yellow for South Africa (bottom-right) to make visible the different tendencies. The detailed questionnaire is in Annex.

Qualitative information

The data collected in the four RUNRES countries show a relative high variation in the way the data has been collected, and therefore in the different topics addressed in the interviews. Since the aim of the socio-economic survey is not to have the same type of data from the different countries, we expose an overview of the topics addressed, with a focus on some countries where necessary.

The interviews were conducted and summarized by the different RUNRES local teams. We coded summarized the data through the different topics that the respondents brought up, structured through the interview guide that we used. Once the data was coded, we sorted the different issues brought up in five different topics:

- General aspects and barriers
- Taboos
- Knowledge and education
- The materials to be recycled
- Governance and development

In the following sessions, we omitted the following coded data: willingness to pay and past projects and aims for RUNRES, since these aspects have been already partly covered through the value-chain survey, waste system mapping and the different workshops we had until now. On top of this, the different quotes presented in the subsequent sections are anonymized. However, we only state the country of origin of the respondent and a letter for their identification in our database. The letters are not the first letters of the names of the respondents.

General aspects and barriers

The respondents reported a positive perspective on the circular economy concepts proposed by the RUNRES project. Several respondents showed a positive stance to circular economy applied to agriculture because it is what they did in the past, as:

> *I accept this [...] circular economy concept because it works with our grand-parents' crop production system before the introduction of artificial fertilizer. (Respondent Z, Ethiopia)*

Several respondents linked the RUNRES approach to recycle organic waste, including human waste, with the practice of using cow manure and urine. The approach seemed to them familiar, with a starting point of using cow manure, as:

> *[I]n the old days cow urine was used in agriculture and often the result was admirable, but due to lack of cattle people don't. (Respondent E, DRC)*

Where we have a similar perspective from Ethiopia:

> *[M]y family in rural area uses cow dung for producing [ensete], potato and Irish potato. The amount of crop yield obtained from fields given cow dung is much more higher than untreated farms. [...] I did not [hear] about circular economy before, but from your clarification it is what our parents used [at] home yard for crop production. We recycled home made wastes of all type be it human, animal & food waste put into home yard crop field. Respondent Q, Ethiopia)*

In some regions like the DRC, farmers already used decomposed human waste from toilet pits, especially for cultivating tomatoes or cabbage, as these crops are reported as being responsive to these types of fertilizers, as:

> *[S]ome initiatives such as the purchase of cow droppings and filled latrines are in force in the village, especially for those who grow tomatoes and cabbages, being sensitive crops. (Respondent C, DRC)*

Where this has been also reported for Rwanda:

> *All peoples are not aware on use those wastes, but some peoples are currently using those wastes in agriculture, some others farmers buy those wastes to use it as fertilizer as buy the fertilizers from cows. (Respondent U, Rwanda)*

However, some respondents reported on the tension of not having enough cow manure, hence the necessity to have more sources of nutrients for cultures, be it from cows or from humans, as:

> *There [are a] lot of benefits [in using organic and human waste] because up to now, to find fertilizer from livestock is difficult because the livestock are decreasing due to different reasons. (Respondent R, Rwanda)*

These data show that some respondents make a direct relation from using cow manure too the necessity to use either organic or human waste. This would imply that using the link between past way to have a “circular economy” through livestock can be transposed to current times through the model proposed by RUNRES to recirculate nutrients back to the fields.

Taboos

In this study, we segmented the concept of taboo into four distinct sub-types of taboos: (1) *segment taboos*: what kind of waste can be recovered, (2) *method taboos*: regulate how waste can be recovered, (3) *group taboos*: regulates who can recover the waste, and (4) *time taboos*: regulate when waste can be recovered. The respondents did not report any time-related taboos. Therefore, we will focus here only on the first three types: segment, method and group taboos.

Segment taboos regulate what kind of waste can be recovered, and we tailored the coding to the RUNRES addressed issues, mainly on waste and what can be recovered and what not. Most respondents did not explicitly report taboos, but showed that there is a nuance on what can be recovered and for whom. Recovering human waste does not seem to be problematic per se, although there are some reported concerns, as for instance:

Just knowing that it was the human waste that went into making this fertilizer or these foods come from poop and I would automatically disagree. I think it can have health effects and there can be germs. For me it's been since I was a kid. My heart cannot tolerate smelly things. […] But if it is any other type of waste except human waste, I can consume the food from this field without a problem. [...] and I can even encourage the use of compost from this waste because that is normal. (Respondent B, DRC)

The respondent reported that the reasons of the aversion for using human waste in agriculture is related to germs and potential health effects, as for instance reported in Rwanda:

I would say that it is a culture issue because in Rwandan culture normally they know that human waste they are considered that they may contain some contaminants, they can bring diseases. (Respondent F, Rwanda)

However, some respondents recalled the link to cow-waste as a way to address this barrier, as for instance:

The reason they don't accept it, is that it is called waste and also they are used to the use of animal waste not human waste. They have to change they mindset and see it as a solution not waste. (Respondent D, Rwanda)

Nevertheless, most respondents reported that a majority would accept to use human waste for agriculture and this confirms the tendencies observed on the quantitative survey on acceptance (see previous chapter).

Method taboos regulate how waste can be recovered. The respondents reported relatively little on the methods to recover human waste. Nevertheless, some pointed out the legal void on how to collect human waste in a safe and legal way:

There are no taboos but only the law in relation to the use of human waste[, which] is not yet clear and to get it adopted by the farmers it will be necessary [...] make it so that it is presentable and involve dealers. (Respondent V, DRC)

The legal void is more thoroughly explained in the other context study policy-context, where we can see that in most RUNRES countries, no law clearly forbids, but also does not explicitly regulate the use of human waste.

Group taboos regulate who can recover the waste. The respondents reported several nuances on this issue. Firstly, they reported how giving away or selling human waste may be considered as being related to low social classes, as for instance in the DRC:

[P]eople do not have the culture of emptying already decomposed toilets and bringing them into fields. It's not a taboo but it's because people think it's poverty when you start getting paid for poop. (Respondent B, DRC).

Secondly, the respondents reported gender-related differences in the way things are done for recovering human waste for agriculture, a for instance, still in the DRC:

Generally it is the men who take care of the composting and the women and children are more in the collection of the raw material (waste) within the household and put them in the compost, the transport of the compost to the field is provided by women and children. (Respondent S, DRC)

Or for instance:

My wife and I are all involved in the process. Often I take care of the construction of the composting frame and my wife of the filling[;] but when it comes to reversing the waste or bringing it to the field when it is not done next to the field we take care of it all of us. (Respondent D, DRC)

It is beyond the aim of this report to detail the differences in gender regarding the recovery of human waste (see the context study on gender for more details). The reported data presented here nevertheless highlight that there may be a social component to recovering waste, associated to poverty, and another component related to gender, where men may deal more with the technical aspects of waste processing and women and children may deal more with the collection of waste.

Knowledge, demonstration and education

Several respondents reported knowledge as a potential barrier to the deployment of the RUNRES innovations. On top of this, re-using human waste is seemingly not a usual topic to be addressed among organizations working in the RUNRES regions, as for instance in the DRC:

I think it is the lack of knowledge that is the main reason for not applying this technique. There have been few projects only in composting based on organic and non-human waste. Most organizations are not really involved in the recovery of organic waste and even less in the recovery of human waste. (Respondent D, DRC)

Or for instance:

Many organizations instead come to teach us how to make compost from biodegradable waste, but they never told us that it was possible to have compost from human waste (Respondent A, DRC)

On top of this, respondents report on a lack of knowledge on different aspects related to human waste recovery, as:

> *I could support the wastes from household at 100/100 but for the Human wastes, [I] could support them with conditions because I don't know the impacts or consequences that may be caused by use those human wastes as fertilizers to human health or on crops. It is known that there [are] standard[s] of quantities of fertilizers to be used in agriculture according specific crops especially on industrial fertilizers. So, it is also necessary to know the quantities of human wastes to be used as fertilizers for each crops planted. For these human wastes, I could support it in time I know the consequences or impacts on crops and for human life. (Respondent R, Rwanda)*

Therefore, some respondents point out education programs to increase knowledge, and thus, enhance nutrient recovery, as:

> *To me success will be from a very long education program. When the program is there later people will buy the toilet because of value chain showing if you do this there will be positive results. For example due to a strong education program on the use of Gas and positive impact many people are now using Gas instead of charcoal. (Respondent Z, Rwanda)*

Many respondents call for demonstrations of organic and human waste recovery in all the RUNRES countries, as for instance in DRC:

> *Public places (school and markets) are best suited to facilitate collection because they are very often accessible and have enough space. We can also collect a large amount in a short time. (Respondent R, DRC)*

Or for instance:

> *People need to experience [human waste recovery] first before taking ownership of this innovation and adopting it in their respective households. (Respondent Q, DRC)*

According to some of the respondents, this will enhance the awareness among the population and thus increase awareness and spread the use, for instance for Ethiopia:

> *People think urine/feaces are harmful and pathogenic if not treated. For awareness creation[,] people need demonstration fields [...]. Compost is fully accepted if treated urine [is not] assumed to pollute plant. But urine sterile can be used as fertilizer. (Respondent K, Ethiopia)*

Or, similarly for the DRC:

> *Awareness is an important tool that other organizations use when there are projects that directly affect the sensitivity of the population. But also when the peasants look at the fruits of the use of these fertilizers then many may adopt it and apply it in their fields. Demonstration fields are useful for a good visibility of the organization and a project exhibition. (Respondent C, DRC)*

Recycling waste

Some respondents highlighted the absence of market for recycled organic waste. This has been mainly highlighted in the DRC, as:

> *The recycling of human waste is not in vogue for lack of information and the necessary expertise. It's a little-known and high-risk business, so everyone is very reluctant to invest in it because entrepreneurs want to invest in a very reassuring and less risky business. [...] Plastic waste offers many more possibilities in terms of profitability, job offer and is a good business unlike organic waste which requires to bear a lot of load in terms of labor for sorting and transport but unfortunately profitability is low. (Respondent U, DRC)*

To make organic waste recovery more efficient and economically affordable, several respondents claim that sorting waste at the household level can work, as:

> *Waste recycling is not effective because there is little expertise in this area, the raw material is also lacking due to the lack of sorting of biodegradable and non-biodegradable waste. [...] This is possible if only households are made aware of the advantages of sorting this waste at source and that the logistical means (bins and means of transport) necessary to facilitate sorting are made available to stakeholders. (Respondent Q, DRC)*

While this issue has not been raised by respondents from other RUNRES countries, there are good reasons to believe that the issues around the recovery of organic waste are similar, as the collection schemes in these countries are confronted to similar issues.

Governance and development

In this study, we explored succinctly the different and broader perspectives that the respondents could have on the way the transition towards a circular economy, and who should be the main actors. In this section, we emphasize on the DRC, where most of the data on this issue are available. We also acknowledge that opening up this subject might also be problematic in some of the RUNRES countries.

In DRC, when it comes to the main actors to lead the way toward a circular economy, the respondents reported divergent views on the role of the state and private actors. Some would give a greater role to the municipality of Bukavu, as a main actor for the collection and sorting of waste. Others report a distrust towards the municipality, pointing out that it misfunctioned in many ways in the past, and there are therefore no reasons that this would change. However, beyond relatively sharp stances to towards the ability of the municipality to play a key role in the transition towards a circular economy, some respondents pointed out some relevant elements on the interplay between the municipality and private actors, as:

> *Today the municipality is the only organization in this field [of organic waste recovery] and that is why the prices are high, but when there are a lot of other organizations in this area then the price can go down and we will be willing to pay. Otherwise, people will continue to pour their septic tanks in rivers and gutters. (Respondent J, DRC)*

In the case of DRC, the key to progress towards a circular economy seems therefore to be in the interplay between municipality and actors, and not in considering these two entities as separate elements.

6.5 Discussion

This study shows in an explorative way some aspects of the socio-economic situation in the different RUNRES countries. Through the different conceptual lenses we used in this study, we show that:

- *Acceptance:* Reported appraisal of reusing organic and human waste is high.
- *Acceptance:* Reported potential acceptance of reusing organic and human waste is high, except a bit lower for using fecal material to grow food in Rwanda.
- *Acceptance:* Reported potential support of reusing organic and human waste is high.
- *Social capital:* Trust is relatively low in DRC, and moderate in Rwanda.
- *Cultural theory:* Grid-response is relatively low in RUNRES countries, except in Rwanda.
- *Cultural theory:* DRC and Rwanda are relatively high on group response, while Ethiopia is relatively lower.
- *Taboos:* Perceived social position and disgust are barriers to embracing a circular economy for human waste

- *Knowledge, demonstration and education:* The lack of knowledge on circular economy can be enhanced through demonstrators.
- *Recycling waste:* There is a low market for recycled waste in DRC and potentially y in other countries.
- *Governance and development:* The interplay between state and private actors could be source of friction, especially in the DRC.

The results are relatively similar for all the RUNRES countries. However, the main disparity is due to the differences in the way data have been collected and in what concepts could be used to evaluate the socio-economic situation of the different countries. The different concepts we used, our lenses, have different advantage and disadvantages. *Acceptance*, while showing the potential acceptances of the RUNRES innovations, is a theoretical concept, and it only show what people may think without knowing the full implications of a give solution. The real levels of acceptance, appraisal and support might therefore be lower in reality. *Social capital* showed a broad variance in the sub-concepts uses, leaving only trust as realistically usable for the explorative character of this socio-economic study. *Cultural theory* has the advantage to how where respondents position themselves on a grid-group scheme, avoiding them to pick responses that might be wished by the interviewers. However, the reduction of the number of items, as a result of their application in the RUNRES countries, might make the results less reliable as in Northern countries. *Taboos* showed to be a useful concept to structure the way respondents perceived barriers to circular economy. However, the concept remains relatively hard to operationalize, as like acceptance, the responses might vary when the respondents are confronted to the reality of the RUNRES innovations. The *qualitative interview* approach also revealed different topics that are relevant to RUNRES, going from knowledge to governance of the transition towards a circular economy. These different aspects should be also considered in the future steps of the RUNRES project.

7 Policy and Regulatory Environment

Introduction

The RUNRES project seeks to close nutrient loops by enhancing waste recycling and re-using it in farmlands, as well as enhancing food value chains in four African countries: DR Congo, Ethiopia, Rwanda, and South Africa. The project aims to establish resilient rural-urban food systems within city-regions, where waste from urban centres is recycled to facilitate agricultural productivity in rural areas. By this, RUNRES seeks to reorganize the current linear food and sanitation chains.

Phase I of RUNRES (Years 1-4) in essence includes (i) an identification of possible innovations that close the nutrient cycles, and (ii) an implementation of pilot projects of the most promising innovations and their biophysical, economic and societal assessment. The purpose of phase II (Years 5-8) is upscaling of the innovations with the greatest potential. Innovations may include all sorts of nutrient containing waste such as waste from food production, possessing and consumption as well as livestock—and human excrements, i.e. urine and faeces.

The aim of the review of legislation and regulation is to obtain an overview of the legislation and regulations that regulate the nutrient cycle in the broadest sense. The results generated through this context study will provide (1) an overview of the legality of the potential RUNRES innovations and (2) an overview of the legal uncertainties surrounding the application of a circular economy as aimed through RUNRES. In this report, we distinguish between *legislation*, describing the general body of laws, usually generated at national level, and *ordinance*, describing the delegated legislation delegated to smaller regions and municipalities. Ordinances are not necessarily laws, but can be formal rules set by local governments. The application of this guideline document should therefore cover the national frame for circular economy as foreseen in RUNRES at national level and in their regions of application.

The focus is on the handling of human urine and faeces to generate human excreta derived fertilizers (HEDF, see Moya et al., 2019). Both faeces and urine are nutrient carriers. However, they are sometimes contaminated with pathogenic germs (bacteria, viruses, parasites), heavy metals, and pharmacological residues. As a rule, they must be treated before they can be used as fertilisers, soil conditioners, or energy sources in order to protect humans, animals and the environment from harm. While animal excreta such as manure fertilizer is generally permitted in agriculture and this type of fertilization is also widely practiced, there are restrictions in vegetable production in this respect. Although the use of human urine and faeces is the same as for animal slurry, the restrictions and the concerns of end consumers are greater. To this end, the legislation in the respective country is to be systematically examined for statements on the admissibility—or illegality—of HEDF such as urine, faeces, sewage sludge etc, particularly in the application to food production. Depending on the innovation, the investigation may have to be extended to other legal bases, for instance on energy production legislation.

Possible areas of legislation are: agriculture, food, environmental protection, water protection, public health. Depending on the country, there may be an ordinance level at which the implementation of the law is regulated. It is currently unknown which legal or regulatory basis exists in the four countries. It may well be that there are currently no regulations at all on the issue at hand. This is also a result that should be recorded.

Review Procedure

Step 1: Online Review

In a first step, we went through governmental websites to find out if information on these issues are available. Information can potentially be found (i) via 'structure/organisation' of Government and (ii) via Ministries such as Agriculture, Environment, Health etc. or (iii) searching terms such as health, food security, health, sanitation etc. For each step, we recorded our search strategy. If available, we scanned the relevant laws by using key words such as faeces, urine, fertilizer, sanitation, health safety, etc. NB: some legislation documents were not available in English for the DRC. We therefore left them in French, and translated the section that were relevant to RUNRES.

As a next step, we checked for information on the regulation level (ordinance level). As we are not experts in the field, we cross-checked with staff from government/administration to see how far our findings are complete. We also recorded who (name, institution, position, contact data) we contacted, when (date), where (place, address). Information of interest were: title of law; articles that provide concrete information; references to further laws or regulation/ordinance level (see the law tables below in the document).

Step 2: Contact and search at the various government agencies

As a first step, we searched who will be our focal institution and particularly our focal person(s) in the respective institution. If we could not find a central registry of all laws, we contacted ministries of interest such Agriculture, Health, Environment, etc. To check that our list of laws/regulation/ordinance are complete, we crosschecked with other ministries/focal persons.

For interviews with relevant key informants, e.g. members of our focal institution, the table below has been used as an interview guide (see Annex1). In case our sample of key informants we too restricted to fill the policy table, we used a snowball sampling method (Bryman, 2009), where the interviewees' sample has been extended by asking the informants about additional potential interviewees.

Output format

During the policy scoping process, we recorded your final findings in a list (see Annex 1). The different policies and ordinances are sorted according to the three main foci of the RUNRES project: farming, trading and consumption, and through the three RUNRES feedback-paths for the nutrients: organic waste, human waste and small-scale processing. The lists usually include laws, regulations and ordinances if available. Information include title of law (ordinance), section of interest in law (ordinance), references to other laws/ordnances and information received from, if available). In addition, in the list of the different policies and ordinances, we included the sources and/or key informants for the information provided.

7.1 Bukavu, Democratic Republic of the Congo

Step 1: Online Review

The constitution itself, different laws and also ordinances were collected from the official governmental data base (leganet.cd) using the following keywords (in French): "déchet organique, assainissement, excreta, déchet, usine de traitement des eaux usées, dépotoir, engrais, santé publique". The relevance for RUNRES was guaranteed by reviewing the respective title, year of publication and content of the according articles. The policy hierarchy is as in other countries the following: (1) constitution, (2) laws, and (3) decrees and ordinances. Overall, it can be stated that little and only very general information was accessible online. Further, most of the legal text sources could be hardly attributed to the proposed table in the protocol. Nevertheless, a list with the found policy context is provided in a slightly adopted style.

No legal text concerning regulation on organic waste, food and human excreta derived fertilizers (HEDF) (e.g. fertilizer production, composting or processing human waste) has been found with the indicated search strategy. However, it has to be mentioned that this research has not been conducted by a lawyer or expert on local laws. Hence, we consulted in step two of the followed protocol the following key informants to confirm and extend the results: (1) ministry of public health, (2) ministry of agriculture, (3) ministry of the environment and the (4) municipality of Bukavu.

Step 2: Contact and search at the various government agencies

The local Research Associate Byamungu Kigangu Moustapha (IITA Kalambo) was responsible to select the key informants from the above-mentioned departments at municipality level. The first contact was made on January the 7th 2020 with the major of Bukavu in his office. The promised documents were then picked up on the 09.01.2020 at the municipality and reviewed. The RUNRES related Articles were extracted and can be found in Table 7.1. For the strategy note, no summary is provided since the information is rather informative than imperative. Nevertheless, the titles of all chapters are cited in Table 7.1.

The overall results of step 2 are (Informal notes from the meeting with the major of Bukavu):

- **There is no law concerning the use of human waste for agricultural production**
- Most human excreta related laws are found in the context of public health
- There should be no issue to set up a study design with human excreta for agricultural purposes in a research context
- The municipality promised to hand out out (1) the official strategic paper (NOTE STRATEGIQUE - Débarrasser la ville des déchets - avoir une ville propre et saine) from the city of Bukavu and (2) the edit (Edit N°001/2013 Portant gestion des dechets en province du Sud Kivu) via his assistant (see in Table 7.1).
- He provided us the contact of Mr. (Expert in Environmental laws) and Mr. (Expert in liquid waste.

Table 7.1: Table of the different policies covering DRC for research step 1, through the three circulation channels considered in the project.

RR-circulation loop	Policy level	Policy title	Year	Articles	Sources	Variables of interest for RUNRES
Organic waste & Human waste processing	Constitution	Constitution de la Republique Democratique du Congo	2006	**Art. 54** Les conditions de construction d'usines, de stockage, de manipulation, d'incinération et d'évacuation des déchets toxiques, polluants ou radioactifs provenant des unités industrielles ou artisanales installées sur le territoire national sont fixées par la loi. Toute pollution ou destruction résultant d'une activité économique donne lieu à compensation et/ou à la réparation. La loi détermine la nature des mesures compensatoires, réparatoires ainsi que les modalités de leur exécution.	https://www.wipo.int/edocs/lexdocs/laws/fr/cd/cd001fr.pdf (Retreived the 02.01.2020)	Contextual
Organic waste	Loi	N°11/009 Portant principes fondamentaux relatifs à la protection de l'environnent	2011	**Section 4 : De la gestion des déchets** **Art. 56** L'Etat, la province et l'entité territoriale décentralisée s'assurent de la gestion rationnelle des déchets de manière à préserver la qualité de l'environnement et la santé. **Art. 57** Sont interdits sur le territoire national :	Journal officiel - Numéro Spécial - 16 juillet 2011 p. 23	Regulations on waste management

				a) la détention, le dépôt ou l'abandon à des endroits non appropriés des déchets de toute nature susceptibles de provoquer des odeurs incommodantes, de causer des nuisances et des dommages à l'environnement, à la santé et à la sécurité publique ; b) l'immersion, l'incinération ou l'élimination, par quelque procédé que ce soit, des déchets dangereux ou radioactifs dans les eaux continentales et/ou maritimes sous juridiction congolaise ainsi que leur enfouissement dans le sol ou le sous-sol. **Art. 58** Toute personne physique ou morale publique ou privée, qui produit ou détient des déchets domestiques, industriels, artisanaux, médicaux, biomédicaux ou pharmaceutiques est tenue d'en assurer la gestion conformément aux dispositions de la présente loi et de ses mesures d'exécution. Un décret délibéré en Conseil des ministres fixe les normes spécifiques de stockage, de recyclage, de traitement et d'élimination des déchets.		
Sanitation, Human waste	Loi	N°15/026 relative à l'eau	2015	**Chapitre 4 : De L'assainissement des agglomérations** **Art. 90** Le gouvernement, le gouvernement provincial et le collège exécutif de l'entité territoriale décentralisée s'occupent de l'assainissement des agglomérations en matière d'évacuation des eaux usées et pluviales. **Art. 91** L'assainissement des agglomérations comprend les travaux, les ouvrages et les mesures visant à assurer l'évacuation rapide et complète des eaux pluviales ainsi que des eaux usées domestiques et industrielles susceptibles de causer des nuisances. Il intègre en outre leurs traitements et recyclage éventuels dans les conditions qui puissent satisfaire aux exigences de la santé publique, de la préservation de la ressource en eau et de l'environnement.	https://www.leganet.cd/Legislation/Droit%20economique/Eaux/Loi.15.026.31.12.2015.html#TIV (Retrieved the 01.01.2020)	Regulations on urban sanitation

				Art. 92 Est obligatoire, dans les agglomérations dotées d'un réseau d'assainissement collectif, le raccordement à l'égout de toute habitation ou établissement rejetant des eaux. Les conditions et délais d'application des dispositions du présent article sont fixés par voie règlementaire. **Art. 93** Est interdite, l'introduction dans les installations d'assainissement et de drainage de toute matière solide, liquide ou gazeuse pouvant affecter la santé du personnel exploitant, occasionner une dégradation ou gêner le fonctionnement des ouvrages de traitement et d'évacuation. **Art. 94** Est soumis à l'autorisation préalable du gestionnaire local du service public d'assainissement, le raccordement au réseau public d'assainissement des eaux résiduaires autres que domestiques. Au cas où, à l'état brut, les eaux résiduaires sont susceptibles d'affecter le bon fonctionnement du réseau public d'assainissement et des installations d'épuration, leur prétraitement, avant rejet, est obligatoire. **Art. 95** Dans les zones où l'habitat est dispersé ou dans les agglomérations non équipées de réseau d'assainissement collectif, l'évacuation des eaux usées et pluviales se fait au moyen d'installations individuelles d'évacuation.		

				Les normes relatives à ces installations et les mesures de suivi sont définies par arrêté provincial délibéré en Conseil des ministres. **Art. 96** La gestion du service public de l'assainissement peut être confiée en tout ou en partie à toute personne physique ou morale, publique ou privée selon les conditions définies aux articles 78 et 79 relatives à la convention de gestion du service public de l'eau potable. **Art. 97** Un décret délibéré en Conseil des ministres fixe les normes, les responsabilités et les conditions de l'organisation, du développement, de la gestion, du fonctionnement et du financement du service public d'assainissement et de la gestion des déchets.		
Agriculture production	Loi	N°11/022 Portant principes fondamentaux relatifs à l'agriculture	2011	**Chapitre 3 : Des intrants et infrastructures agricoles de base** Section 1ère : Des intrants agricoles **Art. 28** L'État, la province et l'entité territoriale décentralisée prennent toutes les mesures nécessaires pour assurer la couverture totale des besoins nationaux en intrants agricoles de qualité. […] **Arti. 30** Le Gouvernement central, en concertation avec les provinces, les entités territoriales décentralisées et les professionnels de l'agriculture, met en œuvre un système national et des structures de promotion, de	https://leganet.cd/Legislation/Droit%20economique/Agriculture/RDC%20-%20Loi%20agriculture%20principes%20fondamentaux-%2024%2012%202011.pdf	**Regulation on agriculture and fertilizer provison**

				production, de commercialisation, d'homologation et de contrôle des intrants agricoles avant leur utilisation.		
Sanitation, Health	Loi	N°18/035 fixant les principes fondamentaux à l'organisation de la santé publique	2018	**Titre V : De la protection sanitaire du cadre de vie et de lphygiene publique** **Chapitre 1er : De la protection sanitaire du cadre de vie** Section 1ère : Des déchets **Art. 102** Les déchets biomédicaux ou hospitaliers sont gérés conformément au plan national établi par le ministre qui a la santé publique dans ses attributions tel qu'édicté par les normes de l'Organisation Mondiale de la Santé, à cet effet. **Art. 103** L'importation de déchets toxiques en République Démocratique du Congo est interdite. Section 2 : Des nuisances sonores **Art. 104** Est interdit, tout bruit qui porte atteinte à la tranquillité et à la santé de la population.	http://www.leganet.cd/Legislation/Droit%20Public/SANTE/Loi.18.035.13.12.2018.html	**Regulations on public health**

				Les ministres ayant la culture, l'environnement, la santé et l'intérieur dans leurs attributions déterminent par arrêté interministériel les mesures d'application de cette disposition.		
	Ordonnance	74-345 Sur l'hygiene publique dans les agglomerations	1959	**Art. 3** Dans les villes, les circonscriptions urbaines, les centres résidentiels, commerciaux, industriels, agricoles, miniers: 1° toute habitation, magasin, atelier, chantier, bureau ou tout autre établissement doit être pourvu de lieux d'aisance salubres et convenables. Par habitation, il faut entendre les locaux occupés par une seule famille; 2° dans les villes et circonscriptions urbaines et à proximité des usines, chantiers, comptoirs, ateliers, bureaux, les chefs d'industrie ou de maison de commerce devront aussi établir des latrines à l'usage de leurs serviteurs et travailleurs, et ce dans la proportion d'au moins un siège par quinze personnes à proximité des usines, chantiers et comptoirs employant moins de 60 personnes, d'au moins un siège par 20 personnes, dans les établissements cités employant de 60 à 200 personnes, d'au moins un siège par 30 personnes à proximité des établissements cités employant plus de 200 personnes; dans la proportion d'un siège par 50 personnes dans les chantiers ambulants ou provisoires. L'obligation prévue au 2° ci-dessus peut être étendue par le commissaire de district à toute personne employant du personnel domestique. Les latrines seront établies dans les conditions prescrites par les or-donnances réglementant les constructions dans les villes et les circonscriptions urbaines.	http://www.leganet.cd/Legislation/Droit%20Public/SANTE/O.74.345.28.06.1959.htm [Retrieved the 03.01.2020]	**Public health, sanitation**

				Les vidanges seront enlevées et enfouies ou déversées dans les con-ditions qui seront déterminées par l'autorité territoriale locale. **Art. 4** Lorsque fonctionne un réseau de distribution d'eau, seul est autorisé l'usage de latrines à chasses d'eau raccordées à des fosses septiques épuratrices, aux collecteurs d'une station d'épuration ou au réseau d'égout public lorsque celui-ci a été établi selon le système de tout-à-l'égout. **Les latrines, les fosses septiques épuratrices et les appareils d'épuration ne peuvent être construits qu'après approbation des plans et dispositifs par la direction technique des travaux d'hygiène au chef-lieu de la province ou par le service d'hygiène publique local. Aucune fosse septique épuratrice ou station d'épuration ne pourra être fermée et mise en service sans avoir été préalablement réceptionnée par l'autorité sanitaire locale**. Les fosses septiques épuratrices et les appareils collectifs d'épuration seront constitués par un élément collecteur et liquéfacteur (fosse septique) et un élément épurateur (lit bactérien percolateur). La fosse septique sera construite de façon à réaliser la rétention, la décantation et la liquéfaction biologique des matières excrémentielles ainsi que la décompression des gaz. Il sera compté 200 litres par personne pour les 6 premiers usagers, 120 litres par personne du 7e au 50e usager et 60 litres par personne au-delà du 50e usager.		

				Le lit bactérien sera constitué par une accumulation d'éléments po-reux de la grandeur d'une noisette à un poing, résistants au tassement et disposés en grosseur croissante de haut en bas. La surface en sera de 1 mètre carré par 10 usagers et la hauteur de 1 mètre à 1,50 m selon le degré d'épuration exigé par l'autorité sanitaire. Il devra être pourvu d'une prise d'air d'un décimètre carré par mètre cube de support, débouchant au niveau du sol, et d'un tuyau de ventilation d'une section d'un pouce à un pouce et demi, montant jusqu'au-dessus des toitures avoisinantes et auquel sera abouché le tuyau de décompression des gaz de la fosse septique. Les liquides qui en proviennent doi-vent être distribués en pluie sur toute la surface du lit bactérien. A aucun moment, il ne pourra être noyé même partiellement. La fosse septique et l'élément épurateur devront être construits en matériaux parfaitement étanches et en dehors des immeubles de façon à être aisément accessibles. lis seront pourvus d'ouvertures à couvercles hermétiques pour pouvoir en effectuer facilement la visite et le curage éventuels ainsi que d'un dispositif permettant d'opérer des prélèvements de l'effluent. Les eaux de bain, de lessive, de cuisine ou de pluie ne peuvent y avoir accès en aucun cas. L'effluent devra satisfaire aux conditions suivantes: 1. il ne pourra contenir plus de 30 mgr de matières organiques en suspension par litre; 2. un échantillon filtre d'environ 60 ml prélevé et conservé en présence de 4 gouttes d'une solution aqueuse de bleu de méthylène à 500 milligr/litre dans un		

				flacon de verre blanc bouche à l'émeri et complètement rempli doit voir sa coloration se maintenir après 4 jours au moins d'incubation à 30° C; 3. la D.B.O.5 à 20° ne peut dépasser 3 ml d'oxygène par litre. Les propriétaires sont tenus d'exécuter les nettoyages, réparations ou modifications jugés nécessaires par l'autorité sanitaire locale aux susdites installations afin de leur garantir un fonctionnement effica-ce, conformément aux dispositions de la présente ordonnance. Sur avis conforme de la direction technique des travaux d'hygiène, le gouverneur de province peut accorder des dérogations aux dispo-sitions énoncées par le présent article. […] **Art. 6** Dans les villes, les circonscriptions urbaines, les centres résidentiels, commerciaux, industriels, agricoles, miniers: 1° les étables, les porcheries, les écuries d'une capacité supérieure à 2 chevaux, les kraals, parcs ou enclos ouverts à la pluie sont interdits;		

				2° les constructions destinées au logement des animaux domestiques, telles que les chèvreries, bergeries, clapiers, poulaillers, en général, toutes les constructions servant au logement des grands et petits animaux domestiques, seront construites et entretenues suivant les règles prescrites par les ordonnances sur les constructions dans les villes et les circonscriptions urbaines; 3° les fosses à purin ouvertes sont interdites. **Art. 8** Le personnel des services d'hygiène publique et les chefs des brigades d'assainissement, les agents des travaux publiques, l'autorité territoriale sont spécialement chargés d'assurer l'observation des règles de la présente ordonnance et d'indiquer les mesures à prendre ou les travaux à exécuter en vertu des articles 1er à 4. Des plans de latrines de différents systèmes, de caniveaux couverts ou découverts, de cuisine, etc., sont déposés au service d'hygiène publique de la localité ou chez l'administrateur de territoire. Si, pour une cause quelconque, ces travaux ne sont pas exécutés dans le délai qui aura été fixé, ils le seront d'office, sans poursuites judiciaires, aux frais et risques des personnes déclarées responsables en vertu de l'alinéa premier de l'article 9. **Art. 10**		

				Les contraventions à la présente ordonnance seront punies d'une peine de servitude pénale de deux mois au maximum et d'une amende qui ne dépassera pas 2.000 francs ou d'une de ces peines seulement. Seront punissables des mêmes peines ceux qui, sur terrain occupé par autrui ou sur terrain public, et sans l'accord des personnes visées à l'article 9, alinéa 1, auront effectué, fait effectuer ou laissé effectuer des dépôts interdits par le 5° de l'article 1er, y auront provoqué la formation d'eaux stagnantes ou y auront jeté des récipients susceptibles de retenir l'eau. Les contraventions à la présente ordonnance peuvent être jugées, dans les limites de leur compétence, par les juridictions indigènes déterminées par le gouverneur de province.		
Environmental and Social impact assessment	Décret	14/019 fixant les règles de fonctionnement des mécanismes procéduraux de la protection de l'environnement	2014	**Annexe au Décret 14/019** 5. Gestion des produits et déchets divers •!• Toute unité de stockage de pesticides, de produits chimiques, pharmaceutiques d'une capacité supérieure à dix tonnes (10 T) ; •!• Toute unité de récupération, d'élimination ou de traitement de déchets domestiques, industriels et autres déchets à caractère dangereux ; •!• Toute unité de traitement ou d'élimination de déchets médicaux ; •!• Tout type de stockage de produits et/ou de déchets radioactifs ; •!• Tout stockage de produits dangereux; •!• Toute unité de traitement d'eaux usées domestiques ;	https://www.leganet.cd/Legislation/Droit%20administratif/Environnement/D.19.019.02.08.214.htm [Retreived the 03.01.2020]	Relevant for implementing the RUNRES innovations.

Human waste	Ordonnance	71-18 relative à l'hygiene et la salubrite publiques	1949	**Art. 1er** Sur les voiries et dans les lieux publics des circonscriptions urbaines et des villes déterminées par le gouverneur de province, seront compétents pour ordonner les mesures excréments et déjections humaines en dehors des endroits aménagés à cet effet par les services publics. **Art. 2** Les infractions à la présente ordonnance sont punies d'une servitude pénale de 7 jours au plus et d'une amende de 200 francs au maximum ou d'une de ces peines seulement.	http://www.leganet.cd/Legislation/Droit%20Public/SANTE/O.71.18.09.01.1949.htm [Retrieived the 02.01.2020]	Excrement handling in public places

Table 7.2: Table of the different policies covering DRC for research step 2, through the three circulation channels considered in the project.

RR-circulation loop	Policy level	Policy title	Year	Articles	Sources	Variables of interest for RUNRES
Waste management	Edit	N°001 Portant gestion des dechets en province du Sud Kivu	2013	**Exposé des motifs** […] La province et les Entités Territoriales Décentralisées ont l'obligation d'élaborer et d'exécuter un plan quinquennal de gestion des déchets. […] Il est vrai que certaines initiatives privées se sont développées, particulièrement dans la ville de Bukavu, en matière de gestion des déchets. Mais le manque de leur inscription dans une politique générale de la Province en la matière et du caractère contractuel de leurs prestations réduisent leur efficacité. […] **Titre I. Dispositions générales** **Chapitre 1 : Objet et champs d'application** **Chapitre 2 : Principes** **Art.3.** La gestion des déchets est une obligation des pouvoirs publics provinciaux et des Entités Territoriales Décentralisées. […] **Art.4.** Chaque citoyen a le droit et le devoir de concourir à la bonne exécution des programmes de gestion des déchets dans son entieté. Il a ainsi le droit d'être pleinement informé mais aussi le devoir de s'acquitter régulièrement et dans le délai de ses obligations pécuniaires relatives aux opérations de gestion des déchets. **Chapitre 3 : Définitions** **Titre II. Plans de gestion des déchets** **Art.7.** Le plan détermine notamment : 1. Les objectifs à atteindre en matière de taux de collecte et d'élimination des déchets ; 2. Les sites appropriés	Printed version of the *Bulletin Officiel de la Province du Sud-Kivu Numéro special Vol. II – 29 novembre 2013* obtained by the majors' assistant of Bukavu on the 09.01.2020; scanned the 13.01.2020	**Authorization for waste processing; Punishment for breaking the law**

				destinés à l’implémentation des installations d’élimination et de stockage des déchets en tentant compte des lieux de production de ces déchets et des orientations des documents d’urbanisme ; […] **Titre III. Service public et processus de gestion des déchets** **Chapitre 1 : Dispositions générales** **Art.11. La ville, la commune, le secteur ou la chefferie décident des modes de gestion du service public des déchets, par voie de régie directe, de régie autonome, de concession ou de toute autre forme de gestion directe ou de gestion déléguée. […]** **Art.13. Chaque ménage ou unité productrice ou détentrice de déchets est tenu de s’impliquer dans la gestion des déchets par le paiment d’une redevance relative à la gestion des déchets dont le taux est fixé par l’autorité territoriale compétente. […]** **Art.14. La ville, la commune, le secteur et la chefferie organisent de manière permanente l’information, l’éducation et la sensibilisation des citoyens sur les procédés, les modalités et l’intérêt de la gestion des déchets dans leurs ressorts respectifs. […]** **Art.15.** L’ouverture, le transfert la fermeture ou la modification substantielle des installations de traitement, de valorisation, d’incinération, de stockage, d’élimination ou de mise en décharge des déchets sont subordonnées à l’autorisation prévue par l’ordonnance 41 à 48 du 18 février 1953 sur les établissements dangereux, insalubres ou incommodes. **Art.16** Sans préjudice des dispositions de l’ordonnance 41 à 48 du 12 février 1953 susmentionnée, la demande d’autorisation prévue à l’article 10 ci-dessus comporte obligatoirement : 1. Les informations sur la personne ou les personnes pétitionnaires ; 2. Les informations sur la décharge contrôlée ou l’installation projetée et leur site ; 3. La nature des activités à exercer et les types et quantités de déchets ; 4. Les prescriptions techniques et les modes de		

				traitement, de valorisation et d'élimination des déchets ; 5. Les précautions devant être prises pour garantir les conditions de sécurité et de protection de l'environnent ; 6. Une étude d'impact sur l'environnement. **Chapitre 2 : Précollecte des déchets** **Art.21. Les services de gestion des déchets indiquent le tri qui doit être préalablement et obligatoriement effectué par celui qui dépose des déchets ainsi que le type d'emballage à utiliser en vue de permettre une identification rapide et une orientation appropriée des déchets.** **Art.22. Le ramassage des déchets est effectué par les services de la ville, de la commune, du secteur et de la chefferie ou par les organismes privés agréés.** **Chapitre 3 : Collecte et transport des déchets** **Chapitre 4 : Mise en décharge** **Art.28.** La ville, la commune, le secteur et la chefferie dösignent, conformément aux caractéristique et presriptions techniques réglementaires, la (les) décharge(s) où (sera) seront déposé(s) d'une façon permanente les déchets. **Art.29.** Sans préjudice de la loi sur la réglementation nationale, les décharges ne peuvent être autorisées à s'installer à la proximité des zones sensibles, des zones d'interdiction et de sauvegarde prévue par la loi. […] **Art. 32.** L'exploitant de la décharge prends les précautions nécessaires en vue d'éviter à l'environnement et aux riverains tout danger ou incommodité résultant des opérations de traitement des déchets. **Titre IV. Contrôle, Infractions et sanctions** **Chapitre 1 : Contrôle**		

				Art. 38. Les agents chargés du contrôle ont libre accès aux décharges contrôlées et aux installations de traitement, de valorisation, de stockage ou d'élimination des déchets. **Chapitre 2 : Infractions et sanctions** **Art.42.** Quiconque, en dehors des endroits désignés à cet effet, dépose, jette ou enfouit des déchets domestiques ou procède à leur stockage, traitement, élimination ou incinération en violation du présent Edit est passible d'un emprisonnement d'un mois à deux ans et d'une amende de 100.000 à 1.000.000 de francs congolais ou de l'une de ces peines seulement. **Art.43.** Quiconque exploite, modifie d'une façon substantielle, transfère ou ferme une décharge contrôlée ou une installation de traitement, de valorisation, de stockage ou d'élimination des déchets sans les autorisations prévues est puni d'un emprisonnement de trois mois à trois ans et d'une amende de 200.000 à 2.000.000 de francs congolais conformément à la Loi n°11/009 du 09 juillet 2011 portant principes fondamentaux relatifs à la protection de l'environnement. **Titre V. Dispositions transitoires et finales**		
Waste management assessment & planning	Strategy note	Débarrasser la ville des déchets - avoir une ville propre et saine	2018	**Chapitre I. Contexte historique et socio-enviornmental** **Chapitre II. Mission et vision de la mairie de Bukavu** **Chapitre III. Definition des axes strategiques d'assainissement urbain** **Annexes**	PDF document obtained from the municipality of Bukavu on the 09.01.2020	Assessment of the waste (management) situation in Bukavu

7.2 Arba Minch, Ethiopia

Step 1: Online Review

In step 1, we searched for policy documents online and downloaded them. The following list of policy documents has been used to describe the policy context:

- Federal Democratic Republic of Ethiopia. March 8th, 2006. "Ethiopian Organic Agriculture System Proclamation No. 488/2006." Announced on Federal Negarit Gazeta
- Federal Democratic Republic of Ethiopia. 13th January, 2010. "Food, Medicine and Health Care Administration and Control Proclamation No. 661/2009". Announced on Federal Negarit Gazeta
- FDRE Environmental Protection Authority. 1997. Environmental Policy, April 2, 1997, Addis Ababa. Announced on Federal Negarit Gazeta
- FDRE House of Peoples Representative. 2007. Solid Waste Management Proclamation No.513 /2007, Announced on Federal Negarit Gazeta

NB: **Part-2 (Article 6)** Ethiopian Organic Agriculture System Proclamation No. 488/2006. Inspection and Certification Bodies article states that Inspection and Certification Bodies Ensure the fulfillment of requirements provided for by this Proclamation and regulations and directives issued hereunder as well as the relevant international standards. From this statement above, we need to understand whether this proclamation generic and whether it needs additional guidelines and regulations, but we could not easily find regulations and guidelines online, we therefore refer to those materials from the ministries (Ministry of health, Ministry of trade, ministry of Agriculture) because they may be available in hard copy. This search has been interrupted because of current situation, but we will search the following guidelines from aforementioned and other offices too:

- ☞ Waste Handling, processing and Disposal Guideline
- ☞ Guideline for Environmental Management Plan
- ☞ Food, Medicine and Health Care Administration and Control guideline
- ☞ Guideline for Waste Handling and Disposal in Health Facilities and others too

Also, from the statements "directives issued hereunder as well as the relevant international standards", we can understand that international standards can be applicable in Ethiopian condition. We can therefore use "WHO guideline Volume 4"...Excreta and Greywater Use in Agriculture guidelines” as reference point.

Table 7.3: Table of the different policies covering Ethiopia, through the three circulation channels considered in the project.

RR-Focus	RR-circulation loops	Policy(-ies) title(s)	Policy objective(s)	Source	Variables of Interest for RUNRES
Farming	Organic waste	a. *Environmental policy* b. *solid waste management proclamation* c. Organic Agriculture System Proclamation	a. to improve and enhance the health and quality of life of all Ethiopians and to promote s ustainable social and economic development thr ough the sound management and use of natural, human-made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. b. aims to promote community participation to prevent adverse impacts and enhance benefits resulting from solid waste management. It provides for preparation of solid waste management action plans by urban local governments. c. Ensure that all stages of production, processing, storage, transport and marketing of organic agricultural products are subject to inspection and comply with the standards specified by regulations and directives issued hereunder	a. FDRE Environmental Policy,1997 b. Solid Waste Management Proclamation No.513 /2007 c. Ethiopian Organic Agriculture System Proclamation.... NO.488/2006.	a. promote the use of appropriate organic matter and nutrient management b. promotes economically and socially beneficial asset development out of compostable solid waste c. Facilitate acceptance of organic agricultural inputs and farm produces.
	Human waste	[TBC]	[TBC]	[TBC]	

	Small-scale processing	d. Environmental Pollution Control Proclamation,	[TBC]	d1.Environmental Pollution control proclamation No. 300/2002 of Ethiopia *d2Management of Municipal Waste*	**d1.Any person engaged in the collection, recycling, transportation, treatment or disposal of any hazardous waste shall take appropriate precaution to prevent any damage to the environment or to human health or well-being.** d2. All urban administrations shall ensure the collection transportation, and, as appropriate, the recycling, treatment or safe disposal of municipal waste through the institution of an integrated municipal waste management system.
Trading	Organic waste	[TBC]	[TBC]	[TBC]	
	Human waste	[TBC]	[TBC]	[TBC]	
	Small-scale processing	[TBC]	[TBC]	[TBC]	
Consumption	Organic waste	a. Solid Waste Management Proclamation	a. aims to promote community participation to prevent adverse impacts and enhance benefits resulting from solid waste management. It provides for preparation of solid waste management action plans by urban local governments.	a. FDRE Solid Waste Management Proclamation No.513 /2007	b. promotes use of recyclable soild waste becaus part-II, Article 11: states that *"The head of each household shall ensure that recyclable solid wastes are segregated from those that are destined for final disposal and are taken to the collection site designated for such wastes"*

	Human waste	[TBC]	[TBC]	[TBC]	
	Small-scale processing	[TBC]	[TBC]	[TBC]	

7.3 Kamonyi, Rwanda

Step 1: Online Review

We used the different websites of the Rwandan national authorities (ministries) to check if there are any policies/acts online available. We went through the different published policy documents. We also checked the other relevant policy documents/acts that the policy document is referring to. We searched in the documents on keys words such as agriculture, waste, organic, human, food safety, consumption, act, laws.

Step 2: Contact and search at the various government agencies

After searching online and collecting online data, we contacted different national government authorities to cross check my findings. In the policies it is mentioned that there is not much legislation in place yet or that legislation is outdated.

Table 7.4: Summary of the persons contacted in the 2nd step for Rwanda

Institution	Policy/act	Contact person	Position	Contact details	Date contacted
Ministry of Agriculture		Mujawimana Florence	Part of agricultural department	ND	09/12/2019
Ministry of Agriculture and Livestock Inspection and Certification (RALIS – responsible for certification) – KN 34	National Fertilizer Policy and Agro Chemical law	Eng. Beatrice Uwumukiza	Director General of RALIS	ND	11/12/2019
Ministry of Environment	Organic law, National Environment and Climate Change Policy. Rwanda Environmental Policy	Kabera Juliet	DG. Environment & Climate change	ND	11/12/2019
Rwanda Standard Board	Solid organic fertilizer standard, fresh cassava leaves, cassava flour, Fresh bitter cassava	Athanasie,	Managing Rwanda Standard Board	ND	16/12/2019
Ministry of Infrastructure	National Sanitation Policy & strategy 2016				
Ministry of Health	Refers back to National Sanitation Policy and Ministry of Infrastructure				

Ministry of Agriculture

- ***There are no regulations towards the use/collection/treat/or consumption of organic/human waste fertilizers***. There is only a National Fertilizer Policy, but it does not include regulations for organic/human waste fertilizers. There is only trainings material for farmers who would like to produce compost from organic waste.
- For standards around processing of cassava, Rwanda Standard Board should be contacted, in order collect information about standardization. Contact person here is Athanasie, 0788483488
- Currently, research is conducted by Rwanda Environmental Management Authority, Jack 076624431.
- Beatrice is interested to learn if there is more research done how human waste should be treated, if there are research available about the (medical) residues that can be found in crops, and if there are standards available in other countries. She would like to know what the composition is of organic fertilizers (what elements are in it). Beatrice would like to receive the findings of the research and to be updated about the project.

Ministry of Environment

- The Ministry of Environment requested a letter of IITA/CIAT that describes the project, before she wants to share any information about this topic.
- She also would like to know who of Ministry of Agriculture refers to the Ministry of Environment, who is coordinating it from the Ministry of Agriculture.
- The letter should be directed to Fatina Mukarubibi, a concept letter is drafted.

Ms. Fatina MUKARUBIBI
Permanent Secretary
Ministry of Environment
ND

Rwanda Standard Board

- After contacting the Ministry of Agriculture, Eng. Beatrice Uwumukiza, has refered to Anthanasie of RSB. Athanasie has informed that there are two standards for processing cassava, namely the flour and the leaves. We went through the standards at the Rwanda Standard Board, however we could only make some small notes since you normally need to buy the standards. Standards for the processing/labelling/packaging/transporting cassava are based on the East-Africa standards. The summery of the standard is presented in the table above.

- In addition, we found a standard for producing Solid Organic Fertilizer, which was not mentioned by the Ministry of Agriculture. According to the Rwanda Standard Board the standard will be only legally binding, if the Ministry of Agriculture will develop a Technical standard/policy. The summery of the Standard is presented in the table above. In case you would like more information, you would need to buy the standard for producing Solid Organic Fertilizer.

Ministry of Infrastructure

- We reached out a couple of times out to the Ministry of Infrastructure, since they are in charge of waste management. We have not been successful yet to reach to them, since they are not picking up the phone or other forms of contact.

Table 7.5: Table of the different policies covering Rwanda, through the three circulation channels considered in the project.

RR-Focus	RR-circulation loops	Policy(-ies) title(s)	Source/code	Articles	Variables of Interest for RUNRES
Farming	**Organic waste**	The National Fertilizer Policy	The National Fertilizer Policy	The National Fertilizer Policy discusses 3 types of fertilizers, (1) mineral/inorganic fertilizers, (2) organic fertilizers (produced from non-synthetic organic material incl. sewage sludge, animal manure, and plant residues produced through the process of drying, cooking, composting, chopping, grinding, fermenting or other methods), (3) biofertilizers (a substance that contains living micro-organism which colonized the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients). The objective of the policy is to contribute to increased agriculture productivity, economic returns and incomes through sustainable use of fertilizers. Specify objectives that are related to regulations/incentives: - Promote fertilizer trade by introducing appropriate and effective incentives that encourage investment by the private sector. - Establish an efficient regulatory and monitoring system that is private sector friendly and ensures the sustainable supply to high quality fertilizer products along the distribution chain in a manner that safeguard human health and the environment. - Establish incentives that permit increased access and use of fertilizers at affordable rates by farmers. Such incentives shall not be limited to agriculture finance, insurance and subsidies. - Foster institutional linkages and gender issues in policies - Promote harmonization of fertilizer policies at regional levels. It is stressed that policies require appropriate legislation to back them up. Currently, the National Fertilizer Policy is referring to Agro-Chemical law and ministerial Instructions governing agro-chemicals, agro-dealers and premises.	
		Agro Chemical Law and Ministerial Instructions, governing agro chemicals,	**Law N°30/2012of 01/08/23012**	This Law governs the manufacturing, importing, distribution, use, storage, sale and disposal and burial of agrochemicals for the protection of human and animal health and the environment, to avoid injury and contamination which may result from their use. However, this law is not focused on organic/human waste fertilizers, which is confirmed by the Ministry of Agriculture. Also, the Strategic Plan for the Transformation of Agriculture in Rwanda - Phase II, refers that there are no regulations in place yet for organic farming/organic fertilizers. However, they do promote organic fertilizers in the Strategic plan in order to improve soil fertility management (SP 1.4.4)	

		agrodealers and premises			
	Organic waste/human waste	Standard Solid Organic Fertilizer	Standard Solid Organic Fertilizer RS: 279 **(**only available through Rwanda Standard Board)	5.1 only allowed materials shall be used. Those restricted shall be used after undergone recommended treatment of quality control. Allowed are: - Corpith, plantation by-product - Animal manure, urine - Vermic compost - Compost organic residues - Green manure/ green leave manure - Oil cakes, milled by-products and wastes - Crop residues - Kitchen waste Prohibited and restricted materials - Sewage sludge (only sludge from farms/biodigester is allowed) - **Raw/undecomposed human excrement including urine (risk of contamination)** - By-products of plant origin of food and textile industries. Restricted without synthetic additives & residues - Blood, bone and other meal brought in from resources; origin of material should be disease free and without preservatives - 5.3 free from foul smell and foul odor 5.4 homogenous in texture 5.5 organic fertilizer shall be fine enough for 100% there of to pass through 12 mm standard sieve. 5.6 tested by physical sorting organic fertilizer shall not contain: - more than 5 seeds/kg -more than 5 % stones larger than 5 mm -more than 0.5% of foreign material larger than 2 mm **5.7 free of pathogens & contamination such as residual hormones, antibiotics, pesticides, heavy metals in amount that be hazard to the soil/plants /applicant/consumers oft he harvest product**.	
	Human waste	Standard Solid Organic Fertilizer		**See comment above in bold: Raw/undecomposed human excrement including urine (risk of contamination) are prohibited according to the Standard Solid Organic Fertilizer**	**Human waste should be treated before applying it is input for farming/fertilizer**

	Organic/human waste	National Enviroment and Climate Policy	National Enviroment and Climate Policy **Policy objective 1, policy statement 5**	There is no specific guidelines that apply for only organic/human waste in this policy, however there are some policy objectives that covers waste in general. One of objectives is: - Policy statement 5 include policy action to promote waste management system to reduce greenhouse gases and to promote private investment, especially the development of appropriate water and sanitation technologies and infrastructure for waste management. I **In order to learn more, the Ministry of Environment is contacted, we are waiting for their response.**	
	Human waste	Organic Law	NO.04/2005 OF 08/04/2005 Organic law determining the modalities of protection, conservation and promotion of the environment in Rwanda	Article 81 The following are prohibited: 1° dumping or disposal of any solid, liquid waste or hazardous gaseous substances in a stream, river, lake and in their surroundings; 2° damaging the quality of air and of the surface or underground water; 3° non authorized bush burning; 4° smoking in public and in any other place where many people meet; 5° defecating or urinating in inappropriate place; 6° spitting, discarding mucus and other human waste in any place. Article 84: It is prohibited to keep or dump waste in a place where it may: 1° encourage the breeding of disease carriers; 2° disrupt the people and the property. Article 88 It is prohibited: 1° to dump, make flow, dispose of and store any substance in a place where it may cause or facilitate water pollution on national territory, 2° to use natural resources in degrading and illegal manner Article 90 It is prohibited: 1° to pile waste on waste on unauthorized public places including lands defined by law 2° to import waste into the country, 3° to immerse, burn or eliminate waste in wetlands by any process without respecting the rules applied in Rwanda Article 93 It is prohibited: 1° to use explosives, drugs, poisonous chemical substances and baits in water that may intoxicate or even kill fish, 2° to use explosives, drugs, poisonous chemical substances and baits that may kill wild animals and which may render them unfit for consumption **To learn more the Ministry of Environment is contacted, we are waiting for their response.**	The availability of drug residues in human waste limits the possibility to use (untreated) human waste as organic fertilizer The availability of diseases in human waste limits the possibility to use (untreated) human waste as a fertilizer The availability of diseases and drugs to pollute water limits the use of (untreated) human waste as a fertilizer Farmland that is surrounded by wetlands (protected) limits the use of human waste as a fertilizer

		National Sanitation policy 2016	National Sanitation Policy	The National Sanitation Policy has the vision to ensure sustainable, equitable and affordable access to safe sanitation and waste management services for all Rwandans, as a contribution to poverty reduction, public health, economic development and environmental protection. One of the objectives is to: - Raise and sustain household sanitation coverage to 100 per cent by 2020. This objective also include to develop, pilot and demonstrate a range of individual sanitation technologies for different standings. This includes composting facilities through improved pit latrines, fossa alterna, ecosan, arbour loo and pour flush toilets. Collective toilets include biogas facilities are considered as feasible solutions in dense population or even in combination with livestock. The **Rwanda Standards Board** (RSB) shall be involved in the standardization of sanitation technologies in accordance with environmental requirements. - Develop safe well regulated and affordable off-side sanitation services for densely populated areas. This objective includes that there is a need for establishing a effective regulatory and institutional framework for collective sewerage and sludge management. **The Ministry of infrastructure should give more clarification.**	The limited availability of legally binding regulations provide opportunities to develop circular regulations.
		Law of putting in place the use, conversation, protection and management of water resources regulations	Law N^{o}62/2008 of 10/09/2008 putting in place the use, conversation, protection and management of water resources regulations.	**Article 58: Special sanitation for waste water** Domestic, animal and industrial waste waters must be routed toward an individual treatment device before their rejection in the nature or being reused. This act is carried out in accordance with legal provisions relating to hygiene and sanitation. **Article 61: Sanitation Management** Collective and non collective sanitation management may be delegated to a competent private legal person **Article 66: Environment protection** Construction works and other various activities shall be carried out in accordance with the organic law n° 04/2005 of 08/04/2005 determining the modalities of protection, conservation and promotion of environment in Rwanda and with this Law	The availability of skilled workers/companies to treat the human-waste/waste-water could limit the possibilities of using human waste as fertilizer
	Small-scale processing			Standards for processing cassava, there are a couple of standards for cassava, namely fresh cassava leaves specification EAS 780; 2012, cassava flour EAS 779 ; 2012 and Fresh bitter cassava EAS 778; 2012. All standards are based on East-African standards. Since cassava processing only applicable for cassava flour, it is chosen to include this standard. The Rwanda Standard Board only provide fully access by buying the standard.	

				High quality cassava flour is intended for human consumption, industrial use and applications. Cassava flour is processed from fresh cassava prepared from fresh cassava roots, through a process of peeling, chipping or granting followed by dewatering, drying and milling. 5.2 General quality requirements; - Safe for human consumption - Free from living insects and foreign matter - Free of extraneous matter - Free of flavors and odors 6.2 other contamination High quality cassava flour shall conform to those max level Codex General Standard for contaminations & Toxin in food and Feed Codex stand 193 Packaging safeguard safety/hygiene nutritious and organoleptic	
Trading	**Organic waste**	Rwanda Trade Policy	**Rwanda Trade Policy**, objective 1, 5.1 Increased productivity and diversified sustainable productive capacities for trading nationally, regionally and internationally	According to the Ministry of Agriculture there are no regulations. The only regulation that can be found is the next policy: The Rwanda Trade Policy refers to the -Strategic Plan for the Transformation of Agriculture in Rwanda - Phase II, 2009, that formulated a couple of priorities, such as market diversification, export value addition, product standards and certification, organic agriculture exports. The implementation of the Strategic Plan will be supported by the trade policy. One of the priorities is to: - The development of organic agriculture sector should be stepped up, and markets for such products found and exploited. Actions in this regard include improving the skills of organic product exporters, provide them technical information and support to grow high-quality organic products successfully and also to keep the necessary records, and ensure consistency in supply. - Agricultural products for exports to international markets must meet international sanitary and phyto-sanitary standards for the protection of human, animal and plant health. Thus the infrastructure for upgrading and improving product standards and certification, for example laboratories for product certification, market compliance, conformity, safety mechanisms, enterprise quality management, will have to be put in place or strengthened.	**Products are grown with inputs of organic waste should follow the internationals standards in order to export the products to international markets.**

	Human waste			**There are no regulations, which is confirmed by the Ministry of Agriculture**	
	Small-scale processing			There are no regulations, which is confirmed by the Ministry of Agriculture. What are guidelines prices of selling/ transport/ how to handle/standards → ministry of Agriculture	
Consumption	**Organic waste**	Fresh bitter cassava standard EAS 778; 2012		There are no regulations towards consuming vegetables/cassava that are produced with inputs of organic waste, which is confirmed by the Ministry of Agriculture There only some standards for consuming cassava roots in general: - Cassava should not be eaten raw - Cassava shall be peeled, de-pitched, scraped, sliced into pieces, risedan fully cooked before consumption - Cooking / wash water shall not be consumed / used for other food preparation purposes.	
	Human waste			**There are no regulations towards consuming vegetables/cassava that are produced with human waste inputs, which is confirmed by the Ministry of Agriculture**	
	Small-scale processing			There are no regulations, which is confirmed by the Ministry of Agriculture	

7.4 Msunduzi, South Africa

South Africa’s legal and regulatory environment regarding the recovery, processing, and reuse of organic and human waste is complex, involving many government departments. Waste management licenses, permits, and registrations are required for waste management activities across the entire solid waste and sanitation service chains. The permitting process for all such activities is led by the Department of Water and Sanitation, which is supported by the Department of Environment, Forestry and Fisheries (National Environmental Management Air Quality Act No. 39 of 2004), Department of Agriculture, Land Reform and Rural Development (Act No. 36 of 1947) and Department of Health (Occupational Health and Safety Act No. 85 of 1993). The Department of Water Affairs and Forestry (DWAF) now the Department of Human Settlements, Water and Sanitation leads the regulatory role in the reuse and disposal of sludge. For example, DWAF requires a positive Record of Decision (ROD) for an Environmental Impact Assessment from DEAT, in order to issue a licence. Similarly, the national and provincial Departments of Health and of Agriculture could have requirements that must be taken into consideration for application of human excreta derived fertilizers (HEDF) on agriculture.

According to National Environmental Management: Waste Act, 2008, a Waste Management License is required for the construction of a facility, storage, treatment (including the composting), and processing of animal manure, at a facility in excess of 10 tons per month for category A material. The treatment of general waste by a method other than biological, physical or physicochemical treatment (pyrolysis of biochar may fall under this bracket) excess of 10 tons per day also require environmental impact assessment and a Waste Management License. The discharge of waste to any water resource in ways which could affect the water resource requires a Water Use License which can take up to 300 days to process, varying on the complexity of the application, benefits to the economy, and potential environmental impacts with high value-low impact applications taking less time.

This review identified that fertilizers derived from human waste are permissible under South African law. However, strict regulations intended to ensure the safe application of these soil inputs do exist and must be met to be in compliance with South African law. For example, clear guidance for the application of wastewater sludge can be found in the document *Guidelines for the utilization and disposal of wastewater sludge Volume 2 of 5: Requirements for the agricultural use of wastewater sludge*. This framework, prepared for the Water Research Commission by Golder Associates Africa, outlines the legal requirements by the Department of Human Settlements, Water and Sanitation, and lays out a detailed protocol for the use of HEDF produced from this waste source.

For example, any actors intending to utilize sludge to support agricultural production must classify the waste source according to three criteria: microbial, stability, and pollution (Table 7.6). Details of the classification levels can be found in the chapter appendix. Liquid and dewatered sewage sludge producers and users must also have a contract specified in Appendix 1 of the volume 2. This is a legal requirement by the Department of Human Settlements, Water and Sanitation. The contract specifies that the user must obtain a general authorization or water use license and adhere to the Volume 2 of the guidelines. These guidelines should also apply on the use of effluent, and source separated urine and human fecal matter on agriculture.

Table 7.6: South African wastewater sludge classification system for sludge derived fertilizers.

Microbial class	A	B	C
Stability class	1	2	3
Pollution class	a	b	c

In addition to a review of the grey literature, direct communication with a representative of the certifying sub-unit of the Department of Agriculture, Land Reform and Rural Development (personal communication, 2020), indicates that a fertilizer can be registered regardless of the material source. The Department of Agriculture, Land Reform and Rural Development through the act 36 of 1947 regulates the classification, blending/fortification, packaging, labelling and certification. This creates clear potential for the adoption of HEDFs to support agricultural production in the city-region.

The inclusion of waste-based products to support animal feed in South Africa is discussed in the *Fertilizers, farm feeds, agricultural remedies and stock remedies act, 1947 (act no. 36 of 1947) and the animal health act.* These documents prohibit the use of processed animal protein derived from ruminants as a source of animal feeds intended for commercial purposes. In addition, the use of feeds for farm animals is illegal if it contains feces, urine, digestive tract material, wastewater, municipal solid waste, or household waste. These regulations were intended primarily for ruminants; given the growing realization of the potential of insect protein to serve as primary ingredient for animal feed, the current regulations will likely need to be updated to provide clearer guidance on the near future.

In the main, the Global Good Agricultural Practice (Global GAP) prohibits the use of human sewage sludge on farms for certified crops as specified in control point-crops base 4.4.1 (Figure 7.1). Although the use of treated sewage sludge is justifiable in control point-crops base 5.3.1 provided water quality meets the (World Health Organization, 2006) guidelines for safe use of wastewater and excreta in agriculture and aquaculture_(Global G.A.P., 2016). Because most countries with missing or unclear legislation tend to adopt the global standards, the Global GAP manual, which is the widely adopted standard for food safety and protection of the welfare of farmworkers can be assumed when such policies are unclear and unregulated for exporting farmers.

CB 4.4	**Organic Fertilizer**		
CB 4.4.1	Does the producer prevent the use of human sewage sludge on the farm?	No treated or untreated human sewage sludge is used on the farm for the production of GLOBALG.A.P. registered crops. No N/A.	Major Must
CB 4.4.2	Has a risk assessment been carried out for organic fertilizer, which, prior to application, considers its source, characteristics and intended use?	Documented evidence is available to demonstrate that a food safety and environmental risk assessment for the use of organic fertilizer has been done, and that at least the following have been considered: • Type of organic fertilizer • Method of treatment to obtain the organic fertilizer • Microbial contamination (plant and human pathogens) • Weed/seed content • Heavy metal content • Timing of application, and placement of organic fertilizer (e.g. direct contact to edible part of crop, ground between crops, etc.). This also applies to substrates from biogas plants.	Minor Must

Nº	Control Points	Compliance Criteria	Level
CB 5.3	**Water Quality**		
CB 5.3.1	Is the use of treated sewage water in pre-harvest activities justified according to a risk assessment?	Untreated sewage is not used for irrigation/fertigation or other pre-harvest activities. Where treated sewage water or reclaimed water is used, water quality shall comply with the WHO published 'Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture 2006'. Also, when there is reason to believe that the water may be coming from a possibly polluted source (i.e. because of a village upstream, etc.) the producer shall demonstrate through analysis that the water complies with the WHO guideline requirements or the local legislation for irrigation water. No N/A.	Major Must

Figure 7.1: Global Gap regulations.

GlobalG.A.P., 2016. Integrated Farm Assurance. All Farm Base – Crops Base - Fruits and Vegetables. Control Points and Compliance.

World Health Organization, 2006. Who Guidelines for the Safe Use of Wastewater , Excreta and Greywater - Policy and regutatory aspects, in: Who Guidelines for the Safe Use of Wastewater , Excreta and Greywater. https://doi.org/10.1007/s13398-014-0173-7.2

https://www.environment.gov.za/sites/default/files/legislations/nema_amendment_act59.pdf

http://www.fse.org.za/Downloads/WATER%20USE%20LICENCE%20APPLICATION.pdf

http://www.dwa.gov.za/WAR/licenceprocess.aspx

Table 7.7: Table of the different policies covering South Africa, through the three circulation channels considered in the project.

RR-Focus	RR-circulation loops	Policy(-ies) title(s)	Source/code	Articles	Variables of Interest for RUNRES
Farming	Human waste	Fertilizers Farm Feeds and Agricultural Remedies Act	Act No. 36 of 1947; https://laws.parliament.na/cms_documents/fertilizers-farm-feeds-and-agricultural-remedies-a26a61ba9a.pdf	"Art. 37, Par. 1d: it must be certified to comply with the following quality requirements: (i) Stabilised – should not cause odour nuisances or fly-breeding (ii) Contains no viable Ascaris ova per 10 g dry sludge (iii) Maximum 0 Salmonella organisms per 10 g dry sludge (iv) Maximum 1000 Faecal coliform per 10 g dry sludge immediately after treatment (disinfection / sterilisation)"	**Utilization of sewage sludge (potentially applying to treated faeces from UDDT)**
		Guidelines For The Utilisation And Disposal Of Wastewater Sludge, Volume 1-5. Impact Assessment	http://www.wrc.org.za/mdocs-posts/guidelines-for-the-utilisation-and-disposal-of-wastewater-sludge-volume-1-5-impact-assessment/ http://sawic.environment.gov.za/documents/268.pdf	All sludge producers currently using or intending to use sludge in agricultural practices must confirm the classification of the sludge Table 2-6. Microbial class A B C Stability class 1 2 3 and Pollution class a b c, Microbiological class A sludge/product could be distributed to the public without any restrictions Contractual agreement between a sludge producer and sludge user Other classes follow the following restrictions Crop restrictions Storage before use Application rates Buffer zones for groundwater and /or surface water Prevention of soil erosion Distance from urban areas and informal settlements	

				Monitoring programme Record keeping	
	Small-scale processing	Constitution of the Republic of South Africa	https://cer.org.za/wp-content/uploads/2014/02/108-of-1996-constitution-of-the-republic-of-south-africa_23-aug-2013-to-date.pdf	**Section 24. Environment** Everyone has the right – (a) to an environment that is not harmful to their health or well-being; and (b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that – (i) prevent pollution and ecological degradation; (ii) promote conservation; and Page 23 of 177 Prepared by: In partnership with: (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development	RUNRES initiatives must only be permitted to the extent that it can be undertaken in a manner that is consistent with section 24 of the Constitution, and that any regulation of RUNRES innovations must constitute "reasonable legislative measures" that comply with the requirements of section 24 of the Constitution.
		National Environmental Management Act (No. 107 of 1998)	https://cer.org.za/wp-content/uploads/2010/03/107-of-1998-national-environmental-management-act_18-dec-2014-to-date.pdf https://www.westerncape.gov.za/eadp/files/atoms/files/WML%20Guideline%202017_web_8.pdf https://cer.org.za/wp-content/uploads/2010/03/107-of-1998-National-Environmental-Management-Act_18-Dec-2014-to-date.pdf	WASTE MANAGEMENT LICENCE These categories are called "Category A", "Category B", and "Category C". "Category A" (Appendix 1) and "Category B" (Appendix 2) activities require an Environmental Impact Assessment ("EIA") process (see section 2 below) to be undertaken prior to obtaining a WML, while "Category C" (Appendix 3) activities require adherence to norms and standard	**Implications for small scale processing**
		National Water Act, 1998 (NWA),	http://www.energy.gov.za/files/policies/act_nationalwater36of1998.pdf	Sanitation services to public institutions and places according to Point 10.1.16 Sanitation services shall	Opportunity for RUNRES recycling in academic institutions

		National norms and standards for domestic water and sanitation services (DWS) Water and Sanitation Dept Budget Vote 2015/16	https://cer.org.za/wp-content/uploads/1997/12/National-norms-and-standards-for-domenstic-water-and-sanitation-services.pdf https://www.gov.za/speeches/address-minister-water-and-sanitation-ms-nomvula-mokonyane-occasion-budget-vote-201516-21	ensure proper solid waste disposal: Effective management of solid waste and re-use/recycling, adhering to the requirements of the Waste Management Act (South Africa, 2008b) and the relevant strategies and guidelines. Waste bins with lids in female toilets must be supplied.	and public places e.g. schools
		National Environmental Management: Waste Act, 2009	https://cer.org.za/wp-content/uploads/2010/03/59-of-2008-national-environmental-management-waste-act_regs-gn-921_24-jul-2015-to-date-1.pdf https://cer.org.za/wp-content/uploads/2010/03/NEMWA-latest.pdf	The objects of this Act are- (a) to protect health, well-being and the environment by providing reasonable measures for- (i) minimizing the consumption of natural resources; (ii) avoiding and minimizing the generation of waste; (iii) reducing, re-using, recycling and recovering waste; (iv) treating and safely disposing of waste as a last resort; (v) preventing pollution and ecological degradation; (vi) securing ecologically sustainable development while promoting justifiable economic and social development; vii) promoting and ensuring the effective delivery of waste services; (viii) remediating land where contamination presents, or may present, a significant risk of harm to health or the environment; and (ix) achieving integrated waste management reporting and planning; (b) to ensure that people are aware of the impact of waste on their health, well-being and the environment; (c) to provide for compliance with the measures set out in paragraph (a); **and (d) generally, to give effect to section 24 of the Constitution in order to secure an environment that is not harmful to health and well-being.**	Another legal opportunity for RUNRES initiatives Need to be worry of **genotoxic waste and 'infectious waste'**

		National Environmental Management: Air Quality Act, 2004 (AQA).	https://www.environment.gov.za/sites/default/files/legislations/nema_amendment_act39.pdf	[TBC]	
		Hazardous Substances Act 15 of 1973	https://www.gov.za/sites/default/files/gcis_document/201504/act-15-1973.pdf	[TBC]	
Trading	**Organic waste**	National Water Security Framework White Paper $or Sustainable Forest Development in South Africa WPSFD), the Policy for Industrial Forestry.	https://www.nationalplanningcommission.org.za/assets/Documents/Frameworks/NWS%20Framework%20Public%20Version%200.0%2011%2006%202019.pdf https://www.nationalplanningcommission.org.za/assets/Documents/Frameworks/NWS%20Framework%20Public%20Version%200.0%2011%2006%202019.pdf	• Address all options to increase timber yields and improve efficiency through research, technological and managerial innovation, recycling and waste • Introduction of circular nonlinear systems that maximize opportunities for water reuse and recycling and generation of energy and nutrients from used water	Presents opportunities to RUNRES for recycling organic waste
	Human waste	[TBC]	[TBC]	[TBC]	
	Small-scale processing	The carbon tax act, 2019	https://www.gov.za/sites/default/files/gcis_document/201905/4248323-5act15of2019carbontaxact.pdf	Gives effect to the polluter-pays-principle for large emitters and helps to ensure that firms and consumers take the negative adverse costs (externalities) into account in their future production, consumption and investment decisions. Firms are incentivized towards adopting cleaner technologies over the next decade and beyond	This presents an opportunity for RUNRES Circular Economy initiatives and for policy influence

		Fertilizers, farm feeds, agricultural remedies and stock remedies act, 1947 (act no. 36 of 1947) regulations relating to farm feeds-Regulation	https://www.nda.agric.za/doaDev/sideMenu/ActNo36_1947/FF/Animal%20Feed%20Regulation.pdf	Prohibited farm feeds if it contains ingredients which are prohibited for use as products intended for animal feeding as listed in Table 3. E.g. point 1. Feces, urine as well as separated digestive tract content resulting from the emptying of removal of the digestive tract point 5. Sludge from sewage plants treating waste waters. And point 6. Solid urban waste, such as household waste.	**Implications for black soldier fly use as animal feed**
		Fertilizers, farm feeds, agricultural remedies and stock remedies act, 1947 (act no. 36 of 1947) farm feeds regulations: amendment	https://www.gov.za/sites/default/files/gcis_document/201409/3293570.pdf	Ruminant protein and by-products prohibited for use in farm feeds for cattle, sheep, goat and game see Table 2 undesirable substances in animal feeds [reg. 11 (3)] substance no. 16	**Implications for black soldier fly use as animal feed**
Consumption	**Organic waste**	[TBC]	[TBC]	[TBC]	
	Human waste	ANIMAL DISEASES ACT, 1984 (ACT No 35 OF 1984)	https://www.daff.gov.za/vetweb/legislation/gov%20gaz%20-%20act%2035%20of%201984%20-%20part%201.pdf	• Under Act 35 of 1984 meat- and bone meal from ruminant origin was banned (May 2001) from being used in all animal feeds, except for cats and dogs. • A person may acquire or handle mammalian derived blood and blood products, which is intended for the manufacture of non-ruminant animal feeds, on condition that an independently inspected auditable traceability system is in place that documents the trail of raw materials from the abattoir or 1. An exemption was granted by the Director of Veterinary Services according to Regulation 24 of the Animal Diseases Act, 1984 (Act No. 35 of 1984) on the acquisition, disposal or use of certain farm feeds 2. This notice replaced notice No. 1360 of 22 September 2006 on the acquisition, disposal or use of certain farm feeds and at least opened the way to allow the wider use of ruminant blood meal in particular also for poultry.	Implications for black soldier fly use as animal feed if contaminated by such substance This also provides an opportunity for poultry but only restricted to blood meal

	Small-scale processing	National Health Act, 2004	https://www.up.ac.za/media/shared/12/zp_files/health-act.zp122778.pdf	National health act, 2003 (act no. 61 of 2003) national environmental health norms and standards for premises and acceptable monitoring standards for environmental health practitioners speaks to the National Waste Management Strategy, GN. 344 of 4 May 2012 which entails steps to the lifecycle approach to waste, which is; firstly waste avoidance, waste reduction, waste re-use, waste recycling and recovery and waste treatment and disposal that are regarded as the last option	RUNRES should be worry of genotoxic and infectious waste.
		Occupational Health and Safety Act	https://www.gov.za/sites/default/files/gcis_document/201409/act85of1993.pdf	[TBC]	

8 Works Cited

8.1 Introduction

United Nations Development Fund. Human Development Indices and Indicators: 2018 Statistical Update Congo (Democratic Republic of the). (2018).

World Bank country profile for DRC. (2018).

World Bank. Democratic Republic of Congo. Poverty Equity Br. (2019). doi:10.1080/10220460509556748

8.2 Agricultural Production Systems

Alan Dodson, S. C. (2013) The Natives Land Act of 1913 and its legacy, Advocate, pp. 29–32. "An overview of postharvest biology and technology of fruits and vegetables. " In *Technology on Reducing Post-harvest Losses and Maintaining Quality of Fruits and Vegetables: Proceedings of 2010 AARDO Workshop*, pp. 2-11. 2010.

Bacigale, S. B. *et al.* Characterizing feeds and feed availability in Sud-Kivu province, DR Congo. *Trop. Grasslands-Forrajes Trop.* **2**, 9–11 (2014).

Beinart, W. and Delius, P. (2014) —The Historical Context and Legacy of the Natives Land Act of 1913 The Historical Context and Legacy of the Natives Land Act of 1913 Journal of Southern African Studies. Taylor & Francis, 40(4), pp. 667–688.

Bisimwa Kayeye, D., Masilya Mulungula, P. & C. Gisèle, J. Essai de compostage comme voi de valorisation des déchets ménagers solides dans la ville de Bukavu au sud-Kivu (RD Congo). *Déchets Sci. Tech.* 30–38 (2013).

Brigitte L. Maass, Dieudonné Katunga Musale, W. L. C. and M. P. Diagnostic survey of livestock production in South Kivu/DR Congo. *CIAT Work. Doc. No. 210* (2010).

Buyukbay, E. O., Uzunoz, M., & Bal, H. S. G. (2011). Post-harvest losses in tomato and fresh bean production in Tokat province of Turkey. *Scientific Research and Essays*, *6*(7), 1656-1666.

Carel, W. M. & Tondeur, G. Érosion, Surpopulation Sous-nutrition dans le Kivu montagneux. 207 (1986). Charles-Dominique, T., Staver, A. C., Midgley, G. F., & Bond, W. J. (2015). Functional differentiation of biomes in an African savanna/forest mosaic. South African Journal of Botany, 101, 82-90.

Climate Data Bukavu. (2020). Available at: https://en.climate-data.org/africa/congo-kinshasa/sud-kivu/bukavu-4604/.

Conradie, D. C. (2012). South Africa's climatic zones: Today, tomorrow.

Cox, T. P. Farming the battlefield: The meanings of war, cattle and soil in South Kivu, Democratic Republic of the Congo. *Disasters* **36**, 233–248 (2012).

CTA. CTA Working Paper 16/06. *2017*Davis R.S, de Lange M.A., Povall M.L (2017*) http://www.msunduzi.gov.za/site/search/downloadencode/nbaqZqKebNeqrYyx/index.pdf (Accessed September 2020*

De Failly, D. L'économie du Sud-Kivu 1990-2000: Mutations profondes cachées par une panne. *L'Afrique des Gd. Lacs* 163–192 (2000).

Department of Agriculture Forestry and Fisheries (2014) Annual report on cooperatives in the agriculture, forestry and fisheries sector, Pretoria, South Africa

Environmental Potential Atlases: User's Reference and Database Guides South Africa. Department of Environmental Affairs and Tourism, University of Pretoria. Geographic Information Systems Laboratory Edition 3.

Fairhead. No Title No Title. **53**, 1689–1699 (1990).

FAO. *World reference base for soil resources 2014. International soil classification system for naming soils and creating legends for soil maps*. *World Soil Resources Reports No. 106* (2014).

Gumede, V. (2014) —Land reform in post-apartheid South Africa: Should South Africa follow Zimbabwe 's footsteps? International Journal of African Renaissance Studies - Multi-, Inter- and Transdisciplinarity, 9(1), pp. 50–68. doi: 10.1080/18186874.2014.916877.

Head T. (2020) Here's how many farm murders happened in 2019 – according to AfriForum https://www.thesouthafrican.com/news/how-many-farm-murders-in-south-africa-stats-afriforum/ Accessed 13 May 2020.

Kader, A. A. (2004). Increasing food availability by reducing postharvest losses of fresh produce. In *V International Postharvest Symposium 682* (pp. 2169-2176).

Kandala, N. B., Madungu, T. P., Emina, J. B. O., Nzita, K. P. D. & Cappuccio, F. P. Malnutrition among children under the age of five in the Democratic Republic of Congo (DRC): Does geographic location matter? *BMC Public Health* **11**, (2011).

Katunga, M. M. D. *et al.* Testing Agro-Ecological Adaptation of Improved Herbaceous Forage Legumes in South-Kivu, D.R. Congo. *Am. J. Plant Sci.* **05**, 1384–1393 (2014).

Klapwijk, C. J. *et al.* Micro-livestock in smallholder farming systems: the role, challenges and opportunities for cavies in South Kivu, eastern DR Congo. *Trop. Anim. Health Prod.* **52**, 1167–1177 (2020).

Karume, K. *et al.* Use of Remote Sensing for Population Number Determination. *Open Access J. Sci. Technol.* **05**, 1–9 (2017).

Land Audit Report (2017) Land audit report 2017. http://www.ruraldevelopment.gov.za/publications/land-auditreport/file/6126. Accessed 10 May 2020.

Lepersonne, J. Structure géologique du bassin intérieur du Zaïre. *Bull. la Cl. des Sci.* **63**, 941–965 (1977). 12. *African Soil Atlas*.

Mairie de Bukavu. *NOTE STRATEGIQUE: Débarrasser la ville des déchets - avoir une ville propre et saine*. *Document technique de travail* (2018).

Matungul, P. M., Lyne, M. C., & Ortmann, G. F. (2001). Transaction costs and crop marketing in the communal areas of Impendle and Swayimana, KwaZulu-Natal. *Development Southern Africa*, *18*(3), 347-363.

Martey, E., Al-Hassan, R. M., & Kuwornu, J. K. (2012). Commercialization of smallholder agriculture in Ghana: A Tobit regression analysis. *African Journal of Agricultural Research*, *7*(14), 2131-2141.

Maass, B. L., Musale, D. K., Chiuri, W. L., Gassner, A. & Peters, M. Challenges and opportunities for smallholder livestock production in post-conflict South Kivu, eastern DR Congo. *Trop. Anim. Health Prod.* **44**, 1221–1232 (2012).

Moloi, M. J. (2010). A comparison of socioeconomic characteristics that determine the farm income of emerging lifestock and horticultural farmers in South Africa (Doctoral dissertation).

Msunduzi (2014) Msunduzi municipality Local Economic Development plan

Munyuli, T. *et al.* Farmers' perceptions, believes, knowledge and management practices of potato pests in South-Kivu Province, eastern of Democratic Republic of Congo. *Open Agric.* **2**, 362–385 (2017).

Nchabeleng, M. J. (2016). Assessing the impact of the Department of Agriculture Farm Together Programme on development and growth of selected agricultural co-operatives in Capricorn District Municipality in Limpopo Province (Doctoral dissertation, University of Limpopo).

Nespresso. Nespresso invest in Kivu. (2020). Available at: https://nestle-nespresso.com/news/nespresso-invests-in-the-democratic-republic-of-congo.

Ntamwira, J. *et al.* Effect of banana leaf pruning on banana and legume yield under intercropping in farmers fields in eastern Democratic Republic of Congo. *J. Hortic. For.* **6**, 72–80 (2014).

Ortmann, G. F., & King, R. P. (2010). Research on agri-food supply chains in Southern Africa involving small-scale farmers: Current status and future possibilities. *Agrekon*, *49*(4), 397-417.

Paul, S. S. Urban Growth and Environmental Risks – A GIS-Based Analysis of Landslide Susceptibility in Bukavu. *Master Thesis* (2019).

Pypers, P., Sanginga, J. M., Kasereka, B., Walangululu, M. & Vanlauwe, B. Increased productivity through integrated soil fertility management in cassava-legume intercropping systems in the highlands of Sud-Kivu, DR Congo. *F. Crop. Res.* **120**, 76–85 (2011).

Rubel, F., & Kottek, M. (2010). Observed and projected climate shifts 1901–2100 depicted by world maps of the Köppen-Geiger climate classification. Meteorologische Zeitschrift, 19(2), 135-141.

http://www.msunduzi.gov.za/site/search/downloadencode/nNyarqWMqp2zp4Sx/index.pdf

http://www.msunduzi.gov.za/site/search/downloadencode/nNyarKWMqp2zp4Sx/index.pdf

van Acker, F. Where did all the land go? Enclosure & social struggle in Kivu (D.R. Congo). *Rev. Afr. Polit. Econ.* **32**, 79–98 (2005).

Verner, K., Megerssa, L. (2018). Explanatory notes to the thematic geoscientific maps of Ethiopia at a scale of 1:50,000. Czech Geological Survey, Geological Survey of Ethiopia.

Vlassenroot, K., Ntububa, S. & Raeymaekers, T. Food security responses to the protracted crisis context of the Democratic Republic of the Congo. 23–25 (2007).

Vwima. ATM-28_Vwima_Mastaki_Lebailly.pdf. (2014).

Zebire, D.A., Ayele, T., Ayana, M. (2019). Characterizing soils and the enduring nature of land uses around the Lake Chamo Basin in South-West Ethiopia. *Journal of Ecology and Environment*, 43:15.

8.3 The food value chain

Bucagu, C., Ndoli, A., Cyamweshi, A. R., Nabahungu, L. N., Mukuralinda, A., & Smethurst, P. (2020). Determining and managing maize yield gaps in Rwanda. *Food Security, 12*(6), 1269-1282. doi:10.1007/s12571-020-01059-2

Climate-Data.org. (2019). Kamonyi Climate. Retrieved from https://en.climate-data.org/africa/congo-kinshasa/sud-kivu/kamonyi-516167/

DFID (2008). Making Value Chain Work Better for the Poor: A Toolbook for Practitioners of Value Chain Analysis, London – UK

Food and Agriculture Organisation. (2001). *Lecture notes on the major soils of the world*. Rome, Italy: FAO.

Food and Agriculture Organization. (1996). *Agro-ecological zoning guidelines* (Vol. FAO Soils Bulletin 73).

Iiyama, M., Mukuralinda, A., Ndayambaje, J., Musana, B., Ndoli, A., Mowo, J., . . . Ruganzu, V. (2018). Tree-Based Ecosystem Approaches (TBEAs) as Multi-Functional Land Management Strategies—Evidence from Rwanda. *Sustainability, 10*(5). doi:10.3390/su10051360

ILO, 2015. A Rough Guide to Value Chain Development: A Short Guide for Development Practitioners, Government and Private Sector Initiatives/ NadjaNutz and MertenSievers. International Labor Organization, Geneva.

Jönsson, H., Stintzing, A. R., Vinnerås, B., & Salomon, E. (2004). *Guidelines on the use of urine and faeces in crop production*: EcoSanRes Programme.

Kamonyi District Municipality. (2013). *District development plan (2013-2018)*. Retrieved from Kamonyi, Rwanda: https://kamonyi.gov.rw/fileadmin/_migrated/content_uploads/kamonyi_district_development_plan_.pdf (Accessed on 13/02/2021)

Kamonyi District Municipality. (2019). *Environmental and social management plan (ESMP)*. Retrieved from Kamonyi, Rwanda:

Karamage, F., Zhang, C., Fang, X., Liu, T., Ndayisaba, F., Nahayo, L., . . . Nsengiyumva, B. J. (2017). Modeling Rainfall-Runoff Response to Land Use and Land Cover Change in Rwanda (1990–2016). *Water, 9*(2). doi:10.3390/w9020147

Kaplinsky R. and M. Morris (2002). A Handbook for Value Chain Research, IDRC.

Kaplinsky (2004). Spreading the Gains from Globalization: What can be learnt from Value Chain Analysis.*Problems of Economic Transition*. 47 (2): 74 – 115

Karamage, F., Zhang, C., Fang, X., Liu, T., Ndayisaba, F., Nahayo, L., . . . Nsengiyumva, B. J. (2017). Modeling Rainfall-Runoff Response to Land Use and Land Cover Change in Rwanda (1990–2016). *Water, 9*(2). doi:10.3390/w9020147

Levy, G. J., Lordian, A., Goldstein, D., & Borisover, M. (2014). Soil structural indices' dependence on irrigation water quality and their association with chromophoric components in dissolved organic matter. *European Journal of Soil Science, 65*(2), 197-205. doi:Doi: 10.1111/ejss.12116

Nambajimana, J. d. D., He, X., Zhou, J., Justine, M. F., Li, J., Khurram, D., . . . Nsabimana, G. (2019). Land Use Change Impacts on Water Erosion in Rwanda. *Sustainability, 12*(1). doi:10.3390/su12010050

Ndayisaba, F., Guo, H., Isabwe, A., Bao, A., Nahayo, L., Khan, G., . . . Muhire, E. N. (2017). Inter-Annual Vegetation Changes in Response to Climate Variability in Rwanda. *Journal of Environmental Protection, 8*(04), 464.

Nduwumuremyi, A., Melis, R., Shanahan, P., & Asiimwe, T. (2016). Participatory appraisal of preferred traits, production constraints and postharvest challenges for cassava farmers in Rwanda. *Food Security, 8*(2), 375-388.

Ogbazghi, Z. M., Tesfamariam, E. H., & Annandale, J. G. (2016). Modelling N mineralisation from sludge-amended soils across agro-ecological zones: A case study from South Africa. *Ecological Modelling, 322*, 19-30. doi:http://dx.doi.org/10.1016/j.ecolmodel.2015.11.019

Petricec, V., Lavreau, J., & Waleffe, A. (Cartographer). (1981). Carte Lithologique du Rwanda

Senecal, J., & Vinnerås, B. (2017). Urea stabilisation and concentration for urine-diverting dry toilets: Urine dehydration in ash. *Science of The Total Environment, 586*, 650-657. doi:https://doi.org/10.1016/j.scitotenv.2017.02.038

WFP, 2010. Market Analysis Tool – How to Conduct a Food Commodity Value Chain Analysis? WFP, Rome – Italy

USAID (2009). Global Food Security Response: West Africa Value Chain Analysis Protocol, microREPORT No.153, February.

8.4 Waste stream mapping

Ashipala, N., & Armitage, N. P. (2011). Impediments to the adoption of alternative sewerage in South African urban informal settlements. *Water Science and Technology, 64*(9), 1781-1789. doi:10.2166/wst.2011.746

Bester, J., & Austin, L. (1997). *Design, construction, operation and maintenance of ventilated improved pit toilets in South Africa*. Pretoria, South Africa: Water Research commission.

Brouckaert, C., Brouckaert, B., Singh, A., & Wu, W. (2016). *Wastewater treatment plant modelling for capacity estimation and risk assesment*. Retrieved from Gezina, Pretoria, South Africa:

Cape Town City. (2008). *Water and Sanitation service standards: preliminary draft 2*. Retrieved from file:///C:/Users/PC/Downloads/Water-and-Sanitation-Service-Standards.pdf (Accessed on 3/05/2020)

CSIR Boutek. (2005). *Guidelines for Human Settlement Planning and Design.* Pretoria, South Africa: CSIR for the Department of Housing.

Department of environmental Affairs. (2018). *South Africa State of Waste Report First draft report*. Retrieved from

DWA. (2013). *Revision of general authorisation in terms of section 39 of the national water act, (Act 39 of 1998)* Pretoria, South Africa: Department of Water Affairs

DWS. (2016). *National Sanitation Policy 2016*. Pretoria, South africa: government

DWS. (2018, 07 November 2018). *Sanitation backlogs in schools: DBE briefing; Sanitation Technologies and Innovations.* Paper presented at the: Water Research Commission briefing, Parlieament of South Africa.

Fewtrell, L. (2004). Drinking-water nitrate, methemoglobinemia, and global burden of disease: a discussion. *Environmental health perspectives, 112*(14), 1371-1374. doi:10.1289/ehp.7216

Geomeasure Group. (2015). *Initial geohydrological and geotechnical investigation report for the Darvill constructed wetland, Pietermaritzburg, KwaZulu-Natal* (REF. NO.: 2015/232). Retrieved from http://www.msunduzi.gov.za/site/search/downloadencode/2015_12_08_Darvill_Constructed_Wetland_Geohydro_Geotech_Report_V2.pdf

Gounden, T., Pfaff, B., Macleod, N., & Buckley, C. (2018). *Provision of free sustainable basic sanitation: the Durban experience*.

Greatwood, M. (2020, 14/03/2020) *Waste stream mapping semi-structured interview (SFD)/Interviewer: W. Musazura*. The Rural Urban Nexus: Establishing a nutrient loop to improve city region food system resilience (RUNRES).

Henry, R., Yongsheng, Z. and Jun, D. (2006). Municipal solid waste management challenges in developing countries. Kenyan case study. Published at journal of *Waste Management 26 (2006) 92-100*.

Jogiat, R. (2014, 26-27 November 2014). *Organic waste opportunites within uMgungundlovu district.* Paper presented at the DST Science Meets ndustry Workshop: Organic Waste UKZN, Durban. Jogiat, R. (2020). [Solid Waste Management in Msunduzi].

Lawrence, A., Macdonald, D., Howard, A., Barrett, M., Pedley, S., Ahmed, K., & Nalubega, M. (2001). *Guidelines for assessing the risk to groundwater from on-site sanitation* (CR/01/142.). Retrieved from http://nora.nerc.ac.uk/id/eprint/20757

Louton, B., Still, D. A., Pearson, G., Sitholimela, G., Mphahlele, T., & Shaylor, S. (2015). *Exploring the Issues around Rural On-Site School Sanitation in South Africain South Africa* (WRC Report No. 2381/P/15). Retrieved from Pretoria, South Africa:

Masindi, V., & Duncker, L. (2016). *State of Water and Sanitation in South Africa*.

Mbulelo, B. (2009). Food for waste programme clean-up puts food on the table. *Vukuzenzele*, p. 1. Retrieved from https://www.vukuzenzele.gov.za/food-waste-programme-clean-puts-food-table (Accessed on 5/05/2020)

Mkhize, N. B. (2018). *Addressing the spatial inequality of economic infrastructure through spatial planning: a case of the proposed Edendale town centre in Msunduzi municipality.*

Mkhize, T. W. (2011). *An analysis of agenda: The management of New England Road Landifill site in Msunduzi municipality*. (Master of Social Science (Policy and Development Studies),). University of KwaZulu-Natal, Pietermaritzburg., Pietermaritzburg, South Africa. Retrieved from https://pdfs.semanticscholar.org/98f0/e45dbbe9fb9c2590090c5edfb93a20fd5962.pdf (Accessed on 5/05/2020)

MINECOFIN (2007) The Economic Development and Poverty Reduction Strategy (EDPRS), Final Draft: Kigali: Government of Rwanda.

MINECOFIN (2002) Vision 2020, Kigali: Government of Rwanda.

MINECOFIN (2002) National Investment Strategy, Kigali: Government of Rwanda.

Msunduzi Municipality. (2013). *Intergrated waste management plan 2014-2018*. Retrieved from Pietermaritzburg, South Africa: http://www.msunduzi.gov.za/site/search/downloadencode/Integrated_Waste_Management_Plan_2014_2018.pdf (Accessed 5/05/2020)

Msunduzi Municipality. (2014a). *Msunduzi South Eastern District Local Area Plan: Final draft report*. Retrieved from http://www.msunduzi.gov.za/site/search/downloadencode/nba4r6PEbNeqrYyx/index.pdf

Msunduzi Municipality. (2014b). *Water services by-laws*. Pietermaritzburg, South Africa: Provincial Gazette Retrieved from http://www.msunduzi.gov.za/site/search/downloadencode/naaaZaOebNeqrYyx/index.pdf

Msunduzi Municipality. (2016a). *Msunduzi final sewer master plan*. Retrieved from Msunduzi Municipality. (2016b). *Vulindlela local area plan: Spatial framework*. Retrieved from http://www.msunduzi.gov.za/site/search/downloadencode/nbaqZqKebNeqrYyx/index.pdf (Accessed on 03/12/2019)

Msunduzi Municipality. (2019). *Msunduzi Local Municipality a strategic plan for the development of sustainable human settlement*. Retrieved from Msunduzi Municipality. (2020). *Intergrated Development Plan 2020/2021*. Retrieved from

Msunduzi Municipality. (2018). *Msunduzi Annual Report 2017/2018*. Retrieved from https://municipalities.co.za/resources/1088/msunduzi-local-municipality

National Planning Commission. (2011). *Diagnostic report*. Retrieved from https://www.gov.za/sites/default/files/gcis_document/201409/npcdiagnosticoverview1.pdf (Accessed on 5/03/2020)

Nojiyeza, S., & Amisi, B. (2008). *The challenges of eradicating bucket sanitation in SA.* Paper presented at the AfriSan conference, Durban, February.

Norris, G. (2000). *Sludge build up in septic tanks, biological digestors and pit latrines in South Africa*. Retrieved from Gezina, Pretoria, South Africa:

Ntombela, C., Funke, N., Meissner, R., Steyn, M., & Masangane, W. (2016). A critical look at South Africa's Green Drop Programme. *Water SA, 42*(4). doi:10.4314/wsa.v42i4.21

Ntuli, N. (2020). 34 boreholes planned. *The Witness*. Retrieved from 34 boreholes planned

Nzuza, R. (2020, 28/02/2020) *Waste stream mapping semi-structured interview (SFD)/Interviewer: W. Musazura*. The Rural Urban Nexus: Establishing a nutrient loop to improve city region food system resilience (RUNRES).

Oelofse, S., Nahman, A., Barjees Baig, M., Salemdeeb, R., Nizami, A.-S., & Reynolds, C. (2020). Food Waste Within South Africa and Saudi Arabia. In Christian Reynolds, Tammara Soma, Charlotte Spring, & J. Lazell (Eds.), *Handbook of Food Waste*. New York, USA: Routledge.

Partners in Development (2019, 13 November 2019). [RUNRES community feedback on the Kick off meeting held at Golden Horse, Pietermaritzburg.].

Pillay, K. (2017). Reckless dumping in city. *The Witness*. Retrieved from https://www.news24.com/SouthAfrica/News/reckless-dumping-in-city-20170507 (Accessed on 7/05/2020)

Rajashekar, A., Bowers, Aiden, Gatoni, A.S. (2019). Assessing waste management services in Kigali. International growth center.

Republic of South Africa. (1996). *National Sanitation Policy (White Paper).* . Pretoria, Republic of South Africa.

Republic of South Africa. (2016). *National Sanitation Policy 2016*. Pretoria, RSA

Rose, C., Parker, A., Jefferson, B., & Cartmell, E. (2015). The Characterization of Feces and Urine: A Review of the Literature to Inform Advanced Treatment Technology. *Critical Reviews in Environmental Science and Technology, 45*(17), 1827-1879. doi:10.1080/10643389.2014.1000761

RSA. (1996). Constitution of the Republic of South Act No. 108, 1996. In (pp. 148). Cape Town, South Africa: Government gazzete.

RSA. (2000). *Local government: Municipal systems act 2000*. Cape Town, Repubilc of South Africa: Government Gazzette Retrieved from https://www.gov.za/sites/default/files/gcis_document/201409/a32-000.pdf (Accessed on 5/05/2020)

RSA. (2009). *No. 59 of 2008: National Environmental Management: Waste Act, 2008.* Cape town, RSA: Government Gazzete Retrieved from https://www.environment.gov.za/sites/default/files/legislations/nema_amendment_act59.pdf (Accessed on 5/05/2020)

Statistics South Africa. (2016). *South African Community Survey 2016: Indicators derived from the full population Community Survey*. .

Still, D., Salsbury, R., Foxon, K., Buckley, C., & Bhagwan, J. (2010). *The challenges in dealing with full VIP latrines*.

Still, D. A., Lorentz, S., & Adhanom, G. (2014). *Entrenchment of pit latrine and waste water sludges and investigation of costs, benefits, risks and rewards.* Retrieved from Gezina, Pretoria: https://www.fsmtoolbox.com/assets/pdf/35_-_TB_2097_entrenchment_of_pit_latrine_and_wastewater_sludges.pdf

Tayler, K. (2018). *Faecal Sludge and Septage Treatment*.

Tsinda, A. (2011). Policies, Regulations and Institutional Framework for Improved Sanitation in Kigali: Rwanda Public Policy Observatory Report 2. Splash Project, IPAR-RWANDA.

Umgeni Water. (2019). *Annual report 2018/2019*. Retrieved from Pietermaritzburg, South Africa: https://www.umgeni.co.za/2018-2019-annual-report/

uMgungundlovu District Municipality. (2014). *Development of Universal Access Plan for Water & Sanitation in KwaZulu-Natal*. Retrieved from Pietermariztburg, Msunduzi, South Africa.:

WHO, & UNICEF. (2019). *Progress on household drinking water, sanitation and hygiene 2000-2017: Special focus on inequalities*. Retrieved from New York, USA: ISBN: 978-92-415-1623-5

WRC. (2007). *Design and operating requirements to optimize the life span of VIP toilets*. Retrieved from Gezina, Pretoria: http://www.susana.org/_resources/documents/default/2-253-wrc-2007-optimize-life-span-vip-en.pdf

8.5 Socio-Economic Background

Bryman, A. (2009). Social Research Methods, Oxford University Press, UK: Oxford.

Colding, J., & Folke, C. (2001). Social Taboos: “Invisible” Systems of Local Resource Management and Biological Conservation. Ecological Applications, 11(2), 584-600.

Daly, Herman E. (1991). Steady-state Economics. 2nd ed., with new essays. Washington, D.C: Island Press.

Helliwell, J. F., & Putnam, R. D. (2004). The social context of well-being. Philosophical Transactions of the Royal Society B, 359, 1435-1446.

Kahan, D. M. (2012). Cultural Cognition as a Conception of the Cultural Theory of Risk In S. Roeser, Handbook of Risk Theory. Springer Publish.ing

Rau, I., Schweizer-Ries, P., & Hildebrand, J. (2012). Participation. The silver bullet for the acceptance of renewable energies? In S. Kabisch, A. Kunath, P. Schweizer-Ries, & A. Steinfuhrer (Eds.), Vulnerability, risks and complexity: Impacts of global change on human habitats (pp. 171-191). Göttingen: Hogrefe.

Sen, A. (1999). Development as Freedom, Oxford UP.

Solow, R. (1993). An almost practical step toward sustainability. Resources Policy, 19(3), 162-172.

Stoltz, D. J. (2014). Diagram of Theory: Douglas and Wildavsky’s Grid/Group Typology of Worldviews. Retrieved on 16th October 2019 on: https://www.dustinstoltz.com/blog/2014/06/04/diagram-of-theory-douglas-and-wildavskys-gridgroup-typology-of-worldviews

Thompson, M., Ellis, R., & Wildavsky, A. (1990). Political cultures. Cultural theory. Boulder, CO, US: Westview Press.

Woolcock, M., & Narayan, D. (2000). Social capital: Implications for development theory, research, and policy. The World Bank Research Observer, 15, 225-249.

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. Energy Policy, 35(5), 2683-2691.

8.6 Policy and Regulatory Environment

Bryman, A. (2009). *Social Research Methods*, Oxford University Press, UK: Oxford.

Global G.A.P., 2016. Integrated Farm Assurance. All Farm Base – Crops Base - Fruits and Vegetables. Control Points and Compliance.

Moya, B., Parker, A., & Sakrabani, R. (2019). Challenges to the use of fertilisers derived from human excreta: The case of vegetable exports from Kenya to Europe and influence of certification systems. *Food Policy*, 85, 72-78.

GlobalG.A.P., 2016. Integrated Farm Assurance. All Farm Base – Crops Base - Fruits and Vegetables. Control Points and Compliance.

World Health Organization, 2006. Who Guidelines for the Safe Use of Wastewater , Excreta and Greywater – Policy and regutatory aspects, in: Who Guidelines for the Safe Use of Wastewater , Excreta and Greywater. https://doi.org/10.1007/s13398-014-0173-7.2

9 Appendix

9.1 Agricultural Production Systems

Bukavu, Democratic Republic of the Congo

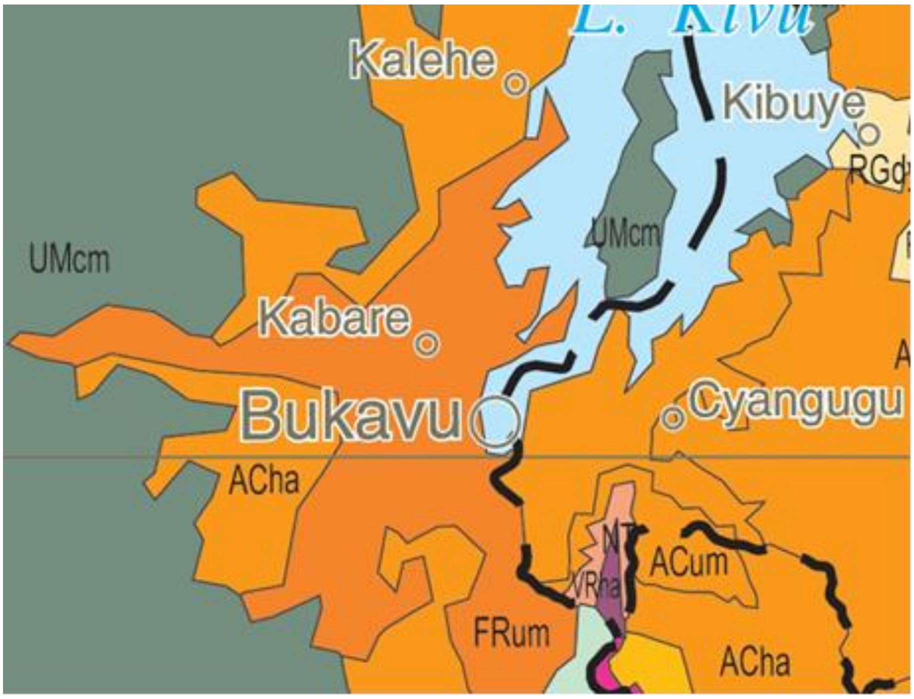

Table 9.1: Soil description according to the WRB (2015)

Item	Haplic Acrisols (ACha)
Overall	Acrisols have a higher clay content in the subsoil than in the topsoil as a result of pedogenic processes leading to an argic subsoil horizon. They have low-activity clay in the argic horizon and low base saturation in the 50-100cm depth.
Parent material	On a wide variety of parent materials, especially from the weathering of acid rocks; and notably in strongly weathered clays that are undergoing further degradation.
Environment	Mostly old land surfaces with hilly or undulating topography, in regions with a wet tropical/ monsoonal, subtropical or warm temperate climate. Forest is the natural vegetation type.
Management	Preservation of the surface soil with its all-important organic matter and preventing erosion are preconditions for farming on Acrisols. Mechanical clearing of natural forest by extraction of root balls and filling of the holes with surrounding surface soil produces land that is largely sterile where Al concentrations of the former subsoil reach toxic levels. Adapted cropping systems with complete fertilization and careful management are required if sedentary farming is to be practiced on Acrisols. The widely used slash-and burn agriculture (shifting cultivation) may seem primitive but it is a well-adapted form of land use, developed over centuries of trial and error. If occupation periods are short (one or a few years only) and followed by a sufficiently long regeneration period (up to several decades), this system makes good use of the limited resources of Acrisols. Agroforestry is recommended as a soil-protecting alternative to shifting cultivation to achieve higher yields without requiring expensive inputs. Low-input farming on Acrisols is not very rewarding. Undemanding acid-tolerant cash crops such as pineapple, cashew, tea and rubber can be grown with some success. Increasing areas of Acrisols are planted with oil-palm (e.g. in Malaysia and on Sumatra). Large areas of Acrisols are under forest, ranging from high, dense rain forest to open woodland. Most of the tree roots are concentrated in the humus surface horizon with only a few tap-roots extending down into the subsoil. Acrisols are suitable for production of rainfed and irrigated crops only after liming and full fertilization. Rotation of annual crops with improved pasture maintains the organic matter content.
Qualifiers	Haplic (ha): having a typical expression of certain features (typical in the sense that there is no further or meaningful characterization) and only used if none of the preceding qualifiers applies.

Item	Umbric Ferralsol (FRum)
Overall	Ferralsols represent the classical, deeply weathered, red or yellow soils of the humid tropics. These soils have diffuse horizon boundaries, a clay assemblage dominated by low-activity clays (mainly kaolinite) and a high content of sesquioxides. Local names usually refer to the colour of the soil.
Parent material	Strongly weathered material on old, stable geomorphic surfaces; develop faster in material weathered from basic rock than from siliceous material.
Environment	Typically in level to undulating land of Pleistocene age or older; less common on younger, easily weathering rocks. Perhumid or humid tropics; minor occurrences elsewhere are considered to be relics from past eras with a warmer and wetter climate than today.
Management	Most Ferralsols have good physical properties. Great soil depth, good permeability and stable microstructure make Ferralsols less susceptible to erosion than most other intensely weathered tropical soils. Moist Ferralsols are friable and easy to work. They are well drained but may at times be droughty because of their low available water storage capacity. The chemical fertility of Ferralsols is poor; weatherable minerals are scarce or absent, and cation retention by the mineral soil fraction is weak. Under natural vegetation, nutrient elements that are taken up by the roots from greater depths are eventually returned to the surface soil with falling leaves and other plant debris. The bulk of all cycling plant nutrients are contained in the biomass; available plant nutrients in the soil are concentrated in the soil organic matter. If the process of nutrient cycling is interrupted, e.g. upon introduction of low-input sedentary subsistence farming, the topsoil will rapidly become depleted of plant nutrients. Maintaining soil fertility by manuring, mulching and/or adequate (i.e. long enough) fallow periods or agroforestry practices, and prevention of surface soil erosion, are important management requirements. Strong retention (fixing) of P is a characteristic problem in Ferralsols. Ferralsols are normally also low in base cations and some 20 micronutrients. Silicon deficiency is possible where silicon-demanding crops (e.g.grasses) are grown. Manganese and zinc, which are very soluble at low pH, may at some time reach toxic levels in the soil or become deficient after intense leaching of the soil. Boron and copper deficiencies may also be encountered. In Ferralsols with a low pH, liming is a means of raising the pH of the rooted surface soil. Liming combats Al toxicity and raises the effective CEC. On the other hand, it lowers the anion exchange capacity, which may lead to collapse of microstructural elements and slaking at the soil surface. Therefore, frequent small doses of lime or basic slag are preferable to one massive application; 0.5–2 tonnes/ha of lime or dolomite are normally enough to supply Ca as a nutrient and to buffer the low soil pH of many Ferralsols. Surface application of gypsum, as a suitably mobile form of Ca, can increase the depth of crop root development (in addition, the sulfate in the gypsum reacts with sesquioxides to produce a "self-liming" effect). Fertilizer selection and the mode and timing of fertilizer application determine to a great extent the success of agriculture on Ferralsols. Slow-release phosphate (phosphate rock) applied at a rate of several tonnes per hectare eliminates P deficiency for a number of years. For a quick fix, much more soluble double or triple superphosphate is used, needed in much smaller quantities, especially if placed in the direct vicinity of the roots. Sedentary subsistence farmers and shifting cultivators on Ferralsols grow a variety of annual and perennial crops. Extensive grazing is also common and considerable areas of Ferralsols are not used for agriculture at all. The good physical properties of Ferralsols and the often level topography would encourage more intensive forms of land use if problems caused by poor chemical properties could be overcome.
Qualifiers	An umbric horizon (from Latin umbra, shade) is a relatively thick, dark-coloured surface horizon with a low base saturation and a moderate to high content of organic matter.

South Africa

Table 1: Description of South African climatic zones

Description	Köppen-Geiger	Rainfall	Temperature	Area (km^2)	Percentage (%)
Equatorial climates	Aw	P_{min}< 60mm in summer		2296	0.20
Arid climates	Bsh	P_{ann}> 5 P_{th}	T_{ann} ≥ +18 °C	192269	16.59
	Bsk	P_{ann}> 5 P_{th}	T_{ann} < +18 °C	275927	23.81
	Bwh	P_{ann} ≤ 5 P_{th}	T_{ann} ≥ +18 °C	188784	16.29
	Bwk	P_{ann} ≤ 5 P_{th}	T_{ann} ≥ +18 °C	164629	14.20
Warm temperate climates	Cfa	P_{smin} < P_{wmin} and P_{smin} < 40 mm	T_{max} ≥ +22 °C	42918	3.7
	Cfb	P_{smin} < P_{wmin} and P_{smin} < 40 mm		93405	8.06
	Cfc	P_{smin} < P_{wmin} and P_{smin} < 40 mm	T_{min} > -38 °C	84	0.01
	Csa	P_{smin} < P_{wmin} and P_{smin} < 40 mm	T_{max} ≥ +22 °C	5120	0.44
	Csb	P_{smin} < P_{wmin} and P_{smin} < 40 mm		18395	1.59
	Cwa	P_{smin} < P_{wmin} and P_{smin} < 40 mm	T_{max} ≥ +22 °C	31162	2.69
	Cwb	P_{smin} < P_{wmin} and P_{smin} < 40 mm		140405	12.11
	Cwc	P_{smin} < P_{wmin} and P_{smin} < 40 mm	T_{min} > -38 °C	3564	0.31

TABLE 2

LAND TYPE	SOIL DESCRIPTION	GEOLOGY
AB116	Red yellow apedal, freely drained soils; red, dystrophic and/or mesotrophic	Mainly shale of the Volksrust Formation, with sandstone and shale of the Vryheid Formation, Ecca Group, and dolerite.
AB119	Red yellow apedal, freely drained soils; red, dystrophic and/or mesotrophic	Mainly mudstone and shale of the Pietermaritzburg Formation, Ecca Group with small areas of dolerite and sandstone, shale and siltstone of the Vryheid Formation and shale, mudstone and sandstone beds of the Volksrust Formation, Ecca Group.
AB120	Red yellow apedal, freely drained soils; red, dystrophic and/or mesotrophic	Mainly sandstone, shale and siltstone of the Vryheid Formation, Ecca Group with small areas of alluvium and dolerite
AB121	Red yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly mudstone and shale of the Pietermaritzburg Formation, Ecca Group, and dolerite.
AB128	Red yellow apedal, freely drained soils; red, dystrophic and/or mesotrophic	Mainly granite, with small areas of sandstone of the Natal Group and alluvium
AC215	Red yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly dolerite, with dark-grey shale, siltstone and sandstone of the Estcourt Formation, Beaufort Group.
AC219	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly mudstone and shale of the Pietermaritzburg Formation, Ecca Group with dolerite
	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly mudstone and shale of the Pietermaritzburg Formation, Ecca Group, and dolerite
AC224	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly dark-grey shale of the Volksrust Formation, Ecca Group, and dolerite.
AC227	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly dark-grey shale of the Volksrust Formation, Ecca Group, and dolerite.
AC228	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly dark-grey shale, siltstone and sandstone of the Estcourt Formation, Beaufort Group, with small areas of dolerite.
AC230	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly mudstone and shale of the Pietermaritzburg Formation, Ecca Group with small areas of sandstone, shale and siltstone of the Vryheid Formation, Ecca Group and dolerite.
AC232	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly sandstone, shale and siltstone of the Vryheid Formation, with shale and mudstone of the Volksrust Formation, Ecca Group and small areas of dolerite.
AC233	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	Mainly shale, mudstone and sandstone of the Volksrust Formation, Ecca Group, with small areas of dolerite.
BB112	Plinthic catena: dystrophic and/or mesotrophic; red soils not widespread, upland duplex and margalitic soils rare	Mainly shale of the Pietermaritzburg Formation, Ecca Group with alluvium and small areas of dolerite and tillite of the Dwyka Formati
BD32	Plinthic catena: dystrophic and/or mesotrophic; red soils not widespread, upland duplex and margalitic soils rare	Mainly mudstone and shale of the Pietermaritzburg Formation, Ecca Group with small areas of dolerite.
BD50	Plinthic catena: dystrophic and/or mesotrophic; red soils not widespread, upland duplex and margalitic soils rare	Mainly tillite of the Dwyka Formation with small areas of mudstone and shale of the Pietermaritzburg Formation, Ecca Group with dolerite.
FA461	Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in the entire landscape	Granite/gneiss.
FA465	Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in the entire landscape	Tillite of the Dwyka Formation.
FA466	Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in the entire landscape	Shale of the Pietermaritzburg Formation, Ecca Group, tillite of the Dwyka Formation, and dolerite
FA471	Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in the entire landscape	Mainly tillite of the Dwyka Formation with small areas of sandstone of the Natal Group and shale of the Pietermaritzburg Formation, Ecca Group.

9.2 The Food Value Chain

Questionnaire used to collect data from all actors in the food value chains

Section 1: Enumeration details

1.	Country	
2.	District	
3.	Sector/Cell/Village	
4.	GPS reading of location	
5.	Name of enumerator	

Section 2: Household Bio data details

1.	Name of the respondent							
2.	Telephone contact of the respondent							
3.	Age of the respondent							
4.	Years of formal education of the respondent							
5.	Name, and distance to the nearest bigger town center							
6.	Gender of the respondent (*Tick right response*)	Male			Female			
7.	Marital status of the respondent	Married		Single		Divorced		Widow
8.	Number of persons under your household	Males			Females			
9.	I am aware of the concept of a Circular Economy	1) Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree						
10.	I have some knowledge of what Circular Economy aspects entail	1) Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree						
11.	Because am aware, and Knowledgeable about Circular Economy aspects and goals, I would support its promotion.	1) Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree						

A. INPUT TRADERS

Section A1: Sector (Input) specific details (*Fertilizers/coffee seedlings/cassava cuttings etc.* ***TICK*** *what matters)*

1.	What kind of farm inputs do you supply? *Tick what matters*	1 (Cassava cuttings) 2 (Coffee seedlings) 3 (Fertilizers) 4 (Tomato seeds) 5 (Banana suckers) 6 (Mango seedlings) 7 (Others – specify)
2.	Where do you get the inputs (fertilizers/cassava cuttings/coffee seedlings / tomato seedlings etc.) you supply to farmers? (*Tick what matters*)	1 (Government ministry/institution e.g. RAB/INERA etc.) 2 (non- government body/institution e.g. IITA, CIP, AGRA etc.) 3 (Own effort) 4 (Farmers' association/cooperative) 5 (Agro Dealers) 6 (Others – specify)
3.	How much quantity (Kgs/seedlings/cuttings) do you supply per week/month/season/year? (*Tick quantity units and timeline that apply*)	
4.	How much cost was incurredto supply the quantity in 3., with regards to each of the activities (a-f,)?*Record the exchange rate to USD*	a. Buying the raw material _______________ Francs b. Processing the input ___________________ Francs c. Transportation and marketing ___________Francs d. Licenses and other legal fees _____________Francs e. Labor _____________________ Francs f. All other costs _________________ Francs
5.	How much do you sell each unit (Kgs/seedlings/cuttings) of input supplied? (*if different quantities were sold at different unit prices, show the differences*)	______________________________Francs
6.	What is your opinion on the quality of the inputs you supply? (*Tick*)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
7.	Are there any laws/regulations/policies/norms guiding your input supplies business that you are aware about?	1 (Yes) 2 (No)
8.	If yes in 7., what are examples these that enable your business?	
9.	If yes in 7., what are examples these that hinder your business?	
10.	If no in 7, who then has power to regulate your business?	
11.	How many women/men are involved in this input (fertilizers/seedlings/cuttings) supply business in your sector/village?	Women ___________ Men __________
12.	What are the key roles of women/men in this business in your sector/village?	Women: 1 (financiers/owners) 2 (shop attendants) 3 (brokers) 4 (others – specify) Men: 1 (financiers/owners) 2 (shop attendants) 3 (brokers) 4 (others – specify)
13.	How do you exchange information with your clients?	1 (person to person) 2 (Phone call) 3 (Phone SMS) 4 (Internet) 5 (Radio/TV) 6 (Other)
14.	What kind of information do you exchange?	1(new inputs arrivals) 2 (prices) 3 (performance of supplied inputs) 4 (Others – specify)
15.	What kind of people do you mainly target as clients?	1 (small scale farmers) 2 (large scale farmers) 3 Others (specify ________________)
16.	Which areas (locations/regions) are your clients located?	
17.	What keeps your clients committed to your inputs?	1 (Supplying genuine inputs) 2 (price cuts) 3 (all-time ready supplies) 4 (others ______)
18.	How about your suppliers, why do they commit to you?	
19.	How do you describe your relationship with clients?	
20.	Are there institutions willing to lend your business?	1 (Yes) 2 (No)
21.	If yes in 20., are these formal or informal financial institutions?	(Formal e.g. microfinances, Banks, etc.)2 (Informal e.g. farmer groups, family etc.)
22.	Are there any research/extension/government institutions providing you with new input technologies to sell to your clients?	1 (Yes) 2 (No)
23.	If yes in 22, what is the kind of these institutions?	1 (Government) 2 (Private) 3 (Non-for-Profit international) 4 (local groups) 5 (others)
24.	What is the major challenge/bottleneck/gap in supplying this input?	
25.	How can this in 24., challenge/bottleneck/gap be addressed?	
26.	What major opportunity do you see in the supply of this input?	
27.	How can you take up this opportunity in 26., effectively?	
28.	Your feelings about trading in composted organic waste as fertilizer to grow food is positive.	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree
29.	Your feelings about trading in urine as a fertilizer to grow food is positive.	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree

30.	Your feelings about trading in treated / decomposed fecal material as a fertilizer is positive.	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree

B. FARMERS / PRODUCERS

Section B1: Sector (Farmers/Producers) specific details – Focus on the RUNRES Crop in the region

1.	What do you mostly produce on your farm? *Tick what matters*	1 (Cassava) 2 (Coffee) 3 (Tomato) 4 (Banana) 5 (Mango) 6 (Others – specify)
2.	Where do you get the inputs (fertilizers/cassava cuttings/coffee seedlings etc.) to use in your farm you? (*Tick what matters*)	1 (Government ministry/institution e.g. RAB/INERA etc.) 2 (non- government body/institution e.g. IITA, CIP, AGRA etc.) 3 (Own effort) 4 (Farmers' association/cooperative) 5 (Agro dealer) 6 (Others – specify)
3.	Where (locations/regions) are your input suppliers located?	
4.	What keeps your input suppliers committed to you?	1 (Prompt payment) 2 (long-time relationship) 3 (I pay if take credit) 4 (others _____)
5.	Where do you get fertilizers to use in your farm you?	1 (Government ministry/institution e.g. RAB/INERA etc.) 2 (non- government body/institution e.g. IITA, CIP, AGRA etc.) 3 (Own effort) 4 (Farmers' association/cooperative) 5 (Agro dealer) 6 (Others – specify) 7 (Never use fertilizers)
6.	Where (locations/regions) are your fertilizers suppliers located?	
7.	What keeps your fertilizers suppliers committed to you?	1 (Prompt payment) 2 (long-time relationship) 3 (I pay if take credit) 4 (others _____)
8.	How much quantity of cassava/coffee/mangoes/tomato/ banana (Kgs/baskets/sacks etc.) did you producelast season/year? (*Tick units and timeline that apply*)	____________ (Units ___) *if not Kgs please specify conversion factor (CF)*
9.	What was the cost of production incurred per last season/year? *Record the exchange rate to USD, timeline must be the same as in 3. Tick timeline that matters*	a. Buying the planting materials _______________ Francs b. Renting land _________________ Francs c. Paying labor __________________ Francs d. If labor was not paid in c., how many man-days were used? _____ man days (1-man day = 6 hours) e. Fertilizers _____________ Francs f. Farm equipment purchase/repair ______ Francs g. All other costs ________________ Francs
10.	What is your opinion on the quality of the planting materials that you used? (*Tick what matters*)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
11.	What is your opinion on the quality of the produce you harvested? (Tick)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
12.	Are there any laws/regulations/policies/norms guiding you on how production of this crop is done in your sector/village of operation?	1 (Yes) 2 (No)
13.	If yes in 11., what are these that enable you produce this crop better?	
14.	If yes in 11, what are these that hinder your better crop production?	
15.	If no in 11, who then has power to regulate your production of this crop?	
16.	How many women/men are involved in the production of this crop?	Women ___________ Men __________
17.	What are the key roles of women/men in the production of this crop?	Women: 1 (financiers/owners) 2 (Farming) 3 (product sellers) 4 (others – specify) Men: 1 (financiers/owners) 2 (farming) 3 (product sellers) 4 (others – specify)
18.	Did you sell any of your farm produce for money?	1 (Yes) 2 (No) IF NO, skip to Question 25
19.	If yes in 15., how much quantity did you sell? And what was the unit price?	Quantity sold ________ Kgs/sacks/baskets etc. (*Specify and CF*) Unit price _______ Francs/Birr/Rand (*Tick what matters*) (*if different quantities were sold at different unit prices, please show these differences*)
20.	In which form do you mostly sell your produce?	a) Flower stage b) Fresh harvest c) dried harvest with husks d) dried harvest without husks e) peeled fresh harvest f) peeled dry harvest g) dry pellets h) powder i) Others
21.	If not all produce was sold; how much quantity was consumed at home? Or was wasted during the process?	Quantity consumed ________ Kgs/sacks/baskets etc. Quantity wasted ________ Kgs/sacks/baskets etc.
22.	Who (persons/agencies) do you sell too (clients)?	
23.	In what forms of the crop, is your final product to the client?	a) Flower stage b) Fresh harvest c) dried harvest with husks d) dried harvest without husks e) peeled fresh harvest f) peeled dry harvest g) dry pellets h) powder i) Others
24.	How do you exchange information with your clients?	1 (person to person) 2 (Phone call) 3 (Phone SMS) 4 (Internet) 5 (Radio/TV) 6 (Other)
25.	What kind of information do you exchange with clients?	1(available produce) 2 (prices) 3 (performance of old supplies) 4 (Others – specify)
26.	Which areas (locations/regions) are your clients located?	
27.	What keeps your clients committed to buying your produce?	1 (Supply genuine products) 2 (price cuts) 3 (all-time ready supplies) 4 (others ______)
28.	How do you describe your relationship with clients?	
29.	Are there institutions willing to lend you in the production of this crop?	1 (Yes) 2 (No)
30.	If yes in 29., are these formal or informal financial institutions?	(Formal e.g. microfinances, Banks etc.)2 (Informal e.g. farmer groups, family etc.)
31.	Are there any research/extension/government institutions providing you with new farm technologies (crops, equipment etc.) to use on your farm?	1 (Yes) 2 (No)
32.	If yes in 31, what is the kind of these institutions?	1 (Government) 2 (Private) 3 (Non-for-Profit international) 4 (local groups) 5 (others)
33.	What is the major challenge/bottleneck/gap in producing of this crop?	
34.	How can this in 33., challenge/bottleneck/gap be addressed?	
35.	What major opportunity do you see in the producing of this crop?	
36.	How can you take up this opportunity in 35., effectively?	
37.	Your feelings about using composted organic waste as fertilizer to grow food is positive.	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree
38.	Your feelings about using urine as a fertilizer to grow food is positive.	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree
39.	Your feelings about using treated / decomposed fecal material as a fertilizer is positive.	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree
40.	If you are feeling positive about using any of the above (organic waste, treated urine, fecal material); would you be willing then to pay for such a product for use as fertilizer?	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree

C. MIDDLEMEN (Assemblers/Collectors/Transporters/Fresh crop Traders)

Section C1: Sector (Middlemen) specific details – Focus on RUNRES Crop

1.	As a middleman (Assemblers/Collectors/Transporters/Traders) what crop do you deal in? *Tick what matters*	1 (Cassava) 2 (Coffee) 3 (Tomato) 4 (Banana) 5 (Mango) 6 (Others – specify)
2.	What do you exactly do with regards to this crop?	1 (Assemblers) 2 (Collectors) 3 (Transporters) 4 (Fresh crop Trader)
3.	Whosupplies you with the crop quantities you deal in? (*Tick what matters*)	1 (Farmers) 2 (Others – Specify)
4.	Which (areas/locations/regions) are your suppliers located?	
5.	What keeps your suppliers committed to you?	1 (Prompt payment) 2 (long-time relationship) 3 (I pay if take credit) 4 (others _____)
6.	How much quantity of this crop (Kgs/baskets/sacks etc.) did you deal in last season/year? (*Tick units and timeline that apply*)	____________ (Units ___) *if not Kgs please specify conversion factor (CF)*
7.	How much do you charge per unit of this crop, as you hand it to the next actor in the chain? (*if different quantities were sold at different unit prices, please show these differences*)	Francs
8.	What was the costs of dealing in this volume (in 6.,) of crop per last season/year? *Record the exchange rate to USD, timeline must be the same as in 3. Tick timeline that matters*	a. Vehicle hire / purchase ______________ Francs b. Fuel _________________ Francs c. Drivers labor __________________ Francs d. If labor was not paid in c., how many man-days were used? _____ man days (1-man day = 6 hours) e. Storage facilities' rent and maintenance ____________ Francs f. Repair ______ Francs g. Packaging _________________ Francs h. Communication _______________ Francs i. All other costs ________________ Francs
9.	What is your opinion on the quality of the crop product that you were handling as was from your supplier? (*Tick what matters*)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
10.	What is your opinion on the quality of the crop product, that you handled as you passed it on to the next actor in the chain? (Tick what matters)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
11.	Are there any laws/regulations/policies/norms guiding your business?	1 (Yes) 2 (No)
12.	If yes in 11., what are these that enable you deal this crop better?	
13.	If yes in 11., what are these that hinder your better dealing in this crop?	
14.	If no in 11, who then has power to regulate your dealings in this crop?	
15.	How many women/men are doing exact activities as yoursin this crop?	Women ___________ Men __________
16.	What are the key roles of women/men with regards to doing the same activities as you, around this crop?	Women: 1 (financiers/owners) 2 (store attendants) 3 (brokers) 4 (others – specify) Men: 1 (financiers/owners) 2 (store attendants) 3 (brokers) 4 (others – specify)
17.	Which (persons/actors) do you sell/hand to after your activity (clients)?	
18.	In what form is your final product before you hand it to your client?	
19.	How do you exchange information with your clients?	1 (person to person) 2 (Phone call) 3 (Phone SMS) 4 (Internet) 5 (Radio/TV) 6 (Other)
20.	What kind of information do you exchange with clients?	1(new markets) 2 (prices) 3 (product management means) 4 (Others – specify)
21.	Which areas (locations/regions) are your clients located?	
22.	What keeps your clients committed to your services?	1 (Supply genuine products) 2 (price cuts) 3 (all-time ready supplies) 4 (others ______)
23.	How do you describe your relationship with clients?	
24.	Are there institutions willing to lend to you with regards to your activity?	1 (Yes) 2 (No)
25.	If yes in 24., are these formal or informal financial institutions?	(Formal e.g. microfinances, Banks, etc.) 2 (Informal e.g. farmer groups, family etc.)
26.	Are there any research/extension/government institutions providing you new technologies (communication, equipment etc.) to enhance business?	1 (Yes) 2 (No)
27.	If yes in 26, what is the kind of these institutions?	1 (Government) 2 (Private) 3 (Non-for-Profit international) 4 (local groups) 5 (others)
28.	What is the major challenge/bottleneck/gap in your business this crop?	
29.	How can this in 28., challenge/bottleneck/gap be addressed?	
30.	What major opportunity do you see in the dealing in this crop?	
31.	How can you take up this opportunity in 30., effectively?	

D. PROCESSORS

Section D1: Sector (Processors) specific details – Focus on RUNRES Crop

1.	What crop do you process on your plan/station/site? *Tick what matters*	1(Cassava) 2 (Coffee) 3 (Tomato) 4 (Banana) 5 (Mango) 6 (Others – specify)
2.	Where do you get the raw material inputs for your processing? (*Tick what matters*)	1 (Farmers) 2 (Assemblers) 3 (collectors) 4 (Transporters) 5 (Fresh crop Traders) 6 (Others – specify)
3.	In what form are these raw materials when are supplied to you?	
4.	Where (locations/regions) are your raw materials suppliers located?	
5.	What keeps your raw materials suppliers committed to you?	1 (Prompt payment) 2 (long-time relationship) 3 (I pay if take credit) 4 (others _____)
6.	What exactly do you do to this raw materials when supplied to you?	
7.	How much quantity of this crop (Kgs/baskets/sacks etc.) did you process last season/year? (*Tick units and timeline that apply*)	____________ (Units ___) *if not Kgs please specify conversion factor (CF)*
8.	How much did you sell each unit of the final processed product? (*if different quantities were sold at different unit prices, please show these differences*)	
9.	What was the costs incurred in processing the above volume in 7.,last season/year? *Record the exchange rate to USD, timeline must be the same as in 3. Tick timeline that matters*	a. Building rent / constriction ______________ Francs b. Machinery installation / repairs __________________ Francs c. Electricity payments ____________ Francs d. Water payments ___________________ Francs e. Fuel for machinery ____________ Francs f. Paying labor ___________________ Francs

		g. If labor was not paid in d., how many man-days were used? _____ man days (1-man day = 6 hours) h. Packaging _________________ Francs i. Transport ________________________ Francs j. Marketing __________Francs k. Processing inputs ________________ Francs l. Administration ____________ Francs m. Licenses and Taxes __________________ Francs n. All other costs ________________ Francs
10.	What is your opinion on the quality of the crop raw materials that you received from your suppliers? (*Tick what matters*)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
11.	What is your opinion on the quality of the processed product that you produced? (Tick what matters)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
12.	Are there any laws/regulations/policies/norms guiding you on how to process this crop?	1 (Yes) 2 (No)
13.	If yes in 12., what are these that enable you process this crop better?	
14.	If yes in 12, what are these that hinder your better processing of this crop?	
15.	If no in 12, who then has power to regulate your production of this crop?	
16.	How many women/men are involved in the processing of this crop?	Women ___________ Men __________
17.	What are the key roles of women/men in processing this crop?	Women: 1 (finance/owners) 2 (store attendants) 3 (brokers) 4 (run machines) 5 (other Men: 1 (finance/owners) 2 (store attendants) 3 (brokers) 4 (run machines) 5 (others)
18.	How much quantity of the processed product was not sold? And why?	Quantity processed and NOT sold ________ Kgs/sacks/baskets etc. Reason ______________________________
19.	Who (persons/agencies) do you sell to (clients) your final product?	
20.	In what forms is your final product sold to the client?	
21.	How do you exchange information with your clients?	1 (person to person) 2 (Phone call) 3 (Phone SMS) 4 (Internet) 5 (Radio/TV) 6 (Other)
22.	What kind of information do you exchange with clients?	1(available market) 2 (prices) 3 (Product quality) 4 (Others – specify)
23.	Which areas (locations/regions) are your clients located?	
24.	What keeps your clients committed to buying your product?	1 (Supply genuine products) 2 (price cuts) 3 (all-time ready supplies) 4 (others ______)
25.	How do you describe your relationship with clients?	
26.	Are there institutions willing to lend you in the production of this crop?	1 (Yes) 2 (No)
27.	If yes in 26., are these formal or informal financial institutions?	(Formal e.g. microfinances, Banks, etc.) 2 (Informal e.g. farmer groups, family etc.)
28.	Are there any research/extension/government institutions providing you new technologies (communication, equipment etc.) to enhance business?	1 (Yes) 2 (No)
29.	If yes in 28, what is the kind of these institutions?	1 (Government) 2 (Private) 3 (Non-for-Profit international) 4 (local groups) 5 (others)
30.	What is the major challenge/bottleneck/gap in processing of this crop?	
31.	How can this in 30., challenge/bottleneck/gap be addressed?	
32.	What major opportunity do you see in the processing of this crop?	
33.	How can you take up this opportunity in 32., effectively?	
34.	What happens to the waste from your processing activities?	Solid waste ______________________ Liquid waste _________________________
35.	For what do you use the waste that you produce?	
36.	Into what do you process the waste ?	
37.	Do you collect waste from other persons for processing?	
38.	Do you pay the persons you collect waste from?	1 (Yes) 2 (No)
39.	Do you process the waste traditionally or mechanically?	1 (Traditionally) 2 (Mechanically)
40.	Do you own equipment/facilities used to collect/treat waste?	1 (Yes) 2 (No)
41.	If no in 40., Who then owns equipment/facilities you use?	
42.	What kind of contract to you have with equip/facilities owner?	
43.	What do you do with the products you process from waste?	
44.	Are there challenges/bottlenecks/gaps in managing waste?	
45.	What is the major challenge/bottleneck/gap in managing the waste you generate?	
46.	How can the challenge/bottleneck/gap be addressed?	
47.	Do you see business opportunities in waste you generate?	
48.	What major opportunity do you see from waste you generate?	
49.	How can you take up this opportunity, effectively?	

E. WHOLESALERS (Exporters/Importers)

Section E1: Sector (Wholesalers) specific details

1.	In what crop do you do you do your wholesale activities? *Tick what matters*	1(Cassava) 2 (Coffee) 3 (Tomato) 4 (Banana) 5 (Mango) 6 (Others – specify)
2.	Where do you get the raw material crops for your wholesale activities? (*Tick what matters*)	1 (Farmers) 2 (Assemblers) 3 (collectors) 4 (Transporters) 5 (Fresh crop Traders) 6 (Others – specify)
3.	In what form are these raw materials when are supplied to you?	
4.	Where (locations/regions) are your raw materials suppliers located?	
5.	What keeps your raw materials suppliers committed to you?	1 (Prompt payment) 2 (long-time relationship) 3 (I pay if take credit) 4 (others _____)
6.	What exactly do you do to in your wholesale activities?	1 (Exporter) 2 (Importer) 3 (Local wholesaler = sales locally)
7.	How much quantity of this crop (Kgs/baskets/sacks/Tons etc.) did you deal in (export or import or sale locally) last season/year? (*Tick units and timeline that apply*)	____________ (Units ___) *if not Kgs please specify conversion factor (CF)*

8.	How much did you sell each unit for? (*if different quantities were sold at different unit prices, please show these differences*)	Francs
9.	What was the costs incurred in handling the above volume in 7.,last season/year? *Record the exchange rate to USD, timeline must be the same as in 3. Tick timeline that matters*	a. Building rent / constriction _______________ Francs b. Machinery installation / repairs ___________________ Francs c. Electricity payments _____________ Francs d. Water payments _____________________ Francs e. Fuel for machinery _____________ Francs f. Paying labor ____________________ Francs g. Packaging _________________ Francs h. Transport _________________________ Francs i. Marketing ___________Francs j. Administration _____________ Francs k. Licenses and Taxes ___________________ Francs l. All other costs _________________ Francs
10.	What is your opinion on the quality of the crop raw materials that you received from your suppliers? (*Tick what matters*)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
11.	What is your opinion on the quality of the product that you produced and sold to your clients? (Tick what matters)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
12.	Are there any laws/regulations/policies/norms guiding your business?	1 (Yes) 2 (No)
13.	If yes in 12., what are these that enable you do better in your business?	
14.	If yes in 12, what are these that hinder you from doing better business?	
15.	If no in 12, who then has power to regulate your business?	
16.	How many women/men are involved in the wholesales of this crop?	Women ___________ Men __________
17.	What are the key roles of women/men in wholesaling this crop?	Women: 1 (finance/owners) 2 (store attendants) 3 (brokers) 4 (run machines) 5 (other Men: 1 (finance/owners) 2 (store attendants) 3 (brokers) 4 (run machines) 5 (others)
18.	How much quantity of the product was not sold? And why?	Quantity NOT sold ________ Kgs/sacks/baskets etc. Reason _____________________________
19.	Who (persons/agencies) do you sell to (clients) your final product?	
20.	In what forms is your final product sold to the client?	
21.	How do you exchange information with your clients?	1 (person to person) 2 (Phone call) 3 (Phone SMS) 4 (Internet) 5 (Radio/TV) 6 (Other)
22.	What kind of information do you exchange with clients?	1(Available market) 2 (prices) 3 (quality of supplied product) 4 (Others – specify)
23.	Which areas (locations/regions) are your clients located?	
24.	What keeps your clients committed to buying your product?	1 (Supply genuine products) 2 (price cuts) 3 (all-time ready supplies) 4 (others ______)
25.	How do you describe your relationship with clients?	
26.	Are there institutions willing to lend you in wholesaling of this crop?	1 (Yes) 2 (No)
27.	If yes in 26., are these formal or informal financial institutions?	1 (Formal e.g. microfinances, Banks, etc.) 2 (Informal e.g. farmer groups, family etc.)
28.	Are there any research/extension/government institutions providing you new technologies (communication, equipment etc.) to enhance business?	1 (Yes) 2 (No)
29.	If yes in 28, what is the kind of these institutions?	1 (Government) 2 (Private) 3 (Non-for-Profit international) 4 (local groups) 5 (others)
30.	What is the major challenge/bottleneck/gap in thiswholesale business?	
31.	How can this challenge/bottleneck/gap in 30., be addressed?	
32.	What major opportunity do you see in the wholesaling of this crop?	
33.	How can you take up this opportunity in 32., effectively?	
34.	What happens to the waste from your wholesaling activities?	Solid waste _______________________ Liquid waste __________________________

F. RETAILERS

Section F1: Sector (Retailers) specific details

1.	In what crop do you do you retail? *Tick what matters*	1(Cassava) 2 (Coffee) 3 (Tomato) 4 (Banana) 5 (Mango) 6 (Others – specify)
2.	Where do you get the raw material for retailing? (*Tick what matters*)	1 (Farmers) 2 (Assemblers) 3 (collectors) 4 (Transporters) 5 (Fresh crop Traders) 6 importers 7 (local wholesalers) 8 (Others – specify)
3.	In what form are these raw materials when are supplied to you?	
4.	Where (locations/regions) are your raw materials suppliers located?	
5.	What keeps your raw materials suppliers committed to you?	1 (Prompt payment) 2 (long-time relationship) 3 (I pay if take credit) 4 (others _____)
6.	How much quantity of this crop (Kgs/baskets/sacks/Tons etc.) did you retaillast season/year? (*Tick units and timeline that apply*)	____________ (Units ___ *if not Kgs please specify conversion factor (CF)*
7.	How much did you sell each unit for? (*if different quantities were sold at different unit prices, please show these differences*)	Francs
8.	What was the costs incurred in retailing the above volume in 6., last season/year? *Record the exchange rate to USD, timeline must be the same as in 3. Tick timeline that matters*	a. Shoprent _______________ Francs b. Storage facilities _______________ Francs c. Electricity payments _____________ Francs d. Paying labor ____________________ Francs e. Packaging _________________ Francs f. Transport _________________________ Francs g. Marketing /Advertising ___________Francs h. Administration _____________ Francs i. Licenses and Taxes ___________________ Francs j. All other costs _________________ Francs
9.	What is your opinion on the quality of the stock that you received from your suppliers? (*Tick what matters*)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
10.	What is your opinion on the quality of the product that you sold to your clients? (Tick what matters)	1 (Bad) 2 (Fair) 3 (Good) 4 (Excellent) 5 (I don't know)
11.	Are there any laws/regulations/policies/norms guiding the retailing activities of this crop?	1 (Yes) 2 (No)
12.	If yes in 11., what are these that enable you retail this crop better?	
13.	If yes in 11, what are these that hinder your better retailing ofthis crop?	
14.	If no in 11, who then has power to regulate your retailing of this crop?	
15.	How many women/men are involved in retailing of this crop?	Women ___________ Men __________

16.	What are the key roles of women/men in retailing this crop?	Women: 1 (finance/owners) 2 (store attendants) 3 (brokers) 4 (run machines) 5 (other Men: 1 (finance/owners) 2 (store attendants) 3 (brokers) 4 (run machines) 5 (others)
17.	How much quantity of the retail stock was not sold? And why?	Quantity NOT sold ________ Kgs/sacks/baskets etc. Reason _____________________________
18.	Who (persons/agencies) do you sell to (clients) your final product?	
19.	In what forms is your final product sold to the client?	
20.	How do you exchange information with your clients?	1 (person to person) 2 (Phone call) 3 (Phone SMS) 4 (Internet) 5 (Radio/TV) 6 (Other)
21.	What kind of information do you exchange with clients?	1(Product forms) 2 (prices) 3 (new products supplies) 4 (Others – specify)
22.	Which areas (locations/regions) are your clients located?	
23.	What keeps your clients committed to buying your product?	1 (Supply genuine products) 2 (price cuts) 3 (all-time ready supplies) 4 (others ______)
24.	How do you describe your relationship with clients?	
25.	Are there institutions willing to lend you in retailing businessof this crop?	1 (Yes) 2 (No)
26.	If yes in 25., are these formal or informal financial institutions?	1 (Formal e.g. microfinances, Banks, etc.) 2 (Informal e.g. farmer groups, family etc.)
27.	Are there any research/extension/government institutions providing you new technologies (communication, equipment etc.) to enhance business?	1 (Yes) 2 (No)
28.	If yes in 27, what is the kind of these institutions?	1 (Government) 2 (Private) 3 (Non-for-Profit international) 4 (local groups) 5 (others)
29.	What is the major challenge/bottleneck/gap in the retailing of this crop?	
30.	How can this in 29.,challenge/bottleneck/gap be addressed?	
31.	What major opportunity do you see in the retailing of this crop?	
32.	How can you take up this opportunity in 31., effectively?	
33.	What happens to the waste from your retailing activities?	Solid waste ______________________ Liquid waste _________________________

G. CONSUMERS

Section G1: Sector (Consumers' Incomes and Expenditures) specific details

	a. Household Incomes:	
1.	What is your major source of Household Income?	1 (From Agriculture activities) 2 (From non-agricultural activities)
2.	How much do you earn per month from these non-agricultural activities?*This includes all incomes that contribute to the sustainability of the household*	a. Salaried employment ____________ Francs b. Wholesale or Retail shop business ____________ Francs c. Service provisions (transport/cleaning etc.) ___________ Francs d. Brick laying and other crafts ____________ Francs e. Remittances from friends and relatives __________ Francs f. Dividends from businesses ___________ Francs g. Pension where applicable _______________ Francs h. Others (specify and total) ________________ Francs
3.	How much do you earn per month/season from agricultural activities? (*Tick time of reference, and if season is ticked, tell how many months are in a season). If various items/units in a category were sold and at different rates (e.g. crops or livestock), list the different items on another paper or the back.*	a. Crops sales ____________ Francs (Qn'ty sold________ * unit Price _____) b. Livestock sales __________ Francs (No. sold _______ * unit Price ______) c. Sales of Livestock products ______ Francs (Qn'ty sold ____ * unit price _____) d. Poultry sales ______________ Francs (No. sold _______* unit price ________) e. Poultry products sales _________ Francs (Qn'ty sold ____ * unit price ________) f. Apiculture (Honey) sales _________ Francs (Qn'ty sold ______ * unit price _______) g. Fish sales _______________ Francs (Qn'ty sold ______ * unit price ________) h. Sale of forest/swamp products __________ (No. sold ______ * unit Price _______) i. Provision of Agricultural labor _____________ Francs j. Others (specify) ______________
	b. Expenditures: Household Non-food expenditure	
4.	How much per week/month/term/year do you spend on the following items? *Please specify the time dimension clearly. NOTE this includes all expenses on all household members*	a. House rent / repairs/ construction ____________ Francs _____ time unit b. Medical insurance / bills/health ____________ Francs _____ time unit c. Education for children/dependents __________ Francs _______ time unit d. Transport fees/ licenses /fuel ____________ Francs _____________ time unit e. Agricultural equipment purchases / repair __________ francs _______ time unit f. Clothes purchases / repairs ___________________ Francs ___________ time unit g. Electricity bills ______________ Francs ___________ time unit h. Water bills _________________ Francs _____________ time unit i. Waste collection ______________ Francs ______________time unit j. Cooking fuel (gas/firewood/charcoal/kerosene) ________ Francs _____ time unit k. Security ___________ Francs ___________ time unit l. Gifts (weddings/funerals etc.) _________ Francs __________ time unit m. Business fees / licenses/ rent / taxes ___________ Francs ________ time unit n. Communication (airtime/TV/Internet/web subscriptions ________ Francs ____ time o. Home help / maids / support _____________ Francs ________ time unit p. Furniture (chairs/beds/sofas etc.) ______________ Francs _______ time unit q. Electronics purchases/repairs (fridge/lights/ pans etc.) ______ Francs ____ time units r. Laundry (soap/paper/pads etc.) __________ Francs ______ time unit s. Others (specify total) ______________ Francs _________ time unit
	c. Household Food Expenditure (*Food item form specific quantities have been avoided for RUNRES aims (we don't aim at micronutrient consumption estimations. However, care must be taken to ensure that the respondent is allowed ample time to remember the total (expense/quantity) figures). Common products are stated independently.*	
5.	How much quantity of these food items or their products did you buy in the last 7 days and how much did you spend per unit of these foods?	

Food item Consumed	Total ExpenseFr	Total Quantity	Units	Unit price	Form most consumed
1) Cassava					
2) Irish potato:					
3) Sweet potato (SP)					

4)	Orange-fleshed SP					
5)	Bananas					
6)	Plantain					
7)	Rice:					
8)	Yam:					
9)	Wheat:					
10)	Bread:					
11)	Maize:					
12)	Yellow maize					
13)	Sorghum:					
14)	Sugarcane:					
15)	Millet					
16)	Milk:					
17)	Poultry meat					
18)	Animal meat					
19)	Fish					
20)	Eggs:					
21)	Cabbages					
22)	Onions					
23)	Amaranth					
24)	Spinach					
25)	Chard					
26)	Carrots					
27)	Squashes / Pumpkins					
28)	Other vegetables					
29)	Mangoes					
30)	Papayas					
31)	Oranges					
32)	Jack fruit					
33)	Other fruits					
34)	Lentils					
35)	Beans					
36)	Ground nuts					
37)	Other nuts					
38)	Peas					
39)	Sim-sim					
40)	Sugar					
41)	Coffee					
42)	Tea					
43)	Salt					
44)	Biscuits					
45)	Chapati					
46)	Doughnuts					
47)	Mandazi					
48)	Samusa					
49)	Sodas					
50)	Packed juices					
51)	Alcoholic drinks					
52)	Cigarettes/Tobacco					
53)	Cooking oil					
54)	Other drinks					
55)	Other foods					

Dark green leafy vegetables e.g. amaranth (red or green), spinach and chard.Vit- A rich vegetable/fruits e.g. Carrots, Squashes/pumpkins.Yellow maize.Mangoes.Papayas.

Section G2: Household Food Insecurity Access (HFIAS) Questions

	Question	Response options	Code
1.	In the past four weeks, did you worry that your household would not have enough food?	0 (No) (if no skip to Q2) 1 (Yes)	
1.a.	How often did this happen?	1 (Rarely (once or twice in the past four weeks) 2 (Sometimes (three to ten times in the past four weeks)) 3 (Often (more than ten times in the past four weeks))	
2.	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of lack of resources?	0 (No) (if no skip to Q3) 1 (Yes)	
2.a.	How often did this happen?	1 (Rarely (once or twice in the past four weeks) 2 (Sometimes (three to ten times in the past four weeks)) 3 (Often (more than ten times in the past four weeks))	
3.	In the past four weeks, did you or any household member have to eat a limited variety of foods due to lack of resources?	0 (No) (if no skip to Q4) 1 (Yes)	
3.a.	How often did this happen?	1 (Rarely (once or twice in the past four weeks) 2 (Sometimes (three to ten times in the past four weeks)) 3 (Often (more than ten times in the past four weeks))	
4.	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of lack of resources to obtain other types of food?	0 (No) (if no skip to Q5) 1 (Yes)	
4.a.	How often did this happen?	1 (Rarely (once or twice in the past four weeks) 2 (Sometimes (three to ten times in the past four weeks)) 3 (Often (more than ten times in the past four weeks))	
5.	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there were not enough food?	0 (No) (if no skip to Q6) 1 (Yes)	
5.a.	How often did this happen?	1 (Rarely (once or twice in the past four weeks)	

		2 (Sometimes (three to ten times in the past four weeks)) 3 (Often (more than ten times in the past four weeks))	
6.	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	0 (No) (if no skip to Q7) 1 (Yes)	
6.a.	How often did this happen?	1 (Rarely (once or twice in the past four weeks) 2 (Sometimes (three to ten times in the past four weeks)) 3 (Often (more than ten times in the past four weeks))	
7.	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	0 (No) (if no skip to Q8) 1 (Yes)	
7.a.	How often did this happen?	1 (Rarely (once or twice in the past four weeks) 2 (Sometimes (three to ten times in the past four weeks)) 3 (Often (more than ten times in the past four weeks))	
8.	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	0 (No) (if no skip to Q9) 1 (Yes)	
8.a.	How often did this happen?	1 (Rarely (once or twice in the past four weeks) 2 (Sometimes (three to ten times in the past four weeks)) 3 (Often (more than ten times in the past four weeks))	
9.	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	0 (No) (if no questions are finished) 1 (Yes)	
9.a.	How often did this happen?	1 (Rarely (once or twice in the past four weeks) 2 (Sometimes (three to ten times in the past four weeks)) 3 (Often (more than ten times in the past four weeks))	

Section G3: Consumers' social attitudes and willingness to pay for waste derived products

1.	I would accept to eat food that has been cultivated using organic compost manure as fertilizers	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree
2.	I would be willing to pay for food that has been cultivated using organic compost as fertilizers	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree
3.	I would accept to consume food that has been cultivated using treated urine as fertilizers	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree
4.	I would be willing to pay for food that has been cultivated using treated urine as fertilizers	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree
5.	I would accept to consume food that has been cultivated using fecal material as fertilizers	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree
6.	I would be willing to pay for food that has been cultivated using treated fecal material as fertilizers	1)Strongly agree 2)Agree 3)Neutral 4)Disagree 5)Strongly disagree

9.3 Waste Stream Mapping

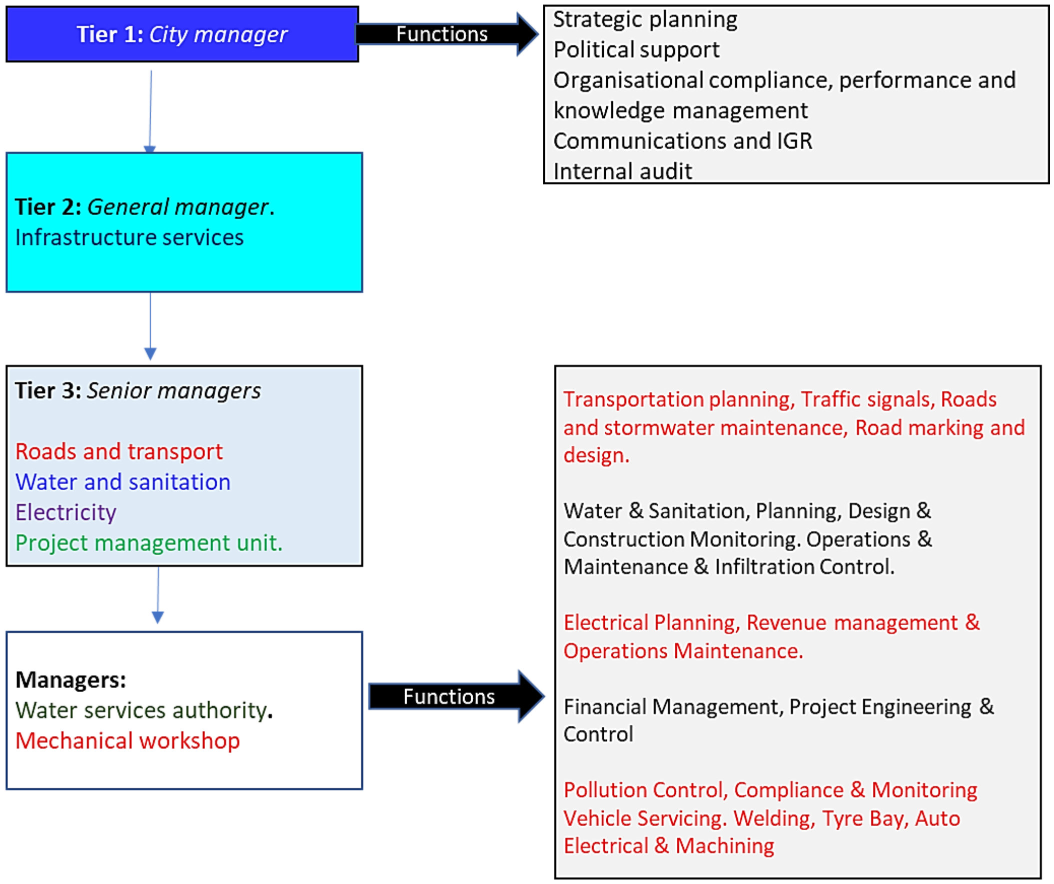

Figure 1: The functional organogram on the sanitation sector within the Msunduzi municipality; Adapted and modified from Msunduzi Municipality (2019).

Table 1: Sanitation policies in South Africa

Policy	Date	Level applicable	Comments
Clean water and sanitation	2015	International	Ensure availability and sustainable management of water and sanitation for all.
National Water and Sanitation Master Plan (NWSMP)	2018	National	To ensure a more co-ordinated approach to water and sanitation management, planning, implementation, monitoring and evaluation.
Water Services Act 108 of 1997	1997	National	The Water Services Act provide for the rights of access to basic water supply and basic sanitation.
The National Environmental Management: waste Act (Act 107 of 1998)	1998	National	To protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation.
National Water Act (No. 36 of 1998)[1]	1998	National	Regulates the water resources of the country, which are impacted by the sanitation services.
Municipal Systems Act (Act 32 of 2000)	2000	National	Responsibility of the local government to assume full responsibility and provision of water and sanitation services.

Table 2: Msunduzi municipality sanitation services across the value chain.

	Population	Percentage	Emptied	Transported	Treated	Disposed	Reused
VIP toilets	203,973	30%	0%	0%	0%	0%	0%
Septic Tanks	30,980	5%	5%	5%	4%	4%	4%
Open defaecation	40,477	6%	0%	0%	0%	0%	0%
*Decentralized	122,838	13%	18%	18%	15%	15%	0%
WW contained centralized	311,749	46%	46%	46%	38%	38%	0%
Total	**679,037**	**100%**	**64%**	**64%**	**53%**	**53%**	**53%**

*Decentralised encompasses conservancy tanks, septic tanks and chemical toilets

9.4 Socio- Economic Background