An urban metabolism approach to understanding household food consumption

By

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Declaration

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Abstract

Cities account for more than 60% of global greenhouse gas emissions and food production activities account for one-fifth of global greenhouse gas emissions as modern farming systems contribute to biodiversity loss acceleration. Paradoxically, one-third of all the food produced for human consumption is lost or wasted while food insecurity and hunger persist. Increased food production and consumption to meet demand continue to increase cities' greenhouse gas emissions and food waste generation. Food production and related food system activities utilise a variety of resources from the land, water, labour, nutrients, biomass, and energy. Food waste further represents a loss in these resources.

Access to adequate, affordable, safe, culturally appropriate, and nutritious food is necessary for the wellbeing of all people. Urban populations experience varying access to available food supply, with the urban poor experiencing low access. To improve access and subsequently improve the food security of urban populations, it is necessary to study household food consumption. This study used the urban metabolism framework to quantify household food inflows and outflows to understand household food consumption.

To assess the food metabolism of different households, this study used a mixed-methods research approach. A survey and a food diary were used to collect data on household food, namely the sources, types consumed, and quantities wasted. The results confirmed that supermarkets were the most frequently accessed source of food across all income groups. Lower-income households, however, had a more diverse source profile, and accessed at least more than one source for their food needs. Sampled households showed a relatively high dietary diversity, consuming foods from at least seven food groups from the selected nine food groups. Higher-income households, however, consumed a wider variety of foods compared to lower-income households, confirming the literature. The larger proportion of the total food waste generated by households fell within the unavoidable and possibly avoidable food waste categories.

Opsomming

Stede is verantwoordelik vir meer as 60% van die wêreld se kweekhuisgasuitlatings en voedselproduksie-aktiwiteite is verantwoordelik vir ’n vyfde van die wêreld se kweekhuisgasuitlatings omdat moderne boerderystelsels bydra tot versnellende biodiversiteitsverlies. Ironies gaan ’n derde van al die voedsel wat vir menslike verbruik geproduseer word, verlore of word vermors terwyl gebrek aan voedselsekuriteit en hongersnood voortduur. Verhoogde voedselproduksie en -verbruik om aan aanvraag te voldoen verhoog voortdurend stede se kweekhuisgasuitlatings en die generering van voedselafval. Voedselproduksie en verwante voedselstelselaktiwiteite maak gebruik van ’n verskeidenheid hulpbronne vanuit die land, water, arbeid, voedingstowwe, biomassa, en energie. Voedselafval verteenwoordig voorts ’n verlies van hierdie hulpbronne.

Toegang tot toepaslike, bekostigbare, veilige, kultureel-aanvaarbare, en voedingsryke voedsel is nodig vir die welstand van alle mense. Stedelike bevolkings ervaar uiteenlopende toegang tot beskikbare voedselvoorraad, terwyl die arm bevolking in stede swak toegang ervaar. Ten einde toegang te verbeter en gevolglik ook die voedselsekuriteit van stedelike bevolkings te verbeter, is dit nodig om huishoudelike voedselverbruik te bestudeer. Hierdie studie het die stedelike metabolismeraamwerk gebruik om huishoudelike voedsel-instromings en -uitstromings te bepaal om sodoende huishoudelike voedselverbruik te verstaan.

Om die voedselmetabolisme van verskillende huishoudings te takseer, het hierdie studie ’n gemengde-navorsingsmetode-benadering gevolg. ’n Opname en ’n voedseldagboek is gebruik om data rakende huishoudelike voedsel in te samel, naamlik die bronne, soorte wat verbruik is, hoeveelhede wat vermors is, en verwante voedsel- en voedselvermorsingspraktyke. Die resultate het bevestig dat supermarkte die algemeenste bron van voedsel oor al die inkomstegroepe was. Laer-inkomstegroepe het egter ’n meer diverse bronprofiel gehad, en het ten minste meer as een bron vir hul voedselbehoeftes gebruik. Steekproefhuishoudings het ’n relatiewe hoë dieetdiversiteit getoon, en het voedsel van ten minste sewe van die nege geselekteerde voedselgroepe verbruik. Hoër-inkomste-huishoudings het egter ’n groter verskeidenheid voedsel verbruik in vergelyking met laer-inkomste-huishoudings, soos deur die literatuur bevestig. Die

groter gedeelte van die totale voedselafval wat deur huishoudings gegenereer is, het binne die onvermydelike en gedeeltelik-vermydelike voedselafval-kategorieë geval.

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List of Acronyms and Abbreviations

AFSUN	African Food Security Urban Network
CSIR	Council for Scientific and Industrial Research
EU	European Union
EW-MFA	Economy wide Material Flow Analysis
FLW	Food Loss and Waste
FSC	Food Supply Chain
GFN	Global Food Network
MFA	Material Flow Analysis
WRAP	Waste and Resources Action Programme
WWF	Worldwide Fund for nature

Definition of terms

For the purposes of this study the following terms were used as defined below.

1. **Energy Cost** (of food): The price of food per megajoule of energy contained in the food (Temple & Steyn, 2011).
2. **Food**: Any substance, whether processed, semi-processed or raw, which is intended for human consumption; this includes drinks, chewing gum and any substance that has been used in the manufacture, preparation or treatment of "food" but does not include cosmetics, tobacco or substances used only as drugs (FAO, 2014a)
3. **Food Supply Chain (FSC)**: The connected series of activities to produce, process, distribute and consume food (FAO, 2014a).
4. **Food system**: A set of activities from production to consumption determined by the interactions between and within bio-geophysical and human environments whose outcomes contribute to food security, environmental security and social welfare (Ericksen, 2008).
5. **Food system activities**: They include production, processing and packaging, distribution and retailing, and consumption (Ingram, 2011).
6. **Household**: A group of people who live together at least four nights a week, eat together and share resources, or a single person who lives alone (STATS SA, 2019).
7. **Sustainable food system:** A food system whose primary goal is to reduce poverty and ensure food and nutrition security for all, in such a way that does not compromise the capacity of the economic, societal and natural environments to provide the same for future generations (FAO, 2014a).
8. **Waste**: Any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, by the holder of the substance, material or object, whether or not such substance, material or object can be reused, recycled or recovered (DEA, 2012).

Chapter 1 – Introduction

1.1 Background

The global population is estimated to reach 9.7 billion by the year 2050 (UN-DESA, 2017). Africa is rapidly urbanising and it is estimated that 50% of its projected population growth will be living in cities (UN-Habitat, 2013).

Cities are typically high resource consumers, consuming about 70% (UN-Habitat, 2013) of the world's energy. Cities account for more than 60% of global greenhouse gas emissions (UN-Habitat, 2013). With population growth in developing countries, food waste and its associated emissions is increasing (Porter *et al*., 2016). Previously, cities would source for resources from its rural hinterland (Wolman, 1965) and deposit waste back to its immediate environment, localising the impact of resource production and consumption. Increased demand for resources, however, is leading to an increasingly global hinterland (Musango *et al*. 2017). Consequently, the impacts of production and consumption are experienced further away from the city, extending cities' ecological footprint (Wackernagel *et al*., 2006).

The global food system causes significant environmental impacts. Food production activities account for one fifth of global greenhouse gas emissions (FAO, 2016), and modern farming systems contribute to biodiversity loss acceleration (FAO, 2016). Paradoxically, one third of all the food produced for human consumption is lost or wasted (Gustavsson *et al*., 2011), while food insecurity and hunger persist. Food production and related food system activities utilise a variety of resources from land, water, labour, nutrients, biomass and energy. Food waste represents a loss in direct and embodied water (Vanham *et al*.2016), energy (Wordwide Fund for nature (WWF), 2017), nutrients (Lin *et al*., 2016) and biomass (Wirsenius, 2003) throughout the food supply chain.

Globally, cities produce about 2.01 billion tonnes of solid waste per year (Kaza *et al*., 2018). South Africa is estimated to have generated 54.2 million tonnes of general waste in 2017 (Department of Environmental Affairs (DEA),, 2018). Municipal waste accounted for 8.9% (approximately 4.82

million tonnes) of the total general waste generated in that year (Department of Environmental Affairs (DEA), 2018) . These estimates are based on calculations from a representative sample of municipalities from the nine South African provinces and extrapolated using the population of South Africa in 2017 to account for municipalities with limited or unavailable reported waste data. The Western Cape Province generates about 4.1 million tonnes of municipal solid waste, which represents 53% of the total waste generated by the province (Green Cape, 2018). Cape Town produces approximately 2.76 million tonnes of municipal solid waste (Green Cape, 2018). These waste volumes are calculated from waste quantities reported in waste reports compiled by waste disposal facilities in the municipality. Given the availability of data, these waste estimates are used as the reference of waste quantities for this study. Though this information is useful, data on food waste quantities is limited (Oelofse & Nahman, 2013) and often lacking in most cases. Available reports give waste categorisations that are too broad (Republic of South Africa, 2008) to give a true picture of the state of food waste production. This hinders the development of appropriate interventions for the reduction of food waste and its re-direction from landfills.

Several perspectives have been used to understand the challenges and impacts of the urban food system. To address urban inequality, food security has been used as a potential strategy for poverty reduction (Mahadevan & Hoang, 2016). To address the impacts of the globalised food system, food sovereignty has been used to chart the transition to a just food system (Holt-Gimenez, 2009). To address the unsustainable consumption of cities, behaviour change studies have been used to understand food waste behaviours (Abdelradi, 2018; Quested *et al*., 2013). This study proposes an alternative lens. By using the urban metabolism framework, a better understanding of the dynamics of food flows in the city can be gained. The framework can be applied to study multiple resource types at different scales. This study applies the framework to study food flows at the household level. At this level, we can gain a better understanding of urban food consumption that can shape a transition to sustainability.

1.2 Urban metabolism: Towards sustainable urban resource consumption

Urban metabolism is defined as "the sum of the technical and socio–economic processes that occur within the cities, resulting in growth, production of energy, and elimination of waste" (Kennedy *et al*., 2007: 44). Most of the resources that cities consume are finite in nature. These are natural

resources such as water, energy, minerals, ecological goods and services, among others. Being high resource consumers, cities are contributing significantly to the unsustainable consumption of resources. Following a systems approach, the urban metabolism framework contextualises the processes of production and consumption as complex and networked interactions. This view allows for the identification of opportunities for re-designing urban flows.

1.3 Household level analysis: The need for a bottom-up approach

The urban metabolism framework is useful for exploring multiple resource types at different levels. Urban metabolism studies are usually conducted at national and city levels with most of the data sourced from national statistics (Currie *et al*., 2015; Hoekman & von Blottnitz, 2017). Such data does not capture the complexities within the city, especially when high income inequalities are considered. A household level analysis (Hoekman & von Blottnitz, 2017) can be valuable in capturing such nuances. The framework is used to conceptualise household food metabolism by tracking and quantifying the types of food flows from the point of entry into the household to the point of exit from the household. This bottom-up approach enables a focused examination of the dynamics of household food flows and the identification of targeted intervention points.

1.4 Household food waste generation

There is growing concern about food loss and waste in the world, stemming from its ethical (Rundgren, 2016), social (Davis *et al*., 2016; Shillington, 2013), ecological and environmental (Ericksen, 2008; Porter *et al*., 2016; Pradhan *et al*.,, 2013), and economic (Basson *et al*., 2017; Nahman *et al*., 2012; WWF, 2017) impacts.

Food loss occurs at the earlier stages of the food supply chain at production, processing and distribution, while food waste occurs at the lower end of the food supply chain at the retail and household level (Gustavsson *et al*., 2011). Food waste serves as an indicator of a household's food efficiency. As part of the strategy to improve efficiency and management, there is a need to quantify and characterise waste generated. Additionally, addressing food waste at the household level provides several opportunities. It has the potential to save three times the energy that would be needed to eradicate food waste at the post-harvest stage (WWF, 2017), lower incidences of food

insecurity in urban households (Godfrey *et al*., 2010; Nahman *et al.*, 2012; Quested *et al.*, 2013), and reduce the amount of methane gas, carbon dioxide and leachate that is produced from decomposing food waste at landfills (WWF, 2017).

1.5 Problem statement

The population of Cape Town continues to rise rapidly (City of Cape Town, 2017). To meet demand, the city consumes more resources, directly contributing to greenhouse gas emissions and a growing food waste stream (Green Cape, 2018). As this is happening, Cape Town has limited landfill airspace for waste disposal, and urban food insecurity persists (Battersby, 2011). Diversion of food and other organic waste from landfills would reduce methane emissions from decomposing waste and lower the risk of potential underground water contamination from sipping leachate (WWF, 2017). Reducing food waste generation has the potential to improve the food security status (Godfray *et al.*, 2010) of Cape Town households.

Urban populations experience varying access to available food supply, with the urban poor experiencing low access. Applying a bottom-up approach to food metabolism offers a focused examination and understanding of urban food flows (Burger Chakraborty *et al*., 2016). The insight gained would be useful in re-designing sustainable urban food systems that provide food and socio-economic security, while maintaining the integrity of the ecological and environmental systems.

1.6 Research objectives

The primary objective of this study is to assess the food metabolism of different households in Cape Town. This will be achieved through three sub-objectives:

1. To determine the food sources accessed by households.
2. To determine the food types consumed by households.
3. To quantify and categorise food waste generated by households.

1.7 Scope of the study

1. The study is limited to the Cape Town metropolitan municipality.

2. The unit of analysis is households.
3. The assessment is limited to municipal solid waste.
4. The assessment is limited to the food waste stream.

1.8 Research strategy

To accomplish the overall objective, the study followed the research strategy visualised in Figure 1. The first activity of the research strategy was to conduct a literature review. This then informed the selection of the research design. With the research design in place, the sample design was selected, and appropriate methods chosen accordingly. Once this was done, the methods were piloted. Using the feedback from the pilot exercise, the methods were adjusted accordingly, after which the survey was disseminated, setting off the data collection phase of the research strategy. After data collection, data analysis was carried out. The whole process was iterative. Information gathered at different phases informed one another. For example, the method selected was informed by both literature and method testing. The feedback from both enabled the refining of the data collection tools. Insights gathered during data analysis informed the adjustment of the literature review.

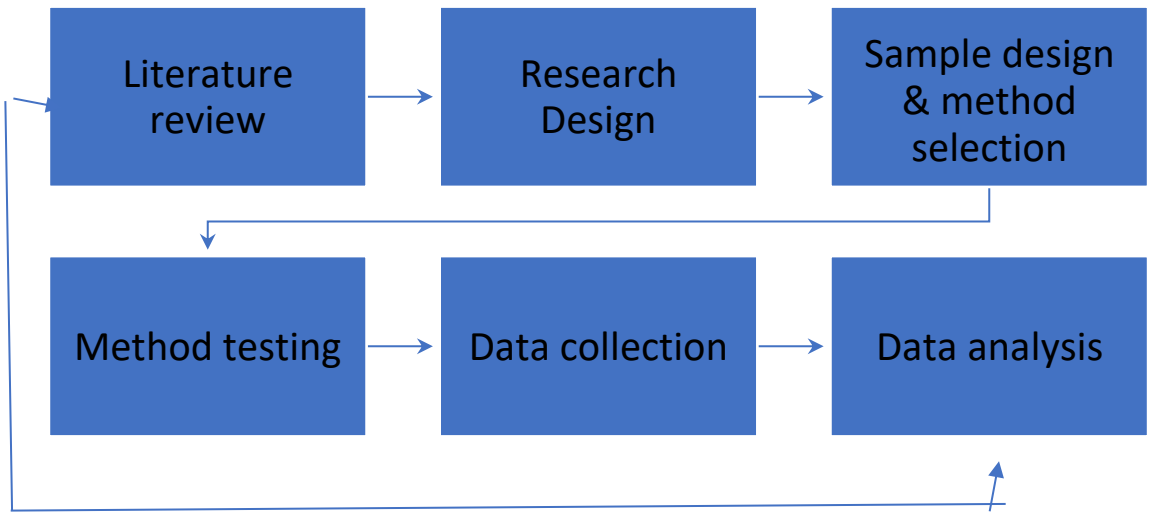

Figure 1: Research strategy used for the study
Source: Author

1.9 Study methodology

The study made use of a cross-sectional survey research design as outlined by Bryman *et al.* (2014). A mixed methods approach was used in which both quantitative and qualitative data collection methods were employed. Accordingly, the study made use of a questionnaire survey and food diary to collect both quantitative and qualitative data.

1.10 Rationale for the study

Available food consumption data for Cape Town is limited in detail. This is specific to the types of foods being consumed, the type of food waste generated and the practices that influence food waste generation. For example, the most recent data on household food waste types and quantities for South Africa dates to 2012 (Nahman *et al.*, 2012). There is a more recent study done for the Gauteng province that assessed household food wastage across several variables, with the main one being income (Ramukhwatho *et al*., 2016). This study looked at four food types that were most commonly eaten by households in the province. There is need for more household food waste studies from the different regions of the country that look at a variety of food types. A household assessment of food inflows and outflows by Cape Town households would not only provide useful information on the current status of household food consumption in the city, it would also contribute to the few food waste studies in the country.

1.11 Chapter outline

Chapter 1 provides the background to the study, problem statement, research objectives, scope of the study, research strategy, definition of terms used, study methodology and the rationale for the study.

Chapter 2 reviews the literature on urban metabolism, household food provisioning, household food waste generation and related food waste practices, to develop a framework that can be applied to study household food consumption.

Chapter 3 provides the research methodology and a summarised review of the methods used to accomplish the research objectives.

Chapter 4 presents and discusses the research results and findings.

Chapter 5 concludes with reflections on conducting a household food metabolism assessment and recommendations for future studies.

Chapter 2 – Literature Review

2.1 Introduction

This chapter begins by framing the study within the context of the challenges of African cities. This is followed by a discussion on the concept of urban metabolism and how the framework can be used to assess food flows at the household level. It then delves into household food provisioning, elaborating on household food sources and food types consumed. This chapter concludes with a discussion on food waste generation and related food waste behaviours and practices.

2.2 Urban challenges

With the estimated projection of more than half the world's population living in cities, cities are faced with the inevitable effects of rapid urbanisation; among them, increased resource consumption and waste production, high rural-urban migration, and rising urban poverty. In addition to these, cities in developing countries are grappling with the proliferation of informal settlements and high urban inequality.

To address these challenges, specific questions must be asked. How can city infrastructure be planned better to provide adequate access to basic services such as water, sanitation and energy to all inhabitants of the city? How can this access be provided equitably, acknowledging the needs and lived contexts of people? Can policy be used to facilitate a re-definition of the relationship between the city and its people? Is it possible to re-design the processes of production and consumption to develop a less destructive relationship between the city and its hinterland? These questions can be summarised into three common themes: concerns over the relationships between natural and social systems; cities and its increasingly global hinterlands; and the sustainability of urban processes. Urban metabolism has proven to be a useful concept that can be applied to these themes to facilitate a 'just transition' into sustainability (Broto, Allen & Rapoport, 2012).

2.3 The concept of urban metabolism

The word ‘metabolism’ in urban metabolism is used as a metaphor (Timmeren, 2013) . It connotes the consumption, production and utilisation of a resource to enable or maintain a given function. Urban ‘metabolism’ uses the term to conceptualise the processes in a city (Wolman, 1965). Using the metaphor, a city can be viewed as a living organism that consumes and assimilates resources for its growth and sustenance, and eliminates what is no longer of use. When viewed as a biological organism, city processes follow a linear process of resource extraction, consumption and waste disposal towards growth and survival. Cities’ consumption and production processes affect the environment, from contributing to greenhouse gas emissions to accumulating waste in the urban environment. Thus, a more relational understanding of metabolism is necessary (Golubiewski, 2012). Ecology can provide a broader understanding of metabolism (Wu, 2014). Ecology can be understood as the study of the interactions among organisms and between organisms and their surrounding environment . From an ecological perspective, a city can be conceptualised as an ecosystem; a complex of interactions between people, the city, its hinterland and the environment. From this perspective, the metabolism analogy takes form and different definitions of urban metabolism are formulated.

In response to water shortages, deteriorating air quality and mismanagement of sewerage in affected American cities, Wolman, (1965) in his article ‘The metabolism of cities’, draws the metabolism of a hypothetical American city in an effort to bring to fore the high resource requirements of the modern city and its inefficiencies in the utilisation of the same resources, which often are finite. It is from his work that the concept of urban metabolism is said to have been first conceptualised. Using an urban ecology view, Wolman (1965) conceptualises the city as an ecosystem. Following with the ecosystem analogy, he describes the needs of a city as ‘metabolic requirements’ (Wolman 1965: 179), which he defines as . . . “all the materials and commodities needed to sustain the city’s inhabitants at home, at work and at play [which] over a period of time… include even the construction materials needed to build and rebuild the city itself” (Wolman 1965: 179). Among the more recent definitions of urban metabolism is Kennedy *et al.'s* (2007: 44) definition of the urban metabolism as “the sum of the technical and socio–economic processes that occur within the cities, resulting in growth, production of energy, and elimination of waste*”*. In this definition, there is an addition of the social and technical components of a city, widening the perspective of urban metabolism. In recognition of the complex and emergent properties of cities

during resource exchanges, Currie & Musango (2016: 4) define urban metabolism as "the collection of complex socio-technical and socio-ecological processes by which flows of materials, energy, people, and information shape the city, service the needs of its populace, and impact the surrounding hinterland". This is an arguably comprehensive definition that is cognisant of the dynamic interactions of cities and the widening scope of our understanding of 'resources' that are increasingly critical for city functioning.

2.3.1 Circular urban metabolism: Improving urban sustainability

Cities are high resource consumers and high waste producers (UN-Habitat, 2013). A large proportion of the resources that cities consume are finite in nature (Rockström *et al*., 2009). Among these resources are crude oil used for energy production, water, soil used in the agricultural and construction industries, minerals and nutrients, ecosystem goods and services, as well as land surface. Cities are open systems (Currie *et al*, 2017a) that source resources from their hinterland. Due to globalisation, cities have become highly interconnected, extending city hinterlands and the associated effects (Longato *et al*., 2019) of resource consumption. Cities are increasingly relying on each other for resources and services. This interdependence affects the resilience capacity (Zasada *et al*., 2017) of cities, especially when cities have an imbalance of imports and local supply.

To improve the sustainability of cities, innovative and practical interventions must be applied. One such intervention is the promotion of a circular metabolism of resources. Initially, the urban metabolism concept followed a linear model (Figure 2).

Figure 2: Linear urban metabolism of unsustainable cities

Source: Adapted from (Musango *et al*., 2017)

The focus was to manage the resource throughput of cities (Kennedy *et al.*, 2007) to limit the amounts and effects of consumption and waste production. This was accomplished by quantifying material and energy fluxes of urban resource inflows and waste outflows (Wolman, 1965). This uni-directional flow of resources is unsustainable (Musango *et al.*, 2017). As cities grow, they consume more resources and produce more waste. The challenge is that these processes are occurring at a rate faster than the hinterlands can regenerate resources and assimilate the waste deposits (Longato *et al.*, 2019). There needs to be a reshaping of these flows for a sustainable city. The circular urban metabolism model (Figure 3) promotes the efficient use of resources through local harvesting and extraction and the re-introduction of waste into the system as potential inputs (Musango *et al.*, 2017) . This can be done through recycling, upcycling, re-using and re-purposing of waste outputs. This lessens dependency (Musango *et al.*, 2017) on hinterlands by reducing the demand for 'virgin' resources.

Figure 3: Circular urban metabolism of sustainable cities

Source: Adapted from Musango *et al.* (2017)

To better understand the processes that drive resource flows and the structures that maintain this system of flows, a networked metabolism model (Zhang, 2013) provides a useful perspective. Building on the circular metabolism perspective, Zhang (2013) put forward a network metabolism that highlights how resources are modified and transformed as interactions between the social and the natural occur, affecting the components of the system in a non-linear manner and often in unpredictable ways (Figure 4).

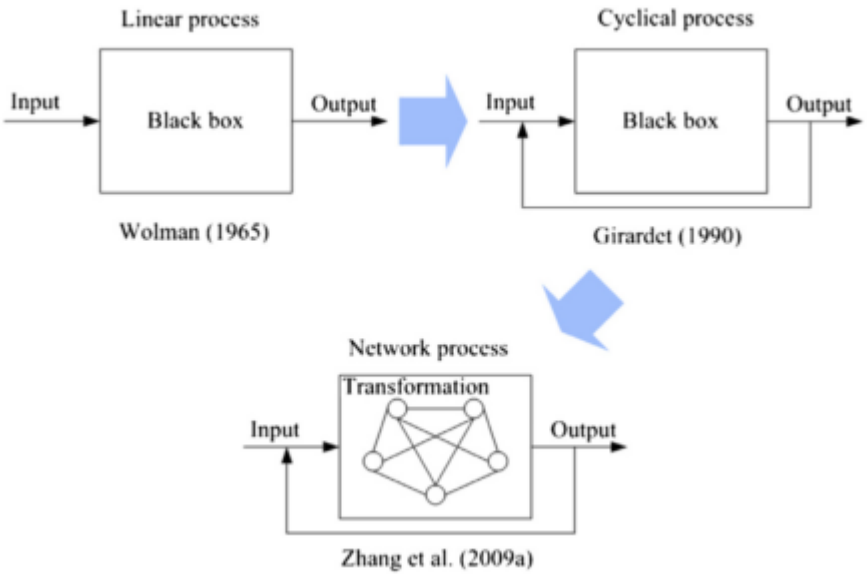

Figure 4: The development of the urban metabolism concept
Source: Zhang (2013: 465)

2.4 Conducting urban metabolism assessments: how to account for urban flows

There are several methods used for urban metabolism analyses. The three main accounting methods are; material flow analysis (MFA), energy flow analysis and ecological foot-print analysis (Zhang, 2013). These can be used at different scales of analysis from country-wide studies to household studies.

The material flow analysis is the most commonly used accounting method (Musango *et al*., 2017). This is because of it provides an effective way to gain information about the resource efficiency

of a city ecosystem (Kennedy *et al.*, 2007), it is an effective means to quantify energy, water, food inputs and waste outputs of a city (Sahely *et al*., 2003). The method involves measuring the stocks and flows of a city's resources based on a mass balance unit. Figure 5 is a diagrammatic representation of the Eurostat material flow analysis used for national scale analyses of resource flows. It illustrates the input flows, throughput flows and output flows that can be accounted for in an urban metabolism assessment.

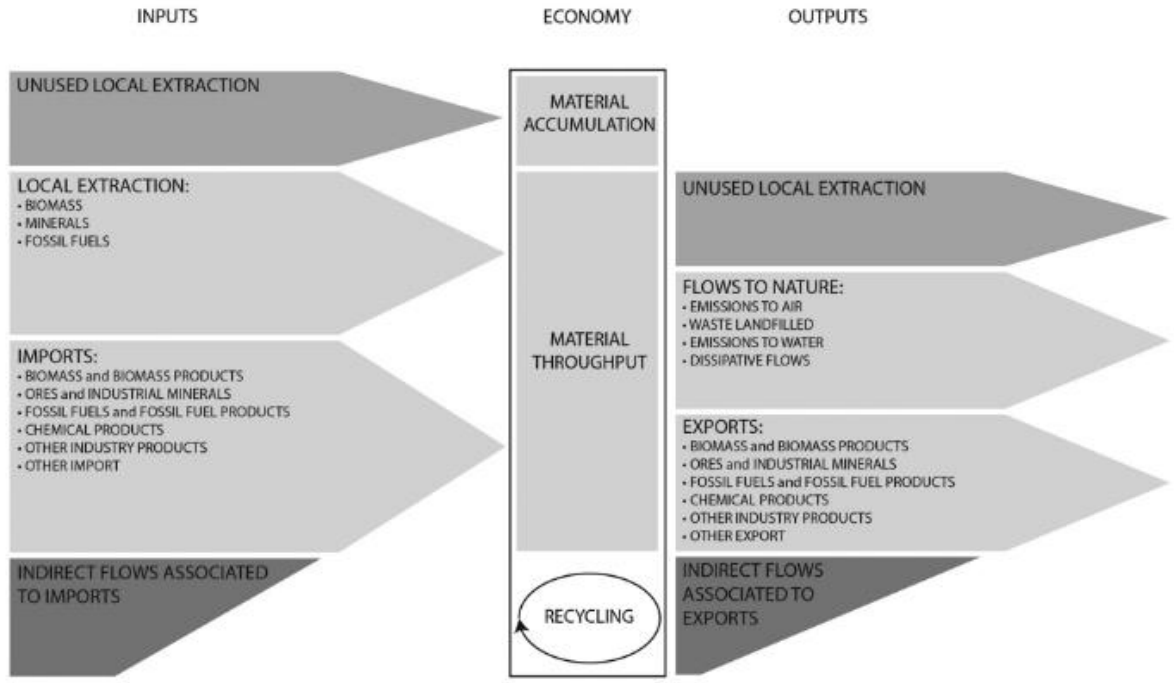

Figure 5: Material flow analysis method showing the main material flows
Source: Voskamp *et al.* (2017: 891)

The first distinction to be made before an assessment is between energy and material flows (Zhang *et al*., 2015). The unit of measurement used for energy flows is joules while the unit of measurement used for material flows is mass or volume. Thereafter the resources are identified and classified before analysis. Material flow analysis thus begins with the classification of the various material flows. Depending on the objectives of a study, flows can be disaggregated to distinguish between individual resources for example energy, water, materials (Donato *et al*., 2015) or they can be disaggregated to distinguish between flows from a resource (Burger Chakraborty *et al.*, 2016).

To successfully carry out an accounting analysis, adequate, reliable data is a pre-requisite (Zhang, 2013). In the absence of such data, common practice is to use a proxy (Zhang, 2013) that can be used to account for the consumption of a resource. The other alternative is to focus on a key resource, for example energy or water or biomass which has led to, among them; energy metabolism studies, water metabolism studies, biomass metabolism studies. For an urban metabolism study to be effective, all consumables must be accounted for (Zhang, 2013). As previously mentioned, a city's resources range from human labour to energy. The unit of measurement for each resource varies accordingly. This therefore necessitates the need for the identification of a common unit of comparison since the method is a basic summation of all consumables (Zhang, 2013) . This is another challenge of the material flow analysis in addition to data availability and reliability. Notwithstanding, this methodology has been effective in providing city administrators with valuable data of the city's consumption and thus bolstered environmental and resource management efforts (Hendriks *et al*., 2000).

As already mentioned, the 3 main accounting methods can be used at different scales of analysis. For example; at the national level, a detailed MFA of South Africa was conducted by Beyers & Swilling (2016),at the city level, Hoekman and von Blottnitz (2017) assessed the metabolism of Cape Town using the economy wide material flow analysis (EW-MFA) framework, which is a detailed accounting method, typically used at a national scale, in which all physical flows moving into or out of a socio-economic system are inventoried. The material flow analysis can also be adapted to household level flow assessments (Hendriks *et al.*, 2000; Leray *et al*., 2016) with the objective to trace and track the input, storage, transformation processes of identified metabolic flows within the household system and the resulting outputs from the household system into other systems (Hendriks *et al.*, 2000).

2.5 Urban metabolic flows

Cities make use of a variety of resources, which vary from essentials such as food, water, and energy to the goods and services used by the city and its people. Collectively, all these resource requirements can be referred to as the metabolic flows of a city.

Metabolic flows can be categorised according to their origin or type. According to origin, there are three basic types of flows in cities (Minx *et al*., 2010). They can be categorised into:

1. Direct extraction and releases: These are the resources directly extracted and the waste and emissions directly released within the urban system.
2. Imports and exports: These are the products imported or exported to/from the urban system.
3. Indirect flows associated with imports and exports: These are the resources indirectly extracted, and emissions and wastes indirectly released in the supply chain of goods and services imported to or exported from the urban system.

According to type of flow, urban flows can be broadly categorised into energy flows, material flows, water flows, and biomass flows. Biomass flows account for all plant and animal based biological organic matter used for direct human and animal consumption or for non-energy consumptive purposes (Wirsenius, 2003). Given the impact and size of biomass flows and city dependence on biomass resources, the European Union (EU) conducted a biomass flow assessment of 28 EU member states (Gurria *et al*., 2017). The result is represented using a Sankey biomass diagram that visually presents the EU-28 biomass balances (Figure 6).

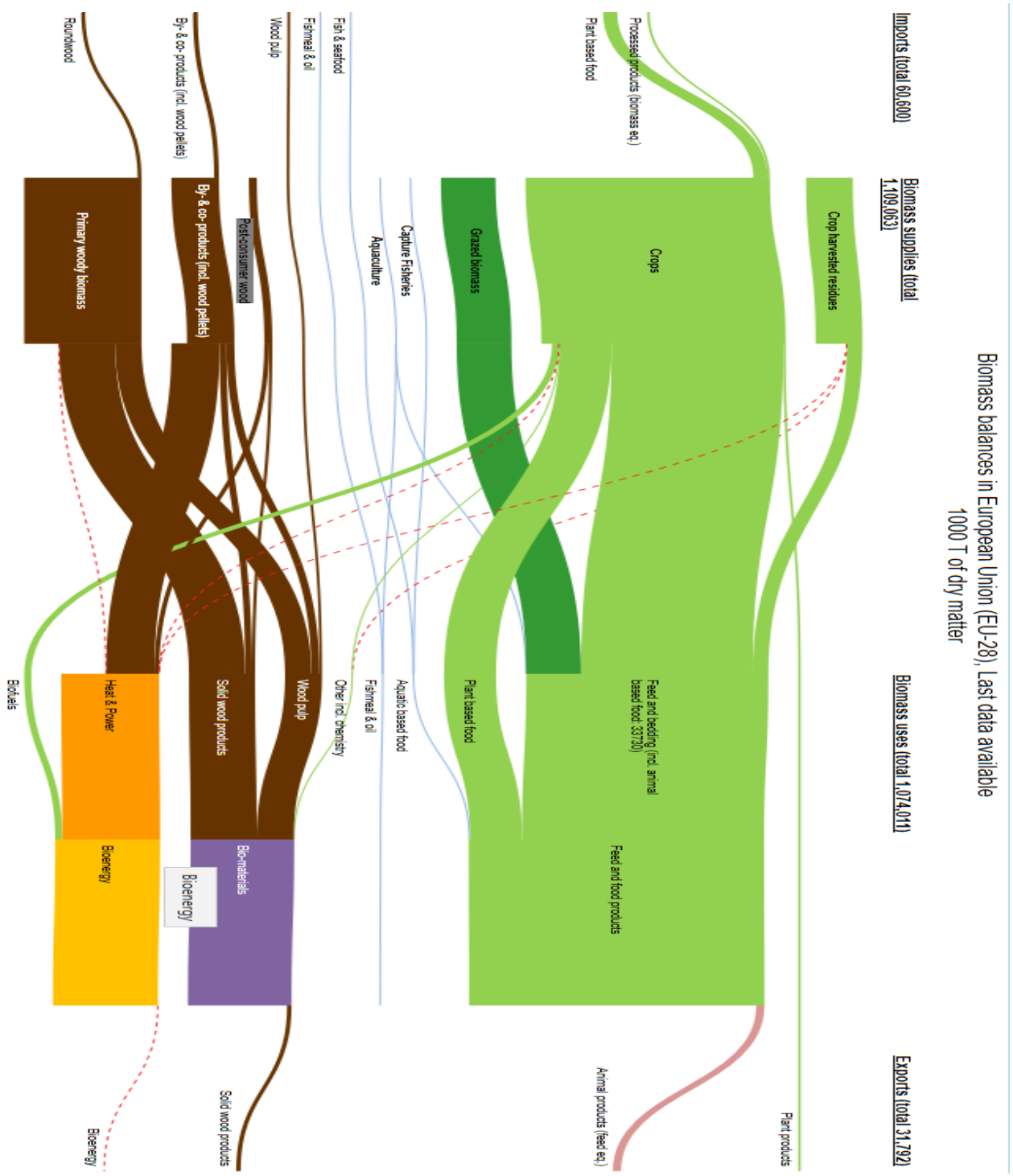

Figure 6: Sankey biomass metabolism of the European Union (EU)

Source: Gurria *et al.* (2017)

The biomass flow assessment captures the flows of biomass for each sector of the bioeconomy, from supply (local and external imports) to uses, including trade. The biomass imports that are accounted for are plant-based products, plant-based food, fish and seafood, fishmeal and oil, wood pulp, by- and co-products of wood, and roundwood. The assessments account for the consumption of biomass by food and non-food systems. Non-food systems' uses include plant-based biological matter, phytomass, (Wirsenius, 2003) used for non-food purposes, such as plants grown for biofuel, trees grown for wood, and plants grown for horticultural use. The assessment enables deeper analysis and comparison of various flows enabled by its disaggregation of individual flows. For example, fish and seafood biomass imports are divided into capture fisheries and aquaculture, which are both utilised for the supply of aquatic-based foods.

Within biomass flows, food biomass flows have received more attention. This is expected as the most essential use of biomass is the provision of food for humans and feed for animals. Also, the food system is the largest single consumer of biomass globally (Wirsenius, 2003), accounting for 60% of global biodiversity losses on land and about 24% of global greenhouse gas emissions (Ingram *et al*., 2016). From the EU biomass metabolism, biomass flows caused by direct food consumption can be identified. These food flows are plant-based foods, aquatic-based foods and associated food products (Figure 6). From these food flows, we can attempt to conceptualise food metabolism at different scales, such as the city or the household level.

2.6 Urban metabolism studies of urban food flows

Food flows refer to the movement of foods meant for human consumption (Wirsenius, 2003), from the point of production to the point of final consumption (Zhou *et al*., 2012). It includes both the flows from rural to urban areas, and between regions and countries (Forster *et al*., 2014). They represent the foods that people eat, such as cereals, poultry, meat, vegetables, fruits, milk, eggs, sweets, among others (Burger Chakraborty *et al.*, 2016). These flows can further be disaggregated according to food type (e.g., spinach, apples, chicken) (Beretta *et al*., 2013), according to nutrient content (e.g., vitamin A rich vegetables), or according to their level of processing or lack thereof (e.g., processed foods and whole foods) (Beretta *et al.*, 2013).

Food production and related food system activities utilise a variety of resources from land, water, labour, nutrients and energy. This process of production results in both the production of food and non-food flows. These non-food flows include: nutrient flows from fertiliser use; carbon flows from emissions during the distribution of food; water flows during the cultivation and processing of crops; labour flows from either employment in the supply chain activities or unemployment caused by supply chain automation; biomass flows from plant biomass used as animal feed and that used in the cultivation process; and waste flows from food consumption activities.

There are a limited number of urban food consumption studies by urban metabolism scholars (Bohle, 1994; Currie *et al*., 2017; Leray *et al.*, 2016). This section reviews metabolism studies that are related to food.

Lin *et al.* (2016) conduct an urban nutrient metabolism assessment in their study of Xiamen's food-sourced nutrients with specific focus on carbon, nitrogen and phosphorus nutrients. Increasing urban nutrient pollution from urban food consumption forms the context and motivation for such research to improve waste management systems and promote nutrient recovery.

Forkes (2007) conducts a nitrogen balance from the urban food metabolism of Toronto. The nitrogen balance for the urban flow of food and pre- and post-consumption food waste was developed to determine the impact of municipal waste management policies and programs on the recovery and recycling of imported nitrogen (Forkes, 2007).

Li *et al*. (2012) present a time-series estimation of urban phosphorus (P) metabolism through food consumption in selected Chinese cities. They study the relationship between the dietary consumption of phosphorus and income for a specified period. The argument for this study is the lack of data on phosphorus flows from food consumption. They define urban dietary phosphorus (P) metabolism as "the phosphorus (P) flow into and out of urban systems through food consumption by urban residents*"* (Li *et al.*, 2012: 589).

Beretta *et al*. (2013) conduct a material flow analysis of food losses within the entire Switzerland food supply chain. They differentiate the food categories into a total of 22 food categories mainly based on their importance for the Swiss food basket. As part of the analysis, they further differentiate the food losses into avoidable, possibly avoidable and unavoidable food losses. The

total mass flows for foods consumed and foods wasted are converted to energy flows i.e. the energy available to human bodies. The aim of the study was to calculate the food efficiency of the total food chain.

From the literature above, it appears that most urban metabolism studies that have been linked to food focus mainly on nutrients embedded in food products with the focus driven by nutrient pollution emanating from the sourcing, consumption and disposal of food products. Using the urban metabolism framework, these studies examine nutrient flows, quantify them, and simulate possible future scenarios, with the purpose of closing the nutrient cycle loop where nutrients are recycled and re-introduced into the producing hinterlands and more specifically re-introduced into the biogeochemical cycle (Lin *et al.*, 2016). This is done to determine the environmental impact of resource use and consumption of the food system. In doing so, 'indicator substances' *(*Faist *et al.*, 2001) that can be tracked and quantified are identified. Examples of indicator substances are 'indicator elements' (Faist *et al.*, 2001), such as the nutrients carbon (C), nitrogen (N) and phosphorus (P), which can be tracked and quantified in measuring the impacts of the food system.

2.7 Conceptualising household food metabolism

Urban metabolism studies conducted at the household level are known as household metabolism studies. Household metabolism is "a concept that is concerned with the analysis of stocks and flows of energy, matter, and information at the household scale*"* (Harder *et al*., 2017: 178). Studies focus on household resource consumption and greenhouse gas emissions driven by aggregate household consumption. This is because many of the environmental impacts caused by resource exploitation and waste production are ultimately driven by household consumption (Harder *et al.*, 2017). This necessitates household metabolism assessments. Existing assessments make use of an energetic perspective that emphasises households' responsibility for greenhouse gas emissions and climate change (Donato *et al*., 2015)

To study urban food metabolism, Leray *et al*., (2016) conceptualise a household scale material flow analysis (Figure 7).

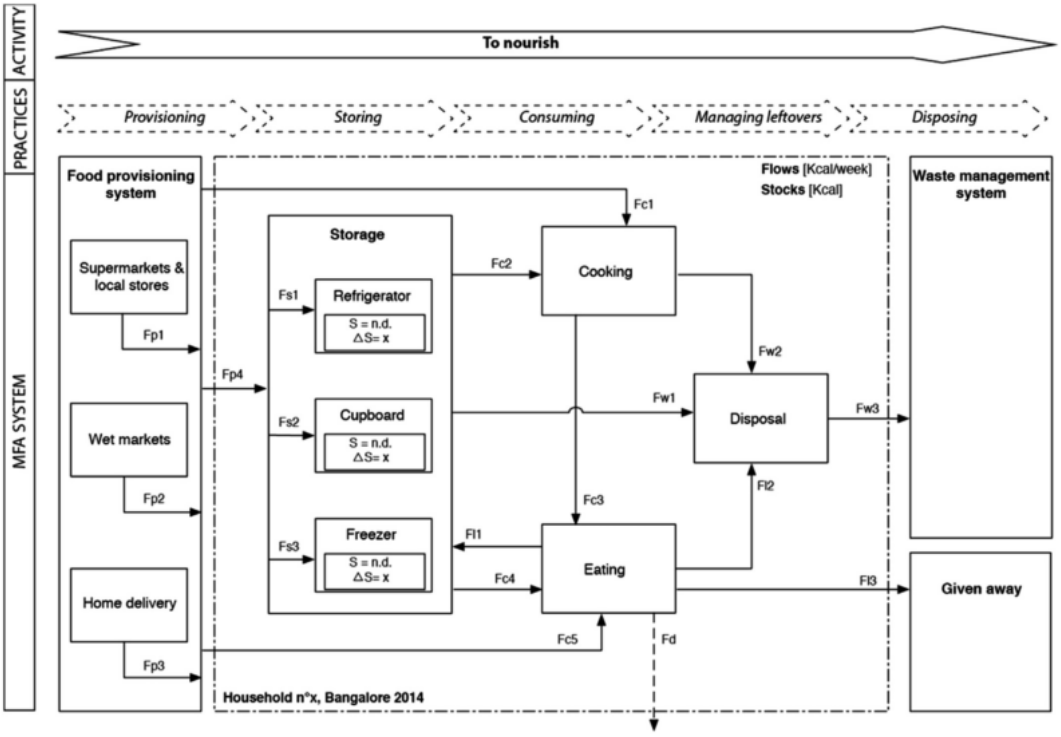

Figure 7: Material flow analysis system to assess household food flows
Source: Leray *et al.* (2016: 47)

The authors use the material flow analysis with the social practice theory to understand food consumption at the household level. From this they develop a 'practice-extended material flow analysis' of selected households in Bangalore, India. By using the social practice theory, the study was able to link the household food practices to quantified food flows. In the study, the social practice theory is used to explain how the sociological and sociotechnical aspects of consumption practices relate to household food metabolism creating different household metabolic profiles. The study defines metabolic profiles as "a set of histograms [that] build on flows and stocks' normalized values presented over different descriptive domains. A descriptive domain is the quantitative or qualitative dimensional spaces within which the dataset is presented and linked to each of the five practices involved in the activity "to nourish"*"* (Leray *et al*., 2016: 48). For example, when looking at food provisioning, the provisioning pattern of different households can be compared using the sum input flows Fp1 (supermarkets and local stores) + Fp2 (wet markets) + Fp3 (home delivery) (Figure 7). Food inputs can further be allocated along the food retailing categories such that the amount of food inputs purchased from each provisioning system can be identified. In this case,

food inputs and retailing categories are the descriptive domains used to describe the household practice of food provisioning. The same approach can be applied to analyse the temporal distribution of food inputs. That is the provisioning frequencies from each retail category. This can be done by determining the daily proportion of food inputs purchased by each household from the total purchased over a specified period such as a week or a month. The first descriptive domain is a product-specific domain that describes the sources of household food inputs. The second descriptive domain is a temporal-specific domain that describes how often a household accesses a food source. Both descriptive domains present a metabolic profile that can be related to the provisioning practice. "It is precisely because household metabolisms are analysed and compared using multiple descriptive domains that they can be explicitly related to practice performances*"* (Leray *et al*., 2016: 48). This qualitative input that the social practice theory provides, supplements the quantitative output of material flow analysis of the household's food consumption creating a deeper understanding of household food consumption dynamics.

In conducting the material flow analysis, the study focuses on the activity 'to nourish' which they link to the household food practices of; provisioning, storing, consuming, managing leftovers and disposing (Figure 7). The choice of scale is argued for by the need to better understand the urban food consumption of a city in a developing country. Due to high disparities in household income among other inequalities that characterise cities in developing countries (Smit, 2016), this 'micro-level' analysis has the potential to capture the nuances that would have otherwise been missed if conducted at a city or national scale. Also, there is limited information on what happens to food once it enters the household and how it ends up as waste (Beretta *et al*., 2013; Leray *et al*., 2016). The model captures the sources of foods, the sinks (or in this case the storage areas), direct consumption, management of leftovers and the disposal routes of food waste (Figure 7). The objective of such an analysis would be; (i) to identify food leakages i.e. points within the household food system that food leaves the food stream into the waste stream, (ii) to identify the types and quantities of flows getting into the household i.e. the types and quantities of foods that households are consuming, (iii) to identify the provisioning intensities of different households i.e. how often households access different sources for the various food inputs.

To improve the efficiency of food consumption in the household, there is need to understand what, where and how food is purchased. The next section discusses food provisioning strategies that households employ to meet their food needs.

2.8 Household food provisioning

People require adequate quantities and quality food to meet their daily calorific and nutritional needs respectively. As much as people need to consume energy-dense foods that enable them to perform work, it is equally important to consume foods containing necessary micro and macro nutrients required to support the metabolic functions of the human body. This section begins with a discussion on food security to help contextualise food provisioning and highlight the importance of food access.

Food security is defined as *"*a situation that exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet dietary needs and food preferences for an active and healthy life*"* (FAO, 2009: 1).This definition is a result of the culmination of multiple critiques and varying interpretations of the term's meaning over the years (Lang & Barling, 2012; Pinstrup-Andersen, 2009; Sen, 1976).

Initially, the term 'food security' was used to describe a country's ability to produce enough food to meet the demand of its populace (Pinstrup-Andersen, 2009) although it was not clear if meeting demand also meant that every person had access to the food in supply. From this description, food security was understood as 'national self-sufficiency', which meant that the food demand had to be met within local borders. Afterwards, food security would be understood as 'national food sovereignty', making the attainment of food security a matter of means, both physical and economic, where a country would only be food sovereign when it could produce what its population demanded and had access to the money needed to import any deficit (Pinstrup-Andersen, 2009). From these two interpretations of food security, the focus is on the availability of food as the answer to hunger. Increasing production and ensuring an abundant supply at a national and global scale was therefore the response to address hunger. Access to and nutritional value of the food was however still lacking, with subsequent research showing that other than availability, hunger was also a result of a lack of access, famously described as 'failures of exchange entitlements' (Sen, 1976).

In response to this, food security took on its current definition at the World Food Summit of 1996, with a few notable additions. The words physical, social and economic access were added in, in recognition of the broader meaning of access. The words safe and nutritious were added in

recognition of food safety and nutritional value. The addition of the words 'food preferences' is still open to interpretation (Alcock, 2008) , although the general assumption is that it means foods that meet the cultural, religious and ethical values of the individual (Hopma & Woods, 2014) . Lastly was the addition of the words 'healthy life'. This not only implies the absence of disease but also implies access to micro and macro nutrients needed to maintain and support the immune system (Battersby *et al*., 2014). This would mean that a household can be said to be food insecure if they live on a diet that is of poor nutritional value; that is, a diet lacking in micro and macro nutrients needed for a healthy diet. This brings into focus the importance of food allocation as a household activity. Members of the same household may have different food security status (Pinstrup-Andersen, 2009) if we consider that each individual may carry a specific nutritional need, which is affected by, among others, how food is allocated among the household members.

Food availability and food access to nutritional foods are key conditions for a food secure household. In the next section, the study looks at the types of foods that households consume and where these foods are sourced from.

2.8.1 Household food sources and types

A grocery store is a retail shop that primarily focuses on the sale of foods. The food retail sector in South Africa can be broadly organised into the formal and informal market segments. The formal constitutes grocery stores such as supermarkets, hypermarkets, and farmer's markets, while the informal largely constitutes independent sellers such as general dealers, spaza shops, hawkers, and street vendors. In addition to these, lower income households have been observed using other non-market sources that do not involve the exchange of currency and that are often communal in nature. The following section will look at the various food provisioning strategies that urban households employ to meet their dietary and nutritional needs as they navigate everyday urban life.

2.8.1.1 Market sources

Market food sources are sources where food is obtained through the exchange of currency or monetary value. They can be categorised into formal and informal market sources; these are outlined in more detail below.

Formal market sources

Formal food retail sources include supermarkets, hypermarkets, farmers' markets, local groceries, restaurants and fast food outlets, fuel station convenience stores and any other formal outlet that sells food.

The modern food retail system is characterised by high technological input, private standards, global sourcing and procurement, and highly advanced and connected global distribution and storage networks (Reardon *et al*., 2002) This is mostly experienced in supermarket retail whose popularity continues to grow. Supermarkets have become a central source of food for urban populations all over the world (Battersby & Crush, 2014; Reardon *et al.*, 2002; Walker *et al*., 2010). They have gained a significant influence in the food market, fast outgrowing and outselling other grocery stores. In Southern Africa, supermarkets have been growing exponentially, penetrating the agri-food market in their numbers (Reardon *et al*., 2002).

The proliferation and rapid rise of supermarkets in urban areas has become an important topic of discussion due to their growing influence and transformative effects on the entire agri-food system and food supply chain (Weatherspoon & Reardon, 2003). In South Africa, the food retail market has seen a significant expansion of supermarkets following global trends (Reardon *et al.*, 2002). By 2003, the supermarket sector in South Africa accounted for 50–60% of all food retail, although supermarkets accounted for just 2% of all food retail outlets (Weatherspoon & Reardon, 2003). The sector continues to grow, with a share of the food retail market increasing to 68% in 2010 (Weatherspoon & Reardon, 2003). The major formal supermarket chains based on store numbers are: Shoprite Checkers and Pick n Pay which have a market share of about 30% each of the formal food retail market, followed by Spar SA with a share of 21%, Woolworths with 9%, Game & Cambridge (Walmart) with 6% and Food lovers and Choppies with 2% each (Dube *et al*., 2018).

Supermarkets have traditionally been perceived as the preserve of the rich in urban areas, filling a specific high and middle-income market niche (Reardon *et al.*, 2002). This is currently not the case as supermarkets have expanded into lower income markets (Reardon *et al.*, 2002) and have become the main food sourcing option across all income groups (Battersby & Peyton, 2014). Cape Town is a good example of this proliferation, as can be seen in Figure 8, in which the presence of supermarkets is widespread across the different suburbs.

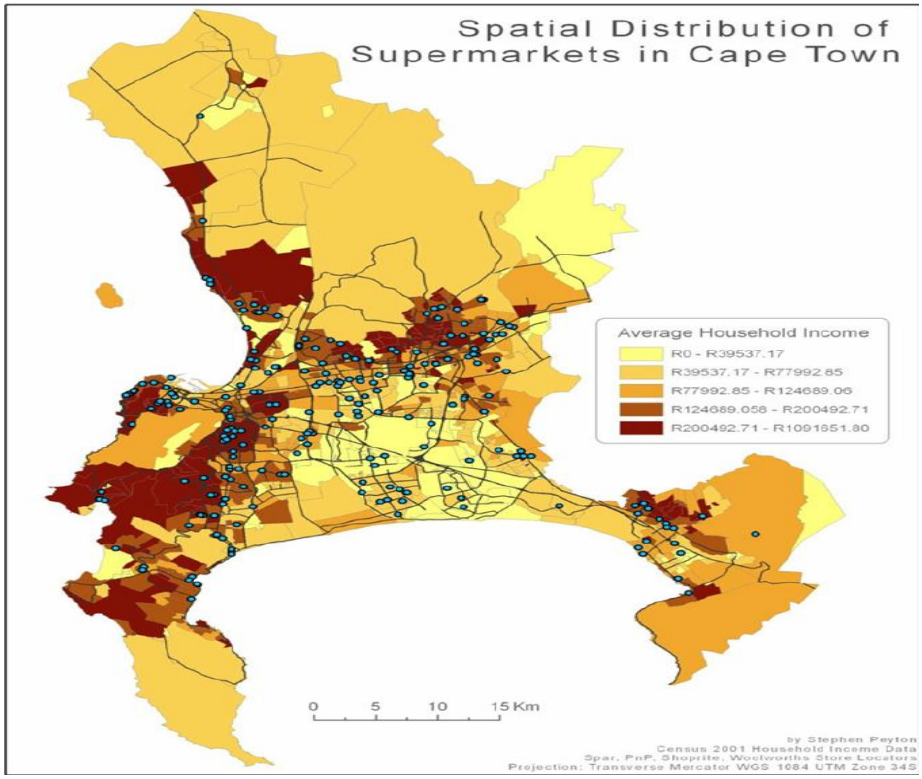

Figure 8: Spatial distribution of the three major supermarkets in Cape Town
Source: Battersby & Peyton (2014: 160)

The expansion of supermarkets into lower income areas has improved the availability of food in urban areas (Battersby & Crush, 2014; Frayne *et al*., 2009). None the less, it is not clear if this expansion has had a similar effect on improving households' access to food (Tawodzera, 2012). The spatial distribution of supermarkets in Cape Town (Figure 8) indicates that there is a greater clustering of supermarkets in higher income suburbs compared to the lower income suburbs. Even with improved infrastructure and higher disposable incomes, supermarkets are still sparsely located in low income suburbs, meaning lower income households do not have the same access to supermarkets as their richer counterparts (Battersby & Peyton, 2014).

Supermarkets' ability to improve access to nutritious foods is also arguable. Supermarkets typically stock foods according to the market that they serve. Supermarkets in up-market areas stock a greater variety of foods that are comparatively higher priced than their stores in lower income areas. The same supermarkets have a wider selection of foods within a given food group in their up-market stores, while those in poorer areas are more likely to have a limited variety of

foods within a food group or even completely lack certain food groups (Battersby & Crush, 2014). An important phenomenon associated with supermarkets is the concept of food deserts. They are worth noting as they affect the types of food that are available to poor urban households, which in turn directly affects their food security status. Food deserts are commonly described "*as poor urban areas, where residents cannot buy affordable, healthy food*" (Cummins & Macintyre, 2002: 436). They are geographical areas characterised by the presence of not more than ten stores (Hendrickson *et al*., 2006). This definition however cannot be adopted in the African context without considering the unique complexities (Battersby & Crush, 2014) that surround the food security terrain of most Sub-Saharan countries. In defining African food deserts, all retail sources should be accounted for and should include the role of informal markets and non-market sources of food. Additionally, the socio-economic and socio-cultural contexts in which African low-income households find themselves should be considered, as these directly affect their access to adequate and nutritional food. African food deserts are thus defined as poor, "often informal, urban neighbourhoods characterized by high food insecurity and low dietary diversity, with multiple market and non-market food sources but variable household access to food" (Battersby & Crush, 2014: 149).

Informal market sources

Informal market sources include street vendors and hawkers. These sources are mainly accessed by the urban poor as part of their provisioning strategy. They are popular with low income populations for several reasons. They: offer credit based on the relationship between the seller and the consumer, and people can buy food on credit and pay later when the money is available; offer foods packed in convenient quantities that meet the needs of the consumer while most are open for long hours which allows consumers to shop at their convenience (Ligthelm, 2003). Some poor households do not have consistent income, and others rely on government social grants as their sole or main source of income. Additionally, many either live in informal shelters or Reconstruction and Development Programme (RDP) housing whose back yard space is likely to be rented out for backyard dwellings to generate supplementary income rather than used for domestic gardening that could potentially supplement their nutritional needs. This further contributes to informal markets' role as an important food provisioning strategy for the urban poor.

Although informal sources are important for poor households, they offer a limited variety of foods that are more often more expensive than foods sold in formal food retail sources (Battersby, 2011). and safety of foods from informal sources is also another concern.

2.8.1.2 Non-market sources

Non-market food sources are those that households access food from without the exchange of currency. They can be categorised under the list of social safety nets.

Food transfers and remittances

Food transfers and remittances are mainly associated with the poor and low-income households in urban populations. It is an important food strategy for urban poor households (Frayne, 2010) whose income may not be enough to cater for all necessities, especially in a highly income-dependent urban environment where one's survival is determined by their purchasing power.

Lower income urban households in developing countries and those in Sub-Saharan Africa in particular are varyingly reliant on food remittances from rural areas as a food provisioning strategy and a coping mechanism (Frayne, 2010; Owuor, 2006). In an African food security urban network (AFSUN) survey, 11 cities in Southern Africa were studied and their food transfers quantified in a bid to understand and value the role of rural-urban food transfers in the food security status of poor urban dwellers (Frayne *et al*., 2010). It was found that 84% of food insecure households received food transfers from rural areas compared to 16% of food secure households who received the same. 81% of the households that received food transfers considered these transfers to be a significant portion of their food budget, while 9% considered the transfers to be "critical to their survival" (Frayne, 2010: 300). For the South African cities sampled, 24% of the total food supply in poor households in Msunduzi came from rural areas, 18% of the total food supply in poor Cape Town households came from food transfers from rural areas, while 14% of the total food supply of poor Johannesburg households came from food transfers from rural areas (Figure 9).

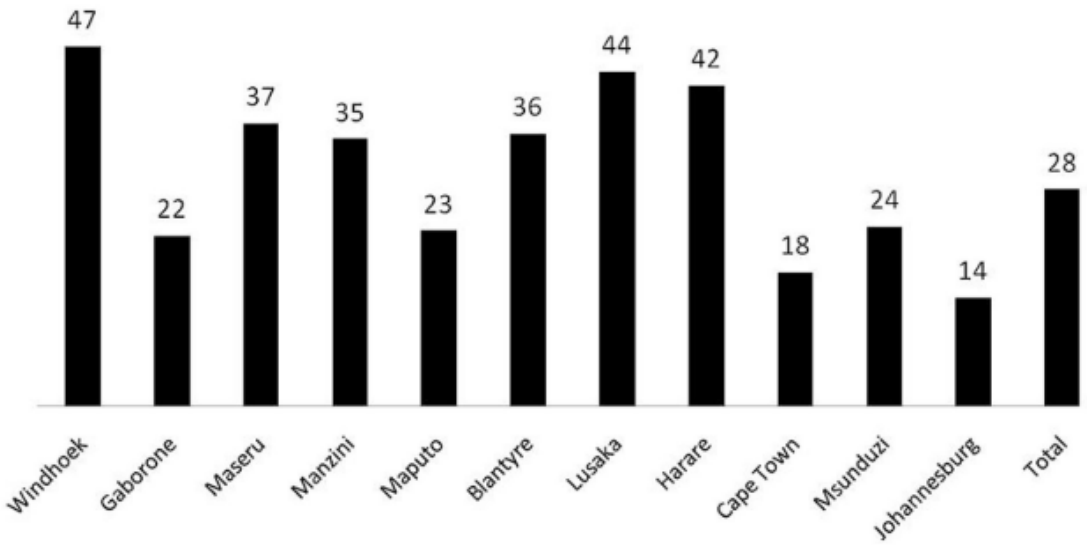

Figure 9: Percentage (%) total food transfers from rural to urban household
Source: Frayne (2010: 300)

Among the types of foods that were transferred between urban and rural households are cereals, vegetables, pulses and nuts, meat and poultry, roots and tubers, sugar and honey, fats and oils, dairy products, fruits, fish and eggs (Figure 10).

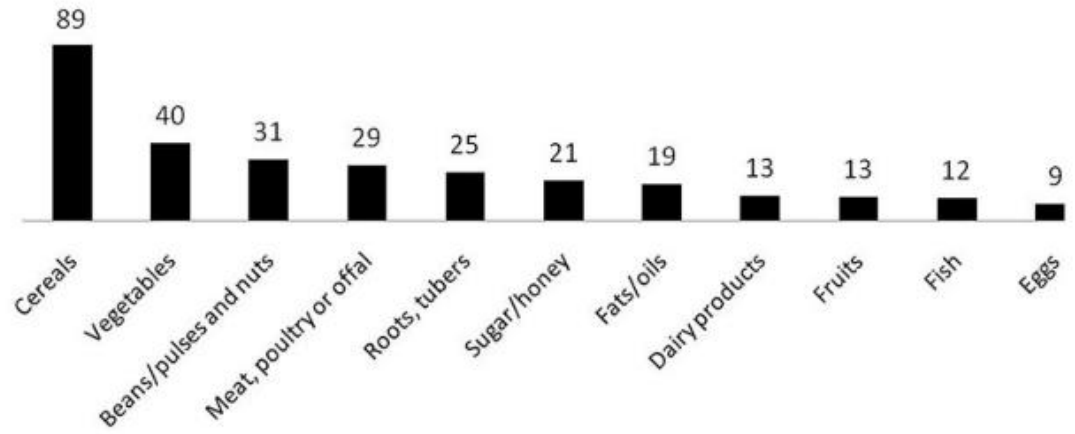

Figure 10: Percentage (%) types of food sent from rural to urban household
Source: Frayne (2010: 301)

Despite a greater proportion of transfers coming from rural areas, there is also a significant proportion of foods coming from other urban areas (i.e., urban-urban transfers) (Frayne, 2010). From the AFSUN survey, it was found that 48% of food transfers came from other urban

households (Frayne, 2010). Put together, 11% of urban households in Southern Africa received food from both rural and urban households (Frayne, 2010). Among the South African cities included in the survey, 83% of Cape Town households reported receiving remittances from fellow households living in other urban areas compared to 82% of households reported in Msunduzi and 67% of households reported in Johannesburg. These food transfers are clearly a significant source of food for the urban poor.

2.9 Household food waste

Household waste falls under the municipal wastes category, whose collection and management is the responsibility of local municipalities. Municipal solid waste consists of all types of solid waste generated by residential, commercial and institutional establishments. The municipal solid waste stream constitutes a large percentage of the total waste generated in urban areas. It typically consists of plastic, paper and cardboard, glass, metal, organic waste and other non-hazardous wastes such as rubber and leather, among others (Kaza *et al*., 2018). Globally, food waste is typically categorised under the organic wastes' category (Kaza *et al*., 2018). Under schedule 3, 'defined wastes', of the South African Waste Act (59 of 2008) (RSA, 2008), food waste is categorised as general, domestic wastes. In the schedule, general waste is defined as non-hazardous waste that does not pose an immediate hazard or threat to health or to the environment. It includes domestic waste, building and demolition waste, business waste, and inert waste (Republic of South Africa, 2008). Domestic waste is defined as waste that originates from premises that are used wholly or mainly for residential, educational, health care, sport or recreation purposes. It includes garden and park wastes, municipal waste and food waste (Republic of South Africa, 2008).

The waste quantities for each stream in the municipal waste stream varies. Globally, food and green waste makes up the largest proportion of the municipal waste stream at 44% of the total waste generated; paper and cardboard follows at 17%, other non-hazardous wastes follow at 14%, plastics at 12%, glass at 5%, metals at 4%, and lastly rubber, leather and wood at 2% each (Figure 11).

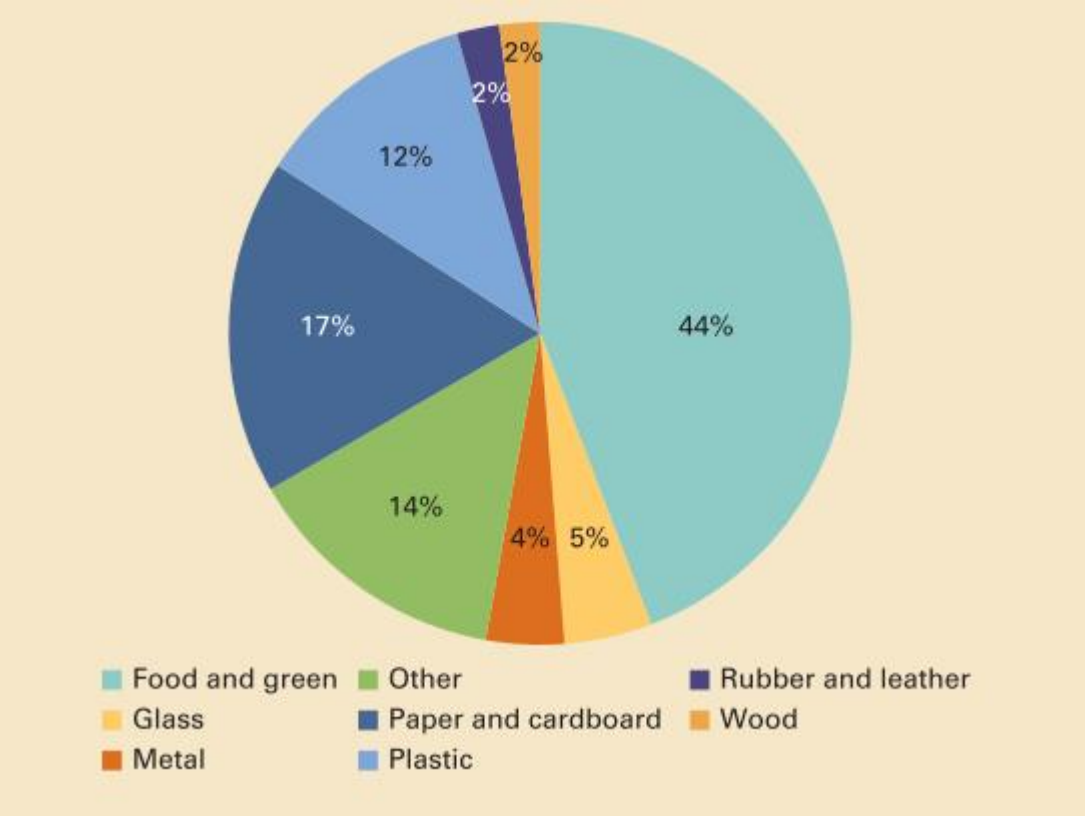

Figure 11: Global municipal waste composition

Source: Kaza *et al*. (2018)

The South African municipal waste composition is less detailed in comparison to global municipal waste composition. Of the four waste streams included, non-recyclables make up 40% of the total waste generated, main recyclables make up 25%, builders' rubble makes up 20% and organics make up 15% of the total municipal waste generated (Figure 12). From this composition, food waste is categorised under the organics waste stream, together with garden waste and wood waste (DEA, 2012).

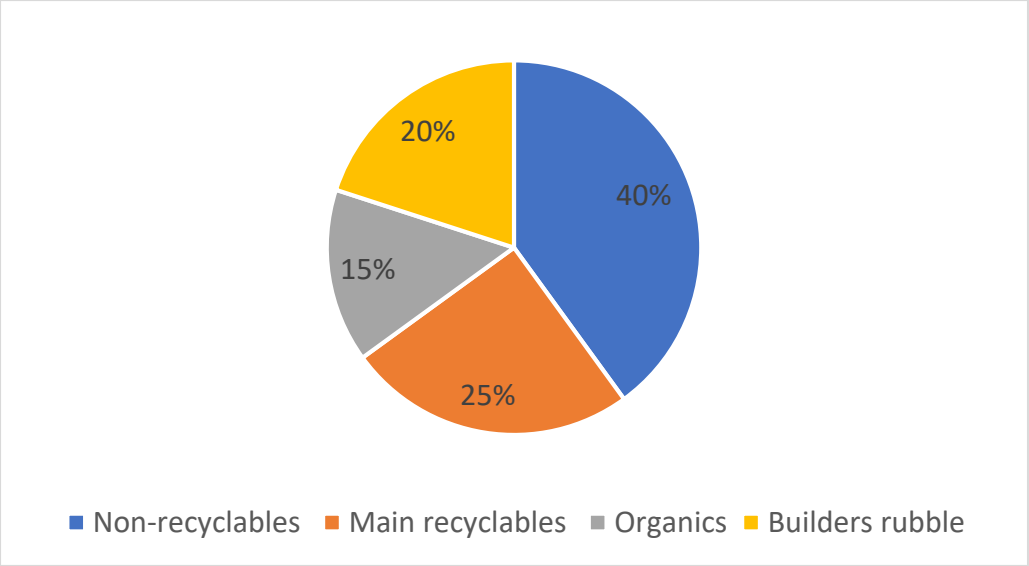

Figure 12: South Africa municipal waste composition

Source: Adapted from DEA (2012)

At the provincial level, the Western Cape generates an estimated 7.7 million tonnes of waste annually (Green Cape, 2018). The organics waste stream contributes the largest proportion to the total waste generated in the province. This waste stream consists of agriculture residues, municipal organics, settled sewage sludge, volatile animal waste and forestry residues. Altogether, the organics waste stream contributes 41% to the total waste generated in Western Cape (Green Cape, 2018), construction/demolition waste contributes 22%, commercial and industrial waste 11%, non-recyclables 9%, metals 7%, paper 4%, plastics 3%, glass 2% and e-waste contributes 1% to the total waste generated (Figure 13).

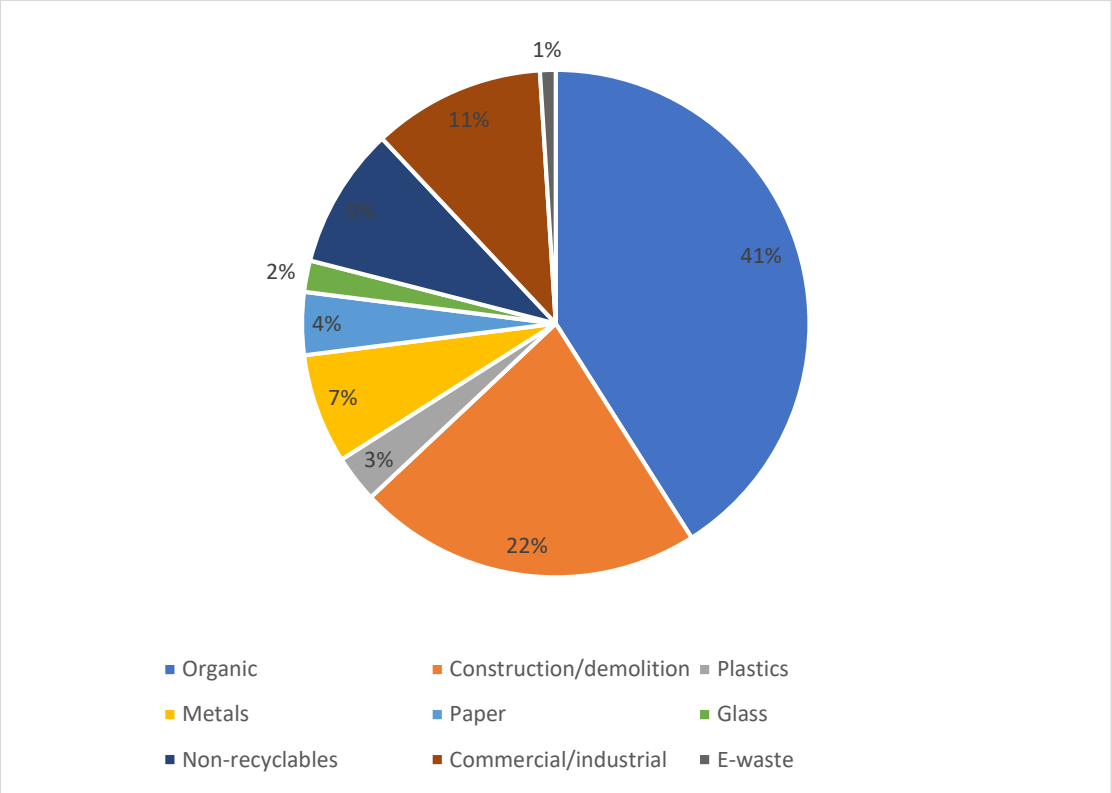

Figure 13: Western Cape municipal waste composition
Source: Adapted from Green Cape (2018)

Cape Town accounts for 48% of the total waste generated in Western Cape Province, which translates into 3.7 million tonnes of waste. Of this 3.7 million, municipal solid waste contributes 2.8 million tonnes (75%) to the total waste generated in the municipality (Green Cape, 2018). It is not known what proportion of this waste is food waste. For most developing countries, food waste is an under-researched area. Even more under-researched is food waste generation at the household level (Nahman *et al.*, 2012).

It is important to quantify and characterise waste within the food waste stream. The risks posed by accumulating quantities of food waste in landfills, such as leachate seepage and methane emissions, necessitate the need to quantify and characterise waste. Leachate from decomposing food waste may seep into underground water systems, posing a risk of contamination, while methane gas from decomposing food waste contributes to greenhouse gas emissions. Cape Town's main waste disposal is landfilling. Two of its general waste landfills, Bellville South and Coastal Park, are situated directly above the recharge zones of the Cape flats aquifer system (Simone &

Pieterse, 2017). The two were constructed using pre-1990 landfill designs that did not have provisions for a leachate detection layer (Simone & Pieterse, 2017). The risk is evident and as such, there is need to divert food waste from landfills. As part of the strategy, the city needs to quantify and characterise waste within the food waste stream.

Globally, 1.3 billion tonnes of the food produced for human consumption goes to waste (Gustavsson *et al.*, 2011). This represents a third of total mass production and quarter of total calorie production (FAO, 2014a). South Africa produces about 31 million tonnes of food yearly (WWF, 2017). Approximately 10 million tonnes, representing a third of total production, goes to waste (WWF, 2017).

South Africa's national food production for the period 2007-2009 stood at an average of 28,785 thousand tonnes per year (Oelofse & Nahman, 2013). During the same period, 9040.9 thousand tonnes of food waste were produced, representing 31% of the total food production (Table 1). Food waste at the consumption stage of the supply chain stood at 372.7 thousand tonnes (Table 1). Although the consumption stage has the least occurrence of food waste production, it is still an important stage to study as it offers several opportunities. Addressing food waste at this stage has the potential to save three times the energy that would be needed to eradicate food waste at the post-harvest stage (WWF, 2017), lower incidences of food insecurity in urban households (Godfray *et al.*, 2010; Nahman *et al.*, 2012; Quested *et al.*, 2013) and reduce the amount of methane gas, carbon dioxide and leachate that is produced from decomposing food waste at landfills (WWF, 2017). Learning from developed countries where food waste occurrence is largest at the consumption stage of the food supply chain could also help developing countries such as South Africa to have the advantage of the leapfrog effect which enables developing countries to learn and potentially avoid the impacts of urbanization and economic growth. Countries do this by learning from the experiences of developed countries with the aim of shortening their learning curve. A rapidly urbanising and increasingly affluent South African population can get ahead of the curve and put strategies in place to tackle household food waste as an inevitable outcome of development.

Table 1: Calculated average per annum food waste generation figures for South Africa (2007-2009)

Commodity group	Production 2007–2009 (average) (1000 tonnes)	Waste (1000 Tonnes)						
		Agricultural production	Post- harvest handling and storage	Processing and packaging	Distribution	Pre-consumer waste	Consumption	Total waste per commodity group
Cereals	13,154	789.3	989	398	220	2396	108	2504
Roots and tubers	2017	282.4	312	213	60	869	23	892
Oil seeds and pulses	453	54.4	32	29	7	122	3	126
Fruits and vegetables	8230	823.0	667	1685	859	4034	210	4244
Meat	1587	238.1	9	67	89	404	24	427
Fish and seafood	224	12.8	13	18	27	71	3	74
Milk	3119	187.1	323	3	261	773	2	775
Total per stage of the food supply chain	**28,785**	**2387.0**	**2344.6**	**2413.4**	**1523.0**	**8668.2**	**372.7**	**9040.9**

Source: Oelofse & Nahman (2013: 84)

Household waste is found within the consumption stage of the food supply chain. As mentioned above, in South Africa, the consumption stage contributed a total of 372.7 thousand tonnes of waste to the total average food waste generated for the period 2007-2009 (Table 1). Of this 372.7 thousand tonnes, the fruits and vegetables contributed 210 thousand tonnes (56.3%), cereals food group contributed 108 thousand tonnes (28.95%), meat contributed 24 thousand tonnes (6.43%), roots and tubers contributed 23 thousand tonnes (6.16%), oil seeds and pulses contributed 3 thousand tonnes (0.8%), fish and seafood contributed 3 thousand tonnes (0.8%), and milk contributed 2 thousand tonnes (0.53%) to the total waste produced at the consumption stage (Figure 14). Fruits, vegetables and cereals account for the food groups with the largest occurrence of food waste at the consumption stage, with percentage proportions of 56.3% and 28.95% respectively. More than 10 years old, these food waste figures represent the most recent estimates of food waste quantities for South Africa (WWF, 2017). Due to a lack of reported food waste data (Oelofse & Nahman, 2013), quantifying food waste in South Africa remains a challenge.

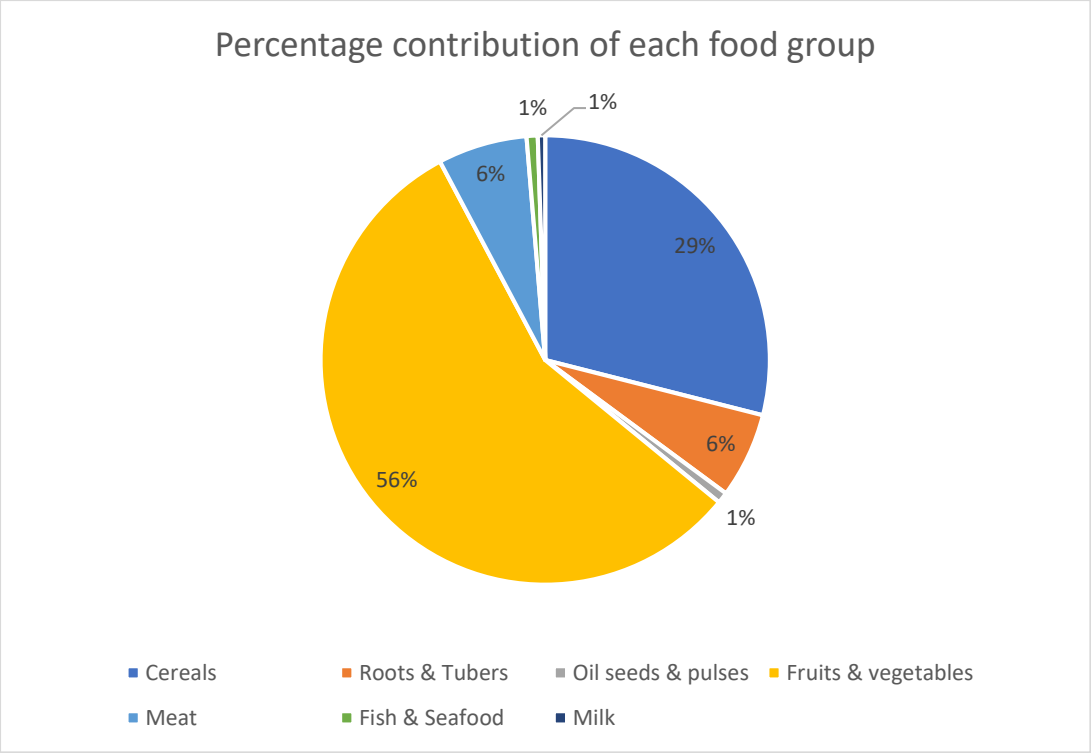

Figure 14: Percentage contribution of each food group to total average food waste produced at consumption stage (2007-2009)
Source: Adapted from Oelofse & Nahman (2013)

2.9.1 Classifying household food waste

Waste is a natural by-product of any production system. Food waste is a product of food supply chain activities; among them, production, storage, distribution, retailing and consumption. There is no globally agreed upon definition of food waste (FAO, 2014a). The term carries different connotations and context plays a key role in the meaning in which the term is ascribed. The meaning may be influenced by the by-product's perceived economic value, and the cultural and religious values and beliefs attached to foods.

There are two main approaches to defining and understanding food waste. The waste approach and the food approach (FAO, 2014a). The waste-focused approach is concerned with the value of waste in general. That is, what value can be derived from waste and in turn how can waste outputs be used to create new value through the activities of recycling, composting, nutrient recovery, energy

production, direct use as feed. The main consideration is "what happens with the waste" that we produce. This approach often reflects environmental impact and waste management concerns whose focus is on reducing the negative impacts of waste production and reducing the costs of treatment and management of wastes. The food-focused approach considers "food and parts of food that are edible and intended for human consumption, but lost or discarded at some point in the food chain" (FAO, 2014a: 21). This approach introduces the different perspectives of "edibility". In the cultural perspective, edible food parts are a function of cultural food practices that determine whether a part of a food is to be eaten or not whether the food is eaten by other people of another culture or not. The effect of this is that parts of food that are originally considered "not edible" will not be accounted as lost or wasted. In the food safety perspective, "edibility" is considered as a function of safety such that food and food parts that were originally edible become non-edible for food-safety reasons such as a lapsed expiry date, or food that has been kept out of storage or exposed for long and may be potentially contaminated. The food-focused approach reflects the challenges and complexities of the food system with a focus on how to improve the food chain (FAO, 2014a).

There is no international consensus on the definition of food waste (FAO, 2014a). The lack of an official definition affects efforts made towards the achievement of SDG 12.3, 'to halve per capita global food waste at the retail and consumer levels by 2030 and by extension SDG 2, 'zero hunger'(Campbell *et al*., 2017; WWF, 2017). As such, there have been several attempts to define food waste by different actors in the food system. FAO (2014b: 4) defines food waste as *the removal from the food supply chain (FSC) of food which is fit for consumption, by choice, or has been left to spoil or expire as a result of negligence by the actor – predominantly but not exclusively the final consumer at household level.* The committee on world food security high level panel of experts (HLPE) defines food waste as "a decrease, at all stages of the food chain from harvest to consumption, in mass, of food that was originally intended for human consumption, regardless of the cause" (FAO, 2014a). This covers edible material that is intentionally fed to animals or is a by-product of food processing diverted away from the human food chain (Stuart, 2009 in Effie *et al*., 2014). Another term that attempts to define food waste is food quality loss or waste (FQLW). This term refers to the decrease of a food quality attribute, such as nutrition, linked to the degradation of the product, at all stages of the food supply chain from production to consumption (FAO, 2014a). FQLW broadens the value of food waste and allows for a finer characterisation of food

waste. Figure 15 presents a diagrammatic representation of the definition of food waste along each stage of the food supply chain from production to final consumption.

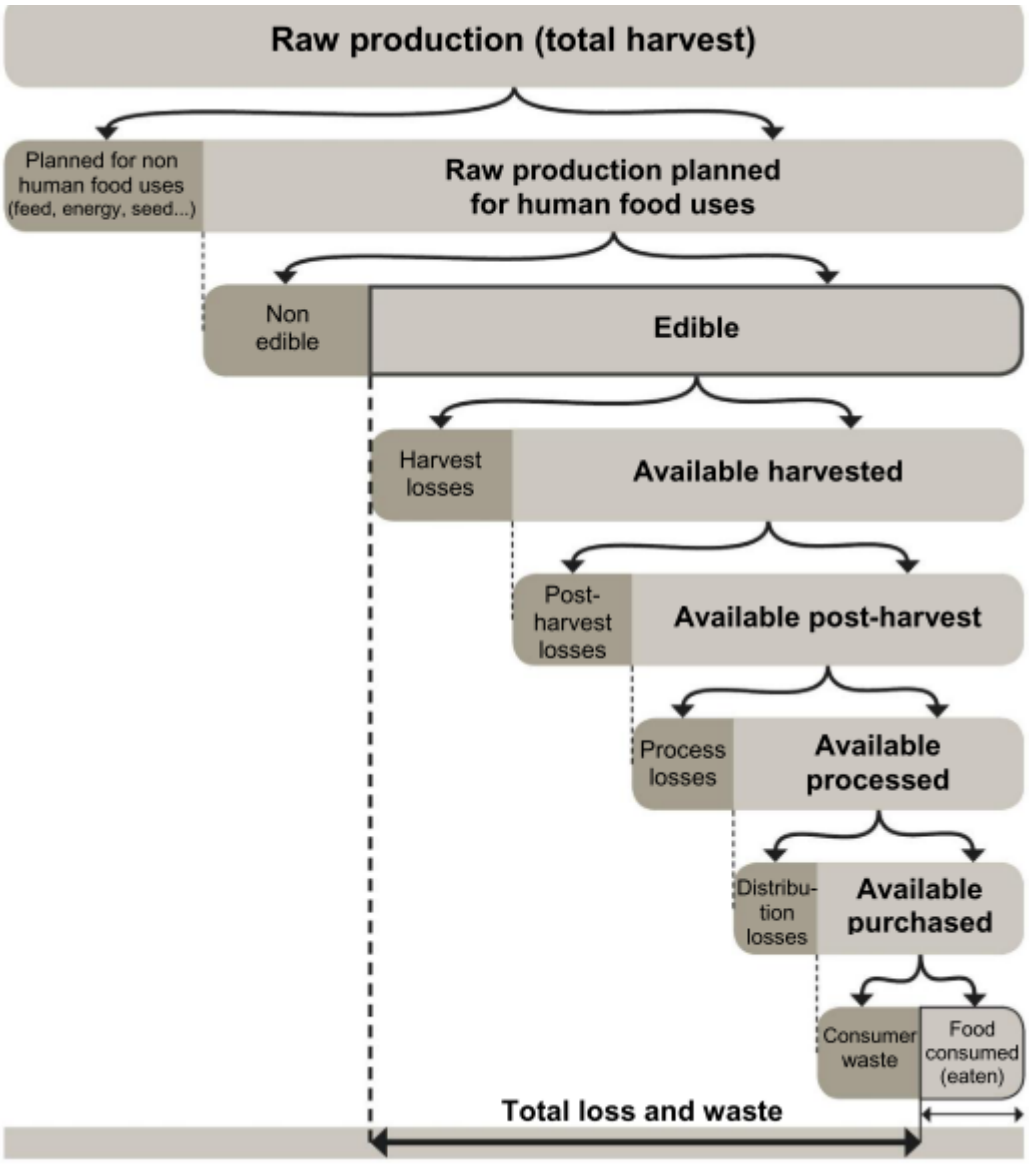

Figure 15: Diagrammatic representation of the definition of food losses and waste along the food supply chain
Source: FAO (2014a)

In summary it can be concluded that food waste is characterised according to its intended use, where it occurs along the food supply chain, and the cause of its occurrence, which ultimately lead to the decrease of a food quality attribute.

When losses in food quality are considered, food waste can be categorised into avoidable, possibly avoidable and unavoidable food waste (Quested *et al.*, 2011). Avoidable food waste is described as food thrown away because it is no longer wanted or has been allowed to go past its 'best before' date (Quested *et al.*, 2011). The bulk of avoidable food waste is composed of food that was, at some point prior to disposal, edible even though a part of it is not edible at the time of disposal. This category often includes foods or food parts that are considered edible by a considerable number of people. Unavoidable food waste is described as waste from food that is not, and has not been, edible under normal circumstances (Quested *et al.*, 2011). This includes parts of foods such as vegetable stems, fruit peels, meat bones, and seeds of fruits and vegetables.

The terms 'avoidable' and 'unavoidable' imply responsibility. It implies agency by emphasising the active role of an actor and/or the household in food waste production. Making the distinction between what is avoidable and unavoidable is an arguably subjective exercise. What is considered edible or inedible depends on several factors, such as cultural values, religious beliefs and social norms. That notwithstanding, such distinctions can prove useful in informing interventions for food waste reduction and to highlight the potential for management.

2.10 Summary

The literature review begins with the setting of a scene. It begins by discussing the general challenges affecting urban areas revolving around resource consumption and distribution. A variety of perspectives are used in viewing and addressing these challenges. The urban metabolism concept is selected as the lens with which urban resource consumption and utilisation can be viewed as well as managed. It is argued that for cities to successfully transition into sustainability, they must adopt a circular urban metabolism of resources which promotes the re-introduction of wastes into the input flows of a city to reduce the demand for virgin resources. Zeroing in on the focus of this study, the concept of urban food metabolism is introduced and discussed at the household level. Using the material flow analysis of household food flows conceptualised by (Leray *et al.*, 2016), the study of food consumption at the household level using an urban metabolism lens is introduced. To delve into assessing household food flows, using Leray's (2016) framework, the literature review discusses household provisioning, highlighting the different types of household food sources and food types consumed. Within the same discussion, food security is

briefly discussed to contextualise the study of household food consumption. To close the consumption loop, the literature review concludes with a discussion on food waste as a significant household food flow. To assess household food waste flows, a discussion on food waste generation, classification and assessment follows.

The key finding from this literature review is that viewing food as an urban resource, like energy or water, is useful in the management of urban food consumption and can potentially bolster efforts towards urban food security. The urban metabolism assessment framework can be used by cities to quantify food and food waste flows as part of their food security and waste management strategy respectively.

The next chapter looks at the process of preparing and conducting a household food flows assessment.

Chapter 3 – Research Design and Methodology

3.1 Introduction

This chapter provides a detailed description of the study area and a comprehensive breakdown of how data were collected, processed and analysed. The methodology applied is discussed and a detailed description of how the selected quantitative and qualitative methods were applied to accomplish the objectives of the study is elaborated on.

3.2 Research design

The study made use of a cross-sectional survey research design as outlined by Bryman *et al.* (2014). A survey is a research method used for collecting data from a pre-defined group of respondents, using questionnaires or structured interviews, to gain information on an area of interest (Bryman *et al.*, 2014).

Depending on the time period under study, surveys can either be cross-sectional or longitudinal. A cross-sectional survey is a type of survey in which data is collected across a large population at a single point in time, mainly to be used to study the relationship between two or more variables at the time that data was collected (Bryman *et al.*, 2014). A longitudinal survey, on the other hand, is one in which the data collected covers a duration from one point in time to another, such that the data can be used to study trends (Bryman *et al.*, 2014).

A cross-sectional survey design was suitable for this study for various reasons. Cape Town's population mix represents the general population mix of the Western Cape Province. The high population and variation in the population characteristics of households, such as income levels and access to basic amenities, required a research design that allowed the researcher to gain insights into different income and demographic groups. Surveys were designed in such a manner that the same information is collected from every respondent. This ensured that the information obtained from the target population was standardised.

The chosen design also allowed for collection of data from sections of the population that would have otherwise been left out due to accessibility challenges. The major benefit of this design was that it allowed the researchers to capture data from people of diverse backgrounds.

The next section is a brief overview of the geographical and socio-economic characteristics of Cape Town, as relevant to the study.

3.2.1 Study area: Cape Town

Cape Town is a city in the Western Cape province in South Africa, located $34^{0}0$'S and $18^{0}30$'E, and covering a total area of 2,461 km^2 (City of Cape Town, 2012) (Figure 16). Cape Town has 190 suburbs (Muringathuparambil *et al*., 2017). The metropolitan municipality known as the City of Cape Town is responsible for the governance and administration of the suburbs.

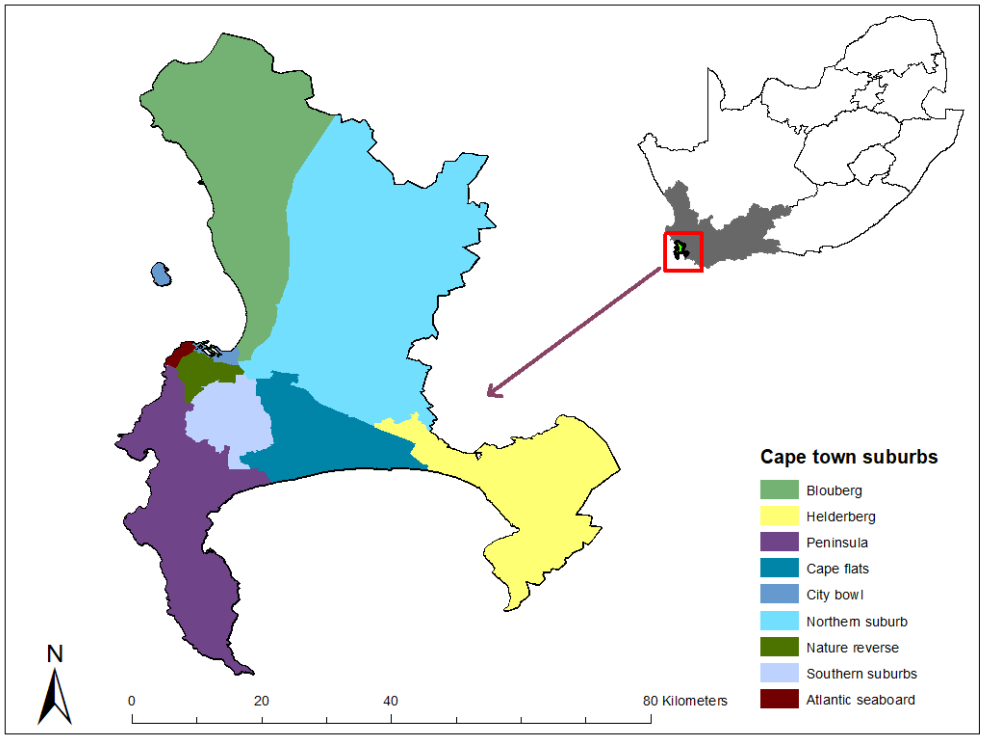

Figure 16: Map of the study area, Cape Town, showing the nine suburb regions

Cape Town has a total population of 4,004,793 (City of Cape Town, 2017). The area has a total of 1,264,849 households, with an average household size of 3.5 persons (City of Cape Town, 2017). It is estimated that 35.7% of these households live below the poverty line, earning a total household monthly income of less than R3,500 (City of Cape Town, 2012). The population of Cape Town

is made up of four major population groups; the largest group is the Black Africans, followed by Coloureds, Whites and Asians. They occupy 42.6%, 39.9%, 16.5% and 1.1% of the total Cape Town population, respectively (City of Cape Town, 2017). The gender distribution of the city is almost equal, with the male population making up 49.2% of the total population and the female population making up 50.8% of the total population (City of Cape Town, 2017).

Cape Town has a total of 41,126.20 hectares of crop land (Elsenburg, 2019). Among the agricultural areas in the municipality, there is Philippi, Constantia, Helderberg, Macassar and Faure, Bottelary and Blackheath, Tygerberg Hills, Botfontein, Mamre, Dassenberg, Olyfantsfontein, and Philadelphia (City of Cape Town, 2008). In Philippi, the Philippi Horticultural Area (PHA) supports subsistence farming, community farming projects, as well as commercial farming activities. Local food production from this area contributes significantly to the city's fresh food supply, mainly acting as an important support system to lower income populations in and around the area. The main food crops grown in the PHA are cabbages, lettuce, cauliflower, broccoli, spinach, carrots, onions and potatoes (Battersby-Lennard & Haysom, 2012). Other food crops grown are listed below in Table 2.

Table 2: General horticultural products grown in the Philippi Horticultural Area (PHA)

Cabbage	Celery	Fennel	Maize	Broccoli leaves
Potatoes	Broccoli	Cauliflower	Peas	Kohlrabi
Carrots	Swiss chard	Beans	Onions	Artichokes
Lettuce (variety)	Spinach	Cucumbers	Covo	Pac choi
Beetroot	Parsley	Celery	Rape	Tat soi
Leeks	Coriander	Eggplants	Kale	Tomatoes
Spring onions	Basil	Rocket	Green Peppers	Rhubarb
Radishes	Squashes (variety)	Parsley	Patty pans	Strawberries
Turnip	Watermelons	Coriander/Danja	Baby Marrows	Chilli

Source: Battersby-Lennard & Haysom (2012)

Cape Town was an ideal case study for various reasons. First, the municipality and the Western Cape Province has available and accessible data that was useful in comparing survey results with secondary data. Second, Cape Town is a major port of entry for goods and people, making it an ideal example of the open nature of cities and the challenges this feature brings in accounting for urban flows. Lastly, there exists several studies on the Cape Town food system, ranging from urban

food security (Battersby, 2011; Battersby *et al.*, 2014; Haysom *et al.*, 2017) to urban food flows (Frayne, 2010; Kroll, 2016). These studies provided a greater understanding of the urban food system of Cape Town. This insight formed the basis for an urban food metabolism study as a potentially valuable alternative framework for conceptualising urban food system challenges.

3.3 Research methodology

To accomplish the research objectives outlined in Chapter One, the study took on a mixed methods approach in which both quantitative and qualitative data collection methods were employed. This approach was chosen primarily to enable the contextualisation of the quantitative data collected. Both closed and open-ended questionnaires were used to collect quantitative and qualitative data. As a central part of the methodology, the study undertook a comprehensive literature review to frame the study within existing literature and to provide a conceptual framework for the study.

3.4 Research methods and data requirements

To achieve the research objectives, a comprehensive literature review was conducted. This helped understand the context of the study. Secondary sources such as published books, peer reviewed journal articles, online published articles, doctoral and master's theses, official reports, conference proceedings, web pages, and newspaper articles were used.

Primary sources including unofficial conversations with industry professionals, experts and consultants were used to inform the literature review process. These were especially useful in facilitating the identification of research gaps, developing the research interest and identifying a body of literature relevant to the society within the greater context of Cape Town.

An online survey and a food diary were used after a series of iterations between literature review and feedback received during data collection. A summary of each data collection and analysis method is discussed in the following section.

3.4.1 Research objective 1 and 2: To determine the food sources accessed and food types consumed by households

To achieve these objectives, three methods were used: literature review, an online survey and a food diary. These explored the different sources of food accessed by households and the types of foods that they obtain from different sources in the process of food provisioning. The literature was reviewed using themes, the survey data was analysed through multivariate analysis, and the diary data was analysed using coding and network analysis. The following sections expound on these processes.

3.4.1.1 Data collection method 1: Literature review

The literature review, conducted based on Objective 1, had three main purposes:

1. to identify the types of foods that are consumed by households in South Africa;
2. to identify a framework for tracking food types; and
3. to determine which food sources existed within and adjacent to the Cape Town municipal area.

After a review of food consumption surveys, the household dietary diversity score (HDDS) was selected for the purposes of this study. The HDDS was used as an indicator of the types of foods that households consume. Dietary diversity is defined as "the number of unique foods consumed over a given period" (Hoddinott & Yisehac, 2002: ii). "It is a qualitative measure of food consumption that reflects household access to a variety of foods and is also a proxy for nutrient adequacy of the diet of individuals" (FAO, 2010: 5). The household dietary diversity score is a useful tool that is used to gather information on the different number of foods or food groups consumed by households over a given period. The assessment involves a count of food groups that a household or an individual has consumed over the past 24 hours from the time of the assessment. A dietary diversity score can also be used as an indicator of the economic ability of a household to access a variety of foods. The higher the socio-economic status of a household, the greater the variety of foods that they are likely to consume (Hoddinott & Yisehac, 2002).

The study tracked selected foods as they passed through the household from sourcing to disposal. Using the FAO (2010) household dietary diversity score food groups, a total of eight food groups were summarised from an initial 16 food groups. The main reason for this was that the FAO food groups were nutrition-based and not food-based. Being a dietary diversity indicator, the FAO food

groups were determined using a nutritional criterion. For example, they make a distinction between white roots and tubers and vitamin A rich vegetables and tubers, dark green leafy vegetables and other vegetables, vitamin A rich fruits and other fruits, and organ meats and flesh meats. This posed two challenges. First, a respondent is likely not to distinguish between the different foods based on a nutritional criterion, therefore affecting the correctness of the data. The original categories also posed a risk of respondent fatigue. To complete the survey, a respondent would have to educate themselves on the nutritional content of the foods that they normally eat. This was highly likely to lower the survey response rate. To minimise this risk, the original 16 food groups were summarised into eight food groups and re-named using typical descriptions with which respondents could easily identify. For example, cereals, legumes, nuts and seeds, oil and fats were merged into cereals and grains, vitamin A rich fruits and other fruits were merged into fruits, organ meat and flesh meat were merged into meat and poultry.

The second challenge was that the food groups given by FAO were too many. To make the survey easier and faster to complete, it was necessary to summarise the groups into a smaller number. Table 3 indicates the original 16 food groups given by FAO that were summarised into the eight food groups used for the survey and food diary.

Table 3: Food group categories used for survey and diary

Household Dietary Diversity Score (HDDS) food groups (FAO, 2010)	**Food groups used for household survey**
Cereals Legumes, nuts & seeds Oils & fats	Cereals & grains
White roots & tubers	Roots & tubers
Vitamin A rich vegetables & tubers Dark green leafy vegetables Other vegetables	Vegetables

Vitamin A rich fruits Other fruits	Fruits
Organ meat Flesh meats	Meat & poultry
Eggs Milk & milk products	Eggs & dairy products
Fish & Seafood	Fish & seafood
Sweets Spices, condiments, beverages	Baked goods

Adapted from FAO (2010)

The foods to be included were selected on the basis that they represented:

1. Solid foods and semi-solid foods such as fresh cream.
2. Foods with a recognised nutritional value. That is, foods containing micro and macro nutrients necessary for a healthy life. Sweets and other sugar confections were therefore omitted, while flour confections and other baked goods were included and categorised into the food group 'baked goods,' to make it easier for participants to categorise these foods.

3.4.1.2 Data collection Method 2: Household food consumption survey

Online surveys are web-based, self-completed questionnaires in which data is collected at a single point in time from a selected sample used to represent a larger population. The structure usually comprises of closed-ended questions that require respondents to select an answer from a list of possible pre-determined responses. The traditional mode of administration for questionnaire surveys is paper, usually sent by mail to a prospective respondent. With time and advancements in survey methods, newer modes of dissemination have been developed, such as online, web-based methods. This study made use of the online dissemination method.

The survey facilitated a general understanding of household food provisioning from a variety of households. Nonetheless, some general characteristics of surveys that are both beneficial and potentially limiting to a household study were considered. Surveys are cheap and quick to

administer, especially when the target population is geographically dispersed. The respondent is also able to complete the questionnaire at their convenience and in private, eliminating the 'observer effect'. While this is true, online surveys give limited control over respondents. Though there is more room for respondents to be honest and less biased due to a lack of supervision, they are more likely to not complete questions or skip some, posing a risk of missing and incomplete data, respectively.

To minimise the risks, the survey questions were designed in a way that a respondent could only move on to the next question if they had completed the previous one. Additionally, the questions were short and clear to reduce respondent fatigue. Most responses required either ticking or checking a box, with a lesser number requiring a brief narration.

Survey questionnaire design and dissemination

The survey captured a variety of demographic and socio-economic variables, paying attention to total monthly household income, household size, highest education level in the household, and type of dwelling (Appendix A).

The questionnaire structure was divided into four sections:

1. a brief introductory note that introduced the study to respondents;
2. a demographic section containing biographic and socio-economic characteristics of respondents;
3. the main body of the food survey section, organised into three headings for ease of navigation; and
4. a concluding note that invited respondents to participate in further research.

The survey was written in English and then translated into the other two main languages of the Western Cape, Afrikaans and IsiXhosa, allowing respondents a choice among the three. This was done to ensure that language was not a deterrent to participation.

In a further effort to eliminate language-related barriers to participation, specifically in the lower income suburbs of Cape Town, enumerators were recruited to assist participants with literacy challenges in answering the questionnaire. This proved useful as it was a challenge translating some English words into Afrikaans and IsiXhosa, as some words either did not exist or carried a

different meaning. The enumerators were able to give relevant examples and translations of such words, allowing the researcher to capture information from a population that would have otherwise been excluded due to the language and literacy barriers.

The surveys were undertaken between August 2019 and September 2019. The food survey was part of a larger survey studying the urban resource consumption of Cape Town. A total of 510 respondents attempted the food survey section from a grand total of 676 respondents who took part in the three-part survey covering energy consumption, water consumption and food consumption (Table 4).

Table 4: Summary of the survey sample characteristics

Total number of households surveyed	**676**	
Total number of households that attempted the food survey	**510**	
Income group (total monthly household income)	**Total number of households in income group**	
R 0	9	
R 1 - R 1 600	25	
R 1 601 - R 3 200	41	
R 3 201 - R 6 400	63	
R 6 401 - R 12 800	63	
R 12 801 - R 25 600	96	
R 25 601 - R 51 200	124	
R 51 201 - R 102 400	59	
R 102 401 - R 204 800	21	
More than R 204 801	9	
Sample Size (N)	**510**	
	Mean	**Median**
Household income	R34,142.53	R19,201
Household size	3.56	3

Source: Author

3.4.1.3 Data collection method 3: Household food diary

A diary is a research tool that requires respondents to make regular records of their daily activities and experiences (Wiseman *et al*., 2005). They are used in three contexts: contexts in which particular activities or events are expected to change over time; contexts where contextual information such as the circumstances leading up to or following an event are deemed important; and in contexts where respondents are likely to experience difficulties recalling past experiences (Wiseman *et al.*, 2005).

A diary is a self-monitoring technique that allows researchers to study individual, and potentially household, behaviour (Reid *et al*., 2011), where the researcher would ordinarily not have access to or not be able to observe daily life (Thiele *et al*., 2002). Diaries have mainly been used in psychology and health and nutrition studies where they have been used to study nutrition and health-related behaviour (Reid *et al.*, 2011; Thiele *et al.*, 2002). To date, diaries have been applied to a wide range of research topics such as food consumption, where food diaries have been used to study household food consumption and expenditure.

Diaries can be applied in a wide range of research designs, from ethnographic studies and single case studies to experimental designs, among others (Thiele *et al.*, 2002). This makes them accessible and adaptable to varying research objectives, such as the study of food perceptions and food waste behaviour, as in the case of this research.

Diaries are among the data collection tools ideal for reflexive research methods (Reid *et al.*, 2011), suitable for enquiries into behaviour such as this study's enquiry into perceptions that influence food consumption. Though seldom highlighted, diaries can prove useful as intervention tools (Thiele *et al.*, 2002). During daily logins, the respondents were required to contemplate and reflect on their behaviour and motivations for their daily actions. This attribute of diaries is what Reid *et al.* (2011) refer to as the 'the reflexive diary approach', where diaries can act as tools to drive behavioural change at the household level by encouraging members to contemplate their motivations, actions and behaviours, and their possible subsequent effects.

Diaries have their limitations as well as benefits. That notwithstanding, the diary is an objective (Thiele *et al.*, 2002) data collection technique that allows for the observation of behaviour over a period, thus enabling us to create better conclusions about lived life. They can help researchers

place behaviour within existing contexts and realities of everyday life, allowing us to have a more wholesome and deeper understanding of the complexities of individual and household behaviour.

A food diary was used in this study as a complementary tool to the online survey. Its main purpose was to capture detailed quantitative and qualitative data that the online survey could not.

Diary questionnaire design

For the accomplishment of Objective 1, the food diary was used to capture both quantitative and qualitative data on food types and food sources; that is, what the households consumed and from where they sourced the foods. Additionally, the diary had a section where respondents were asked to identify the reasons for their food sourcing and eating behaviour. This was accomplished by having participants narrate their experiences with food and food-related household practices that influenced food choices and food waste generation.

The data collection period was 30 days. The assumption made was that increasing the duration to 30 days from the prescribed minimum duration of at least one week (Richter & Bokelmann, 2017) would allow for an in-depth observation of household food consumption dynamics. Although increasing the duration posed a risk of respondent fatigue, there was more potential in the choice to extend the duration. The longer the observation period, the less likely the participants were to succumb to 'the observer effect'. The assumption made was that the participants would get to a point where they would be less focused on appearing a certain way and thus increase the trueness of their responses.

The diary was disseminated in the month of March 2019 and participating households were asked to begin filling the diary immediately after receiving the diary. Due to the amount of work and detail required for such a study, the households that participated were purposively selected.

Purposive sampling is a non-random sampling technique. It is used in qualitative research whereby the researcher deliberately selects a participant for a study due to specific attributes (Etikan *et al*., 2016). The researcher makes a conscious judgement of what information is required and selects participants who are available, able and willing to take part in the study. Participants selected should have prior experience (Etikan *et al.*, 2016) with the question under investigation such that the information given is based on a lived experience or knowledge of the issue. This prior

knowledge allows participants to communicate experiences in an articulate, expressive and reflective manner.

To select which households would participate, the researcher, initiated conversations about food and food waste with friends and colleagues. From these informal conversations, the researcher was able to identify potential participants who would later recommend other potentially willing participants. Additionally, the help of the enumerators who had assisted with the online surveys was enlisted to help in identifying and recruiting potential participants, specifically in the lower income suburbs of Cape Town. From this recruitment process, 10 households were recruited. Five households dropped out of the study for various reasons including: i) lack of time to fill the diary consistently every day; ii) unexpected travel commitments iii); and demanding work commitments that limited the amount of time allocated for the diary. The other five respondents completed the diaries for varied durations. Table 5 summarises the characteristics of the final sample.

Table 5: Household food diary sample characteristics

Household Characteristic	Number of diary days completed	Income bracket	Household size	Household composition
Household 1	30 days	R25,601 - R51,200	2	Age bracket 25-64: 1 male & 1 female
Household 2	15 days	R1 - R1600	1	Age bracket 25-64: 1 male
Household 3	12 days	R12,801 - R25,600	2	Age bracket 25-64: 2 females
Household 4	6 days	R51,201 - R102,400	4	Age bracket 25-64: 1 male & 1 female Age bracket 5-14: 2 females
Household 5	10 days	R51,201 - R102,400	3	Age bracket 25-64: 1 male & 1 female Age bracket 0-4: 1 female

Source: Author

Group meetings were held with the participants to discuss the study and the diary as a method. The meetings were also necessary to ensure that participants had similar understanding of details in the diary. The meetings were held on different days according to participants' schedules. Some of the insights learned from these discussions were used to improve the diary method.

In addition to meetings, detailed instructions and information were provided, and a short video was shared that explained how to take weight measurements and demonstrated how to record daily information in the diary.

The diary was disseminated electronically, although there was an option for a hard copy version. The electronic version was shared through google drive's google docs application for participants with easy access to google mail. Participants who did not have access to google mail were provided with a word document version that was emailed to them.

The reason for opting for a google drive document was based on google drive's functionalities that allow a document creator to share documents that can be edited in real time by participants with access to the document. Additionally, it allows the creator of the document to determine what others can do with the document. For example, the creator can give a participant rights to view and edit the document or rights to only view the document. Lastly google drive allows all participants with access to track all changes made on a document which ensures accountability. Google drive allowed the researcher to monitor the participants' activities in order to detect any errors and provide support during the process. Given the extended duration of the study, it was necessary to keep in constant communication with the participants to ensure that they were completing the diary and doing so correctly. Through weekly check-ins with participants, challenges encountered were occasionally addressed, further improving the diary process.

Data collected for objective 1

Using the online survey and food diary, a variety of data were collected and collated to understand food provisioning at the household level. Table 6 provides an outline summary of data collected for Objective 1 using both data collection tools.

Table 6: An outline summary of data collected for Objectives 1 and 2

Quantitative Data		
	Food group	**Food source**
Online Survey	A list of food groups consumed by households	A list of food sources that household's access
	A volume measurement estimate, of the quantities of foods consumed by households	Frequency of sourcing from the different food sources
Food Diary	A list of the specific food types consumed by households	A list of the specific food sources accessed by households
	A weight measurement estimate, of the quantity of food consumed by households	Frequency of sourcing from the different food sources
Qualitative Data		
Food Diary	How households make choice selections among different foods	A description of the household's shopping routine based on the food sources that they opt for

Source: Author

3.4.2 Research objective 3: To quantify and classify food waste generated by households

To accomplish the third objective, three data collection methods were used: literature review, household food consumption survey, and a food diary.

3.4.2.1 Data collection method 1: Literature review

A literature review on food waste generation was conducted to gain an understanding of the occurrence and quantities of food waste at the household level. The review specifically looked at the various methods used to measure household food waste with a specific focus on methods that have been used in Africa. An overview on waste classification helped with the framing of household food waste at the household level in terms of the quality of waste generated.

The review informed the primary data collection methods that were used to collect data on waste generation quantities. It also informed the analysis of the quantitative data collected from the household food diary.

3.4.2.2 Data collection Method 2: Household waste generation survey

The food consumption survey captured data that were used to estimate food waste generation. Respondents were asked three questions that were used to estimate the amount of food waste generated for each household:

1. How many black waste bags do you typically produce weekly?
2. How full are the waste bags at the time of disposal typically?
3. What proportion of the waste bag does food waste, plastics, glass, paper, cardboard, metal, typically occupy?

The capacity of a waste bag was determined from an average of three standard wheelie bin sizes purchased for domestic use in South Africa; their capacities were 120 litres, 240 litres and 360 litres (Wheelie bins SA, 2019; World of plastics, 2019), giving an average size of 240 litres.

3.4.2.3 Data collection method 3: Household food diary

As part of the household food diary, there was a section that captured data on the amount of food waste generated. The food waste section of the diary captured weight measurements of foods disposed of and a description of the state and nature of the waste at the time of disposal. Table 7 is an excerpt of the table from the household diary. The household waste quantities were calculated using the information captured in the highlighted columns.

Table 7: Data collected for Objective 3 using household food diary

What did we eat today/ What did we use to make our meal today?	How much did it weigh?	What did we throw away? (E.g. which part was it?)	How much did it weigh?	Why was it thrown away? (The reason/s for disposal)	How did you dispose of it? (where did it end up?)

Source: Author

3.4.2.4 Data analysis: Research Objective 2 & 3

Research Objective 2

The quantity of food consumed by households was determined by multiplying the volume of a shopping bag with the number of shopping bags purchased by a household in a typical week. The shopping bag volume used 16.692litres, which was an average of three typical supermarket shopping bags sizes. The formula used was as follows:

Quantity of food purchased per household *= number of shopping bags purchased per week* ***x*** *volume of shopping bag*

Research Objective 3

Food waste generation quantities were captured in the household survey and the household food diary. To get the quantity of food waste generated per household per week, the level of fullness and proportion of food waste present in a bag was multiplied by the number of black waste bags produced by a household in a typical week. The formula used was as follows:

Quantity of food waste produced per household = *proportion of food waste present in black waste bag* ***x*** *filled capacity of waste bag (capacity of a full black waste bag being 240 litres)* ***x*** *number of black waste bags disposed of per week*

For the food diary, the quantity of food waste produced by a household was taken directly from the weight measurements recorded by participants. Daily weights were summed up and divided by the number of days that the diary was completed to get an average waste amount per household per day. The formula used was as follows:

Quantity of food waste produced per household **=** *total weight recorded (in grams) / number of diary days completed*

To give a more detailed analysis of the kind of food wasted by households, recorded waste was further categorised according to the nature of the waste. This categorisation was done by the researcher during data analysis. The categories were defined as follows:

1. **Avoidable food waste** is food that was edible at some point prior to disposal (e.g., a slice of bread, plate residues, etc,);
2. **Possibly avoidable food waste** is waste generated because of different consumer habits (e.g., bread crusts, apple skins, potato peels);
3. **Unavoidable food waste** is food that is not edible and derives from preparation and consumption (e.g., bones, eggshells, coffee grounds, etc.)

Source: Quested et al. (2011)

Figure 17 represents the overall analysis procedure followed to determine food waste types and quantities generated in households.

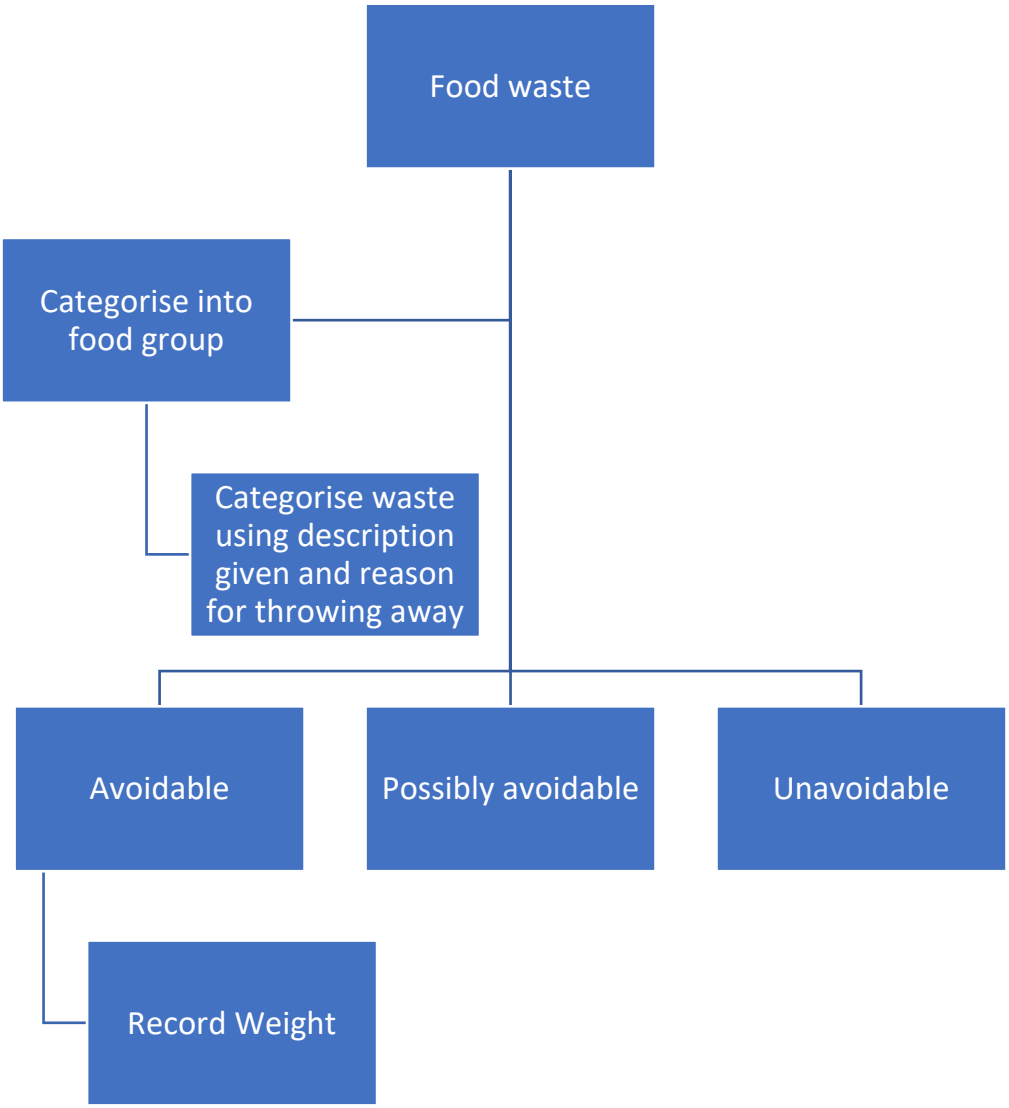

Figure 17: Data analysis procedure for determining food waste types and quantities produced in households

Source: Author

3.5 Summary

To accomplish the research objectives, a mixed methods approach was applied. Various methods of data collection including literature review, a survey and a diary, and analysis tools and techniques were used that collectively enabled a better understanding of household food consumption.

Chapter 4 – Results and Discussion

4.1 Introduction

In this chapter, the results of the study are presented and discussed. The chapter presents discussions on the types of household food types and household food sources, amounts and types of food wasted. A series of charts and tables are used to display the various results.

The results are organised according to research objective for purposes of flow. Each section begins with the presentation of results from the household survey, followed by the results from the food diary that provides more detail about the sources accessed, types of foods consumed and food waste generated by sampled households. It should be noted that the household food consumption survey results are indicative rather than representative of urban households' food consumption and waste generation. This is because, the survey did not produce the expected results. The proxies used to estimate food consumption and food waste generation volumes resulted in data over-estimations. None the less, the data was valuable in indicating the general consumption and waste generation of urban households.

To this effect, an alternative method was applied to the same research questions to offer supplementary data that could be used to make conclusions about the food consumption and waste generation of urban households. To this effect, a food diary was disseminated to five households of different household income. The sample selected was not intended to be representative of the Cape Town households, rather it was more indicative of the larger population.

4.2 Household food sources

The survey results indicated that sampled households use multiple food sources at different frequencies. In the survey, respondents were asked to indicate how often they visited selected food sources. The summary of results is given in Table 8.

Table 8: Type of source and frequency of sourcing by sampled households

(N=402)	**Food source**					
Frequency	**Supermarket**	**Farmer's market**	**Local grocer**	**Street vendor**	**Relatives**	**We grow our own**
Never	3%	45%	27%	47%	68%	84%
Every few months	0%	15%	5%	7%	15%	5%
Once a month	19%	16%	7%	3%	6%	3%
Several times a month	14%	6%	10%	7%	5%	2%
Once a week	25%	11%	15%	11%	3%	2%
Several times a week	33%	5%	23%	17%	3%	1%
Everyday	5%	1%	13%	8%	0%	2%

33% (131 households) of the respondents said that they visited the supermarket several times a week. From the data, the supermarket has the largest proportion of households accessing it most frequently. The option 'we grown our own' recorded the largest proportion of households accessing it least frequently with 84% of the respondents (339 households) saying that they never grow their own food.

A further enquiry into which food group households purchased from the variety of sources revealed that households purchased a variety of food groups from the selected food sources (Table 9).

Table 9: Number of households purchasing different types of food group from selected food sources

(N=510)	Food source					
Food group	**Supermarket**	**Farmer's market**	**Local grocer**	**Street vendor**	**Relatives**	**We grow our own**
Baked goods	305	24	132	31	9	11
Canned/tinned fruit & vegetables	311	16	66	29	8	Not enough valid cases
Canned/tinned meat	296	13	66	22	6	Not enough valid cases
Cereals & grains	364	25	105	55	12	Not enough valid cases
Dairy products & eggs	354	41	115	33	7	Not enough valid cases
Fish & seafood	297	24	51	34	7	Not enough valid cases
Fruit	300	69	100	133	11	5
Meat & poultry	346	45	83	29	12	Not enough valid cases
Vegetables, roots & tubers	309	79	98	132	13	20

Given that households access multiple sources, this was not an unexpected finding. The enquiry revealed several additional findings. Based on count, fruits, vegetables, roots and tubers are the food groups mostly purchased from street vendors. That is, 133 households reported purchasing fruits from street vendors while 132 reported purchasing vegetables, roots and tubers from street vendors (Table 9).

The 'relatives' source recorded a small count of households that reported using it as a source of food. Though small, it is an important source for low-income households (Frayne, 2010). Of the

food groups that were commonly sourced from relatives were vegetables, roots and tubers, meat and poultry, cereals and grains, and fruit. Information about the location of these relatives would be useful; that is, whether they live in the same urban areas or they live in rural areas. This is because community sharing is a common feature (Frayne, 2010) of low-income suburbs, thus identifying where they live would be important in strengthening these social networks that support the food security of low-income households

It was observed that fresh plant produce from the fruit and vegetable food groups are what households are likely to be producing for themselves under the source type ‘we grow our own’. This would typically be done in little vegetable patches or pots where vegetables and herbs can be grown. As for the fruits, they would typically be grown as fruit trees. What should be distinguished though, is if the trees are grown for aesthetic or direct consumption purposes. This would be an innovative point of intervention to get households to grow their own fresh produce by doubling up the function of the tree as an aesthetic, shade producing plant.

For some sources, there were not enough valid cases to be analysed. This was the case for the option ‘we grow our own’; for example, there were either a small number of households or no households that grew or reared their own canned foods, cereals and grains, dairy products and eggs, fish and seafood, and meat poultry. Only the fruits and vegetables, and roots and tubers food groups had enough valid cases that could be analysed. This is not surprising because it is not expected that households would make their own tinned food products.

4.2.1 Low-income household food sources

Figure 18 is a presentation of the different food sources used by the low-income household sampled using the food diary. It is a frequency calculation showing how many times the household accessed the different food sources within a diary period of 15 days.

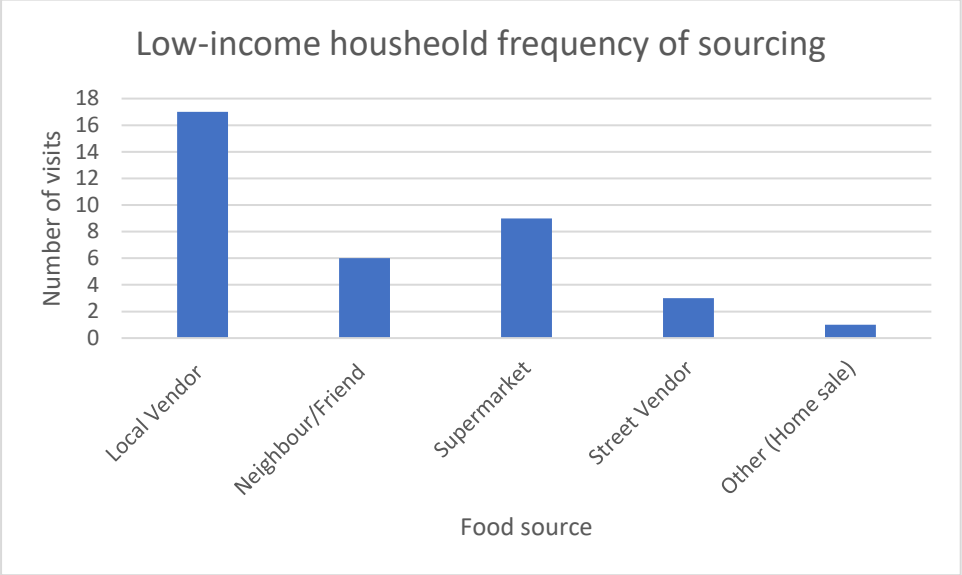

Figure 18: Food sources accessed by the low-income household sampled

The sampled household sourced their foods from five sources. Based on the frequency of sourcing, the local vendor was sought 17 times within a period of 15 days. The neighbour/friend was sought six times, the supermarket nine times, the street vendor three times and other sources just once (Figure 18). Literature (Battersby & Crush, 2014; Reardon *et al.*, 2002) and findings from the food survey indicate that supermarkets are the main source of food for urban households across all income groups. None the less, low-income households have been found to access a variety (Even-zahav, 2016; Frayne *et al.*, 2009) of sources that allows them access to food that they would otherwise not have because of their limited income (Even-zahav, 2016; Frayne, 2010).

Based on frequency, the local vendor is the most accessed source of food for the low-income household sampled. It is important to note that the local vendor and street vendor sources are differentiated based on formality and informality respectively. Local vendors are small local shops that sell re-packaged items that are usually in convenient, often small quantities that

are affordable to low-income households. Considering that low-income households spend a considerable amount of their income on food (Even-Zahav, 2016), such shops offer them access to foods that they need to function. It was observed that the local vendor was synonymous with 'Somali shops'; in the diary, the household referred to them as 'Somali shops'. It is interesting to note how the sampled household made a distinction between 'Somali shops' and other similar local vendor shops. It could be an indicator of their proliferation in the lower-income suburbs.

The 'other' source was foods that were sold by other households. In this case, the household that was sampled bought chilli burgers from a neighbour who sells food from the house for a living. This is a key finding because this is overlooked in literature. From this finding, it is evident that low-income households opt for a variety of sources. Given their income capacity, they are bound to look for innovative ways to provision for their households. As much as price is an important concern when looking for alternative ways of getting food, often these alternative provisioning strategies are based on trust relationships and community sharing. For example, the sampled household received some foods from a neighbour/friend six times during the duration of 15 days; this was in is the form of shared meals and borrowed ingredients used to make food. This source further indicates the communal nature of food provisioning and its importance to low-income households. The sampled household indicated that they do not have a constant income. Their ability to borrow food or share food with neighbours is an essential provisioning strategy for their survival and indicates the desire to fulfil more than just the need for food; it also fulfils the need for social safety and community interaction.

4.2.2 Lower middle-income household food sources

The lower middle-income household sampled accessed supermarkets as the single source for their food. Within a period of 12 days, the household visited the supermarket three times. The household's characteristics could offer a possible explanation for this finding. The household was made up of two female adults who were both graduate students. Given these characteristics, it is not unusual that they only made use of one source and that they had a low shopping frequency of three. Due to their student status, they are likely to opt for convenience when making their food provisions, as was indicated in their diary entries. Supermarkets offer convenience in having ready-made foods that can be purchased and

eaten at the house or school. Supermarkets also offer a variety of products (Checkers, 2019) other than food, making it a convenient source. That means that the household could do toiletry shopping and food shopping all at once and at an affordable price relative to the convenience offered.

4.2.3 Middle-income household food sources

Figure 19 is a presentation of the different food sources accessed by the middle-income household sampled. It is a frequency calculation showing how many times the household accessed the different food sources within a diary period of 30 days.

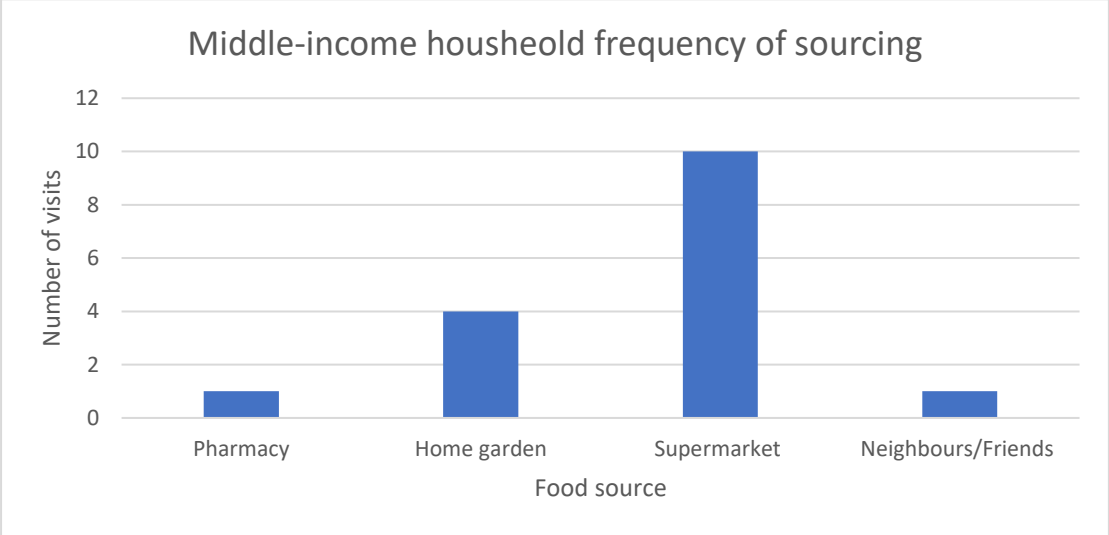

Figure 19: Food sources accessed by the middle-income household sampled

The middle-income household sampled sourced their foods from four sources. Based on the frequency of sourcing, they accessed the pharmacy once, received some food from a home garden four times, accessed the supermarket 10 times and received some food from a neighbour/friend once (Figure 19).

From the frequencies recorded, the supermarket was the most used food source for the household. The household used the supermarket 10 times within a period of 30 days. This is a relatively high frequency. When asked about their shopping routine, the household noted that they did not like shopping as an activity in general. The relatively high shopping frequency is thus explained by the household's desire for fresh foods. The household did

indicate that they preferred to purchase fresh foods often as they like to consume them fresh. This may have influenced the number of times they went to the supermarket for food supplies. This led to another observation; because of the household's diet, which they noted as "largely vegetarian", and their preference for freshness, which they interpreted as eating food on the same day it is bought, their shopping routine was directly influenced. This could explain why despite indicating their general disinterest in shopping as an activity, they would visit the supermarket often.

The middle-income household indicated that they grew some of the fresh produce that they consumed. As the data indicates, they made use of this option four times during the duration of the study. What is to be noted here is that this household could utilise this option because they live in a free-standing house with a backyard where they have a garden. That being said, it cannot be assumed that food gardening is an excepted practice of those who have access to land. For example, the lower middle-income household lived in a free-standing house with a backyard but did not practice food gardening. There could be several reasons for this. The first possible reason could be limited time and the subsequent desire for convenience. In their diary entries, the lower middle-income household noted that they prioritised convenience due to their student schedules. The key finding from this observation is that the choice of what source to access food from can be influenced by non-food determinants; for example, the type of dwelling that a household lives in, as observed in with the middle-income household.

4.2.4 Upper middle-income household food sources

There were two upper middle-income households that were sampled for the study. Figure 20 and figure 21 present the results obtained from the two households which were named Household 4 and Household 5, respectively.

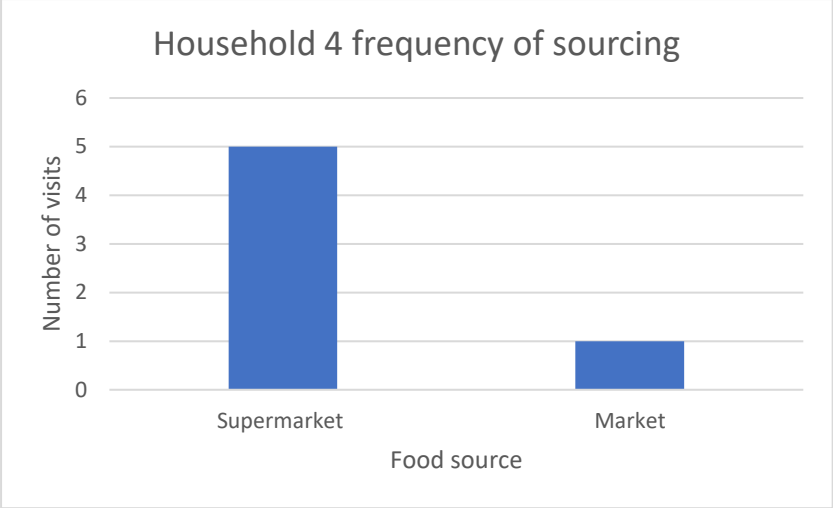

Figure 20: Food sources accessed by the upper middle-income household sampled (Household 4)

Household 4 accessed two food sources. They used the supermarket five times and the market once during a diary duration of six days. Given the frequency, it can be concluded that their main source of food was the supermarket. A possible explanation for this finding could be that the sampled household lives in a middle-income suburb, Muizenberg that has relatively high access to supermarkets. The literature indicates that supermarket distribution in Cape town is clustered in the middle- and high-income areas (Battersby & Peyton, 2014), thus the finding confirms the literature.

The only food item that was sourced from the market was figs, which falls under the vegetable food group. Although ordinarily, throughout the period of the study, this household purchased their vegetables from the supermarket, this one-off purchase of figs could be an indication that the market serves as an alternative source for the household's fresh produce needs.

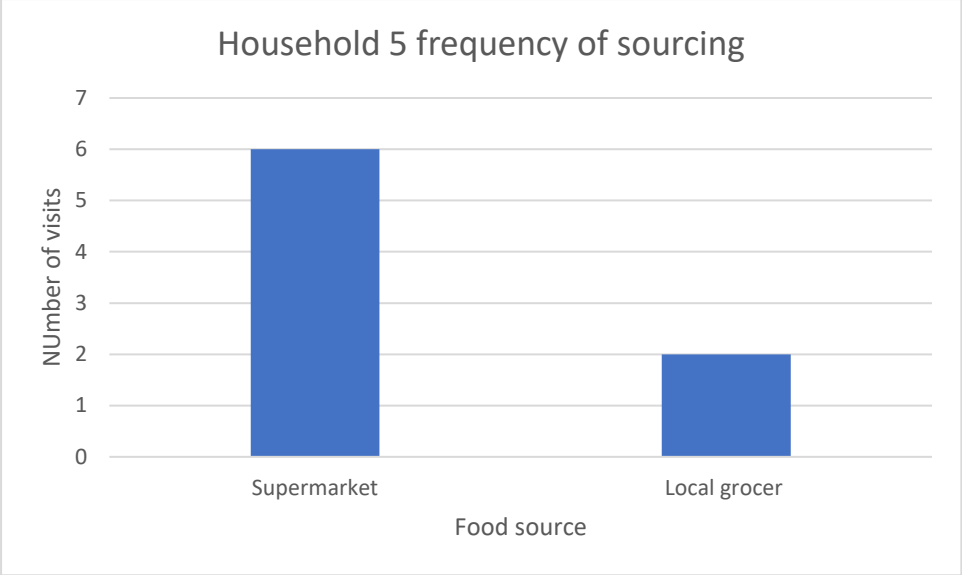

Figure 21: Food sources accessed by the upper middle-income household sampled (Household 5)

Household 5 accessed two food sources. They used the supermarket six times and the local grocer two times during a diary duration of 10 days. From the frequency of visits, the supermarket is the main source of food for Household 5. The foods that were purchased from the local grocer fell within the dairy products, cereals and grains, vegetables, fruits and meat food groups. Compared to Household 4, this household bought a variety of foods from another source other than the supermarket. Given this finding and the frequency of access, it can be concluded that the local grocer is an important food source for Household 5. From the diary entries, the specific foods that were bought from the local grocer were mostly snacks such as nuts, yoghurt, and 'oaties' (a food product made of oats) that they purchased mainly for their daughter, as noted in the diary.

4.3 Household food types

Households consume a variety of foods. The following section presents results and discussions on the types and quantities of food that the sampled households consume.

A total of 499 households consumed foods from the cereals and grains food group, 506 consumed foods from fruits, 510 consumed foods from vegetables, roots and tubers, 505

consumed foods from dairy products and eggs, 455 consumed foods from fish and seafood, 495 consumed foods from meat and poultry, 486 consumed foods from baked goods, 422 consumed foods from canned/tinned meat, and 442 households consumed foods from canned/tinned fruits and vegetables food group (Table 10). A more detailed presentation of the results is attached in Appendices C to K. Each appendix represents a food group. The information on the appendices displays the number of people consuming foods from a given food group, according to income group. Additionally, they indicate, in percentage, what proportion of the population the household numbers represent.

Table 10: Types of food consumed by the sampled household, according to income group

Income group	Food group Cereals & Grains	Fruit	Vegetables, Roots & Tubers	Dairy products & Eggs	Fish & Seafood	Meat & Poultry	Baked Goods	Canned/Tinned Meat	Canned/Tinned fruit & vegetables
R 0	9	9	9	9	6	9	8	7	6
R 1 - R 1 600	25	23	25	24	19	25	23	20	21
R 1 601 - R 3 200	41	39	41	41	39	40	41	34	36
R 3 201 - R 6 400	63	63	63	63	55	62	62	58	59
R 6 401 - R 12 800	62	63	63	63	55	61	62	57	61
R 12 801 - R 25 600	95	96	96	94	86	91	90	78	83
R 25 601 - R 51 200	117	124	124	123	112	119	117	103	106
R 51 201 - R 102 400	57	59	59	58	53	59	56	43	48
R 102 401 - R 204 800	21	21	21	21	21	20	18	15	16
More than R 204 801	9	9	9	9	9	9	9	7	6
Totals)	**499**	**506**	**510**	**505**	**455**	**495**	**486**	**422**	**442**

More than 50% of households in each income group reported eating foods from all the nine food groups selected. From this finding, it can be concluded that on average, sampled households within each income group consumed foods from all the selected food groups. This finding raised an emerging concern about the disaggregation of food groups. The survey data provided limited information on the foods that households consume. There could be several reasons for this. The food groups that were used, were created by merging other food groups for practical reasons in order to simplify and shorten the survey to avoid respondent fatigue and subsequent drop out. For example, the 'roots and tubers' food group were merged into 'vegetables, roots and tubers' food group. This made it difficult to

differentiate and identify specific foods consumed and thus there could not be any significant distinctions made from the data.

Sampled households purchased an average volume of 56.6 litres of food per week in a typical week. Households in the income group R51,201 – R102,400 purchased the highest volume of food at 102.8 litres per week, followed by income group R102,401 – R204,800 with 78.5 litres/week, R25,601 – R51,200 with 59.4 litres/week, R6,401 – R12,800 purchasing 58.6 litres/week, R12,801- R25,600 purchasing 56.2 litres/week, R3,201 – R6,400 purchasing 49.6litres/week, R1,601 – R3,200 purchasing 47.9litres/week, and R1 – R 1,600 purchasing the lowest volume of food at 38.7litres/week (Table 11).

Table 11: Total volume of food purchased weekly by the sampled households

	Total food purchased weekly per income group			
Effect	Level of factor (Income group)	Number of households (N)	Shopping per week (Litres) Mean	Shopping per week (Litres) Standard deviation.
Total		268	56.6	54.7
Income	R 1 - R 1 600	22	38.7	32.8
Income	R 1 601 - R 3 200	30	47.9	39.3
Income	R 3 201 - R 6 400	55	49.6	34.3
Income	R 6 401 - R 12 800	41	58.6	62.8
Income	R 12 801 - R 25 600	56	56.2	63.9
Income	R 25 601 - R 51 200	43	59.4	55.2
Income	R 51 201 - R 102 400	16	102.8	81.5
Income	R 102 401 - R 204 800	5	78.5	44.8

These results though indicative, were over-estimated. This can be attributed to the method used to calculate the average consumption. It was assumed that shopping bag volume equivalents could be used to estimate the quantity of food that households consume. This

was not the case; the shopping bag volume averages used over-estimated the quantities of foods purchased.

None the less, the data was useful in revealing the general picture of household consumption quantities. From this data, a correlation analysis was conducted to determine whether there was any correlation between the quantities of food purchased and consumed, and the household income of sampled houses.

A Pearson correlation analysis was conducted on 272 households. It was found that there was a significant correlation ($p<0.01$) between the volume of food purchased and consumed by households and total household income, for the sampled households (Table 12). This finding confirmed the literature that indicated the higher the household income, the higher the quantity of food purchased and consumed (Zezza *et al*., 2017).

Table 12: Correlation between total volume of food consumed and total household income

Variable 1	Variable 2	Pearson	Pearson p-value	Number of cases
Total income	Shopping per week	0.2	<0.01	272

4.3.1 Low-income household food types and quantities

The low-income household sampled consumed foods from all the eight food groups selected for the diary. The household consumed foods from the following food types: vegetables, meat and poultry, baked goods, dairy products and eggs, cereals and grains, fruit, fish and seafood and roots and tubers, food groups. The household consumed a total weight of 28,823g worth of food. The household consumed 7,145g worth of roots and tubers, 6,062g worth of meat and poultry, 5,748g worth of cereals and grains, 3,206g worth of baked goods, 2,754g worth of ready-made meals, 1,483g worth of dairy products and eggs, 1,233g worth of vegetables, 987g worth of fish and seafood, and 205g worth of fruit (Figure 22).

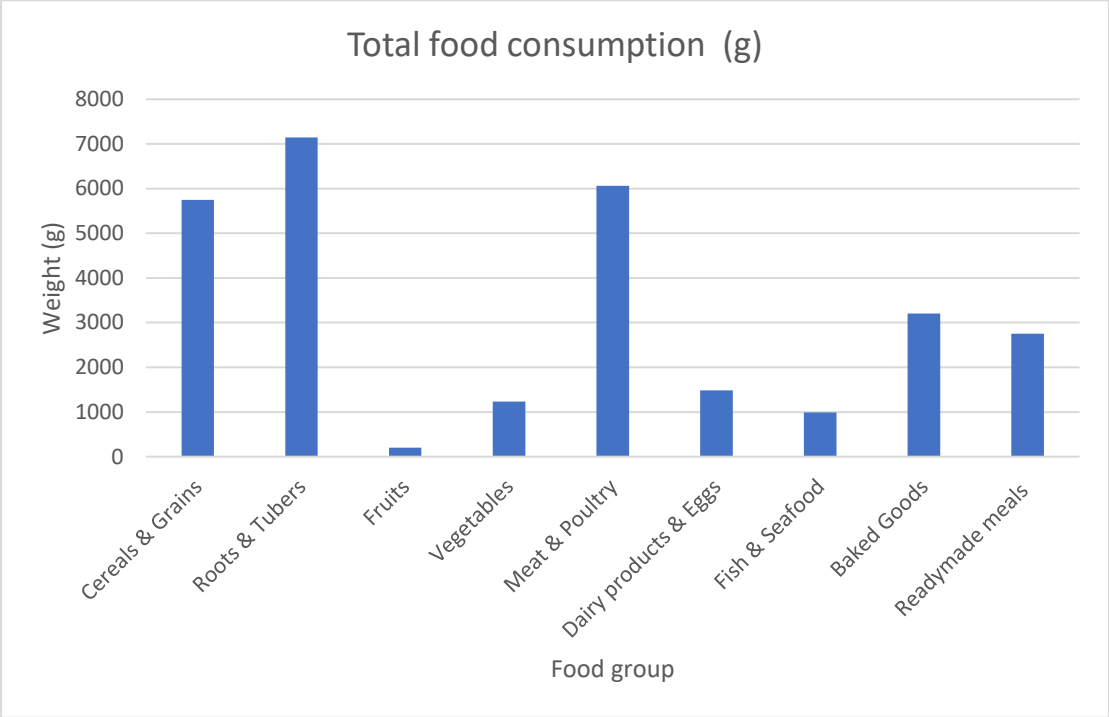

Figure 22: Low income household total food consumption

The low-income household sampled consumed foods from all the eight selected food groups.

The meat and poultry food group had the highest variety of food types consumed. The meat types consisted of beef and sheep, while the poultry type consumed was chicken. The food group consisted of a mix of processed and whole meats such as smoked Viennas which can be a mixture of meats such as beef and pork or beef, pork and poultry (e.g., chicken or turkey). Another processed meat consumed was sausages (Table 13).

Table 13: Low-income household food types

Vegetables	Meat & Poultry	Baked goods	Dairy products & eggs	Cereals & grains	Fruit	Fish & Seafood	Roots & Tubers
Tomatoes	Chicken wings	Bread	Eggs	Samp	Avocado	Tinned Pilchards	Potatoes
	Minced meat		Cheese	Rice			Onions Butternut
	Traditional Chicken						Carrots
	Smoked viennas						
	Beef burger						
	Sausage						
	Sheep liver Tripe Lamb						

The fruits and baked goods food group categories had the lowest variety of food types. There was only one fruit type consumed, which was avocado, and the only baked good consumed was bread. What was interesting to note was the weight of bread consumed by the household. The total weight of bread consumed was 3,206g.

Given the weight of bread and the household size of one, this was a significant amount of bread consumed. On average, the household consumed 213.7g of bread per day. This was a single household and so this figure also translates into the total bread consumed per person: 213.7g/day/person. This is well above the prescribed recommended daily consumption of 100g/day. Despite this, this finding was expected because bread is a relatively cheap, energy-dense food (Temple & Steyn, 2011) and as such, low-income households are likely to consume higher proportions of bread compared to higher-income households. Although it is a cheap source of energy, bread and refined cereals with added sugar and fat have a low nutrient density (Temple & Steyn, 2011). High dependence on bread would then affect the nutrient intake of a household.

This household spends about R1,000/month on food supplies, as reported in the food diary. This is approximately R33.33/day spent on food. For the 15 days that the diary was used, the household spent a total of R616.99 on food purchases, which translates to approximately R41.13 spent per day. This household has a total household income within the R1-R1600 income category. Using the R1,000 reported by the household, it can be concluded that the household spends about 62.5% of their total household income on food. This is significantly above the estimated figure for low-income households that are estimated to be spending approximately 34% (Statistics South Africa, 2014) of total household expenditure on food purchases.

The household also consumed other foods that were ready-made. These were the foods that came from the neighbour/friend source category. They were foods made using bread, tripe, carrots, potatoes, rice, onions, lamb and gravy. These food types fall under the following food groups: baked goods, meat and poultry, roots and tubers, vegetables, cereals and grains. Since the readymade meals contained foods that they were already mixed up, it was not possible to get the weight of individual food types; rather a total weight of the meal was given.

4.3.2 Lower middle-income household food types

The lower middle-income household sampled consumed foods from seven food groups within the eight selected food groups used for this study. These food groups were: cereals and grains, roots and tubers, fruits, vegetables, meat and poultry, dairy products and eggs, and baked goods. The household did not consume any fish or seafood. The total weight of foods consumed for a period of 12 diary days was 17,617g. The household consumed 2,310g worth of cereals and grains, 2,921g worth of roots and tubers, 4,233g worth of fruit, 4,185g worth of vegetables, 1,550g worth of meat and poultry, 1,314g worth of dairy products and eggs, and 1,104g worth of baked goods (Figure 23).

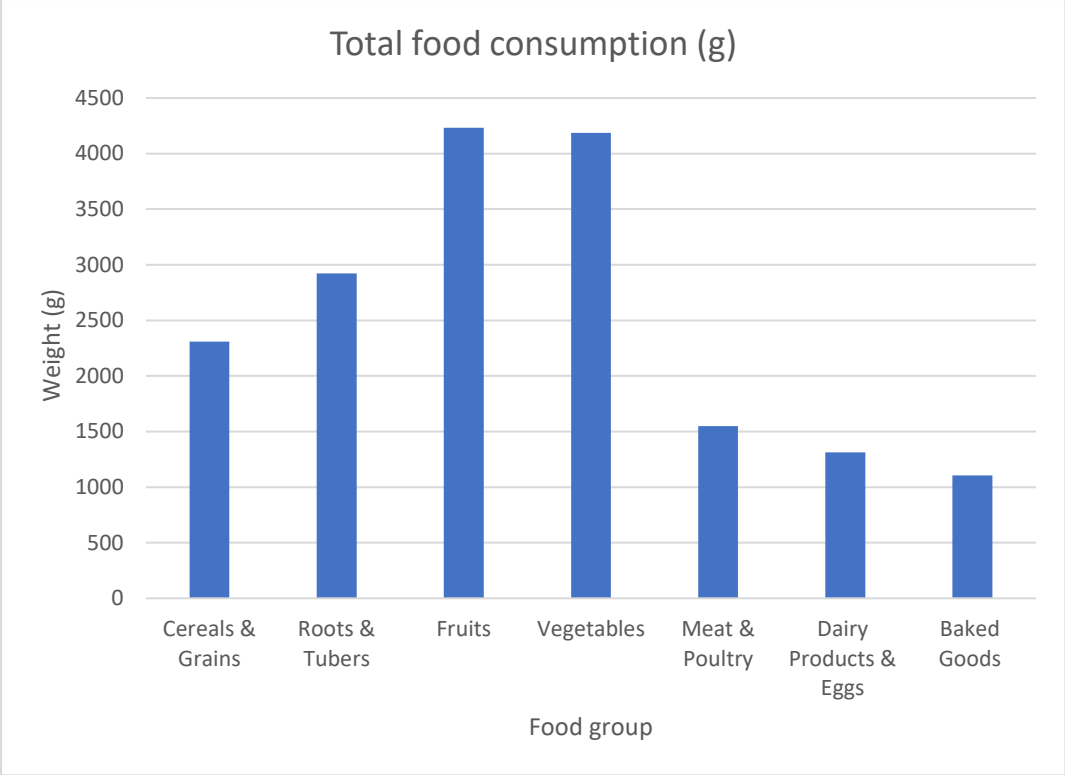

Figure 23: Lower middle-income household total food consumption

The fruits and vegetables food groups had the highest consumption by weight. The varieties of vegetables consumed had a relatively low weight except for cabbage, which had a total weight of 1,074g (Figure 24), which is 25.66% of the total weight of vegetables consumed. Additionally, cabbage was only eaten once during the duration of the study as compared to other vegetables like cucumbers that were eaten more frequently. This finding brought up the question of the value of weight in making assumptions about food consumption and comparisons between food types. Depending on the make-up of a food, it may be naturally heavy or naturally light. For example, potatoes are naturally heavier than leafy vegetables. They have a higher mass and weight compared to leafy vegetables. Also, different foods within the same food group could have the same nutritional value but could differ in weight. The same is true for foods that have a high weight but low nutritional value.

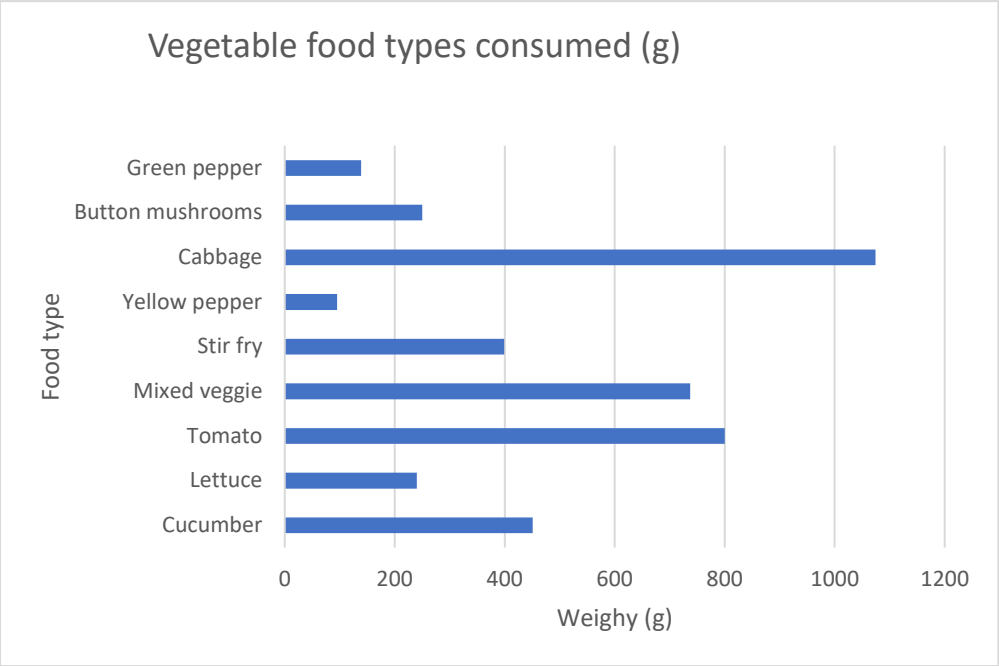

Figure 24: Lower middle-income household vegetable types consumed by weight:

The household consumed a variety of vegetables, cereals and grains and fruits (Table 14). They consumed six types of fruits, nine types of vegetables, and seven types of cereals and grains. It is possible that this household consumes an even greater variety of cereals and grains and vegetables. This is because the 'mixed veggies' food type, categorised under the vegetables food group, can be a mix of vegetables, cereals and grains and fruits such as sweet corn, mushrooms, green peas, pineapples, carrots, potatoes, peas, bell peppers, chilli peppers, cauliflower, and broccoli, depending on the brand or recipe (Checkers, 2019).

Table 14: Lower middle-income household food types

Vegetables	Meat & Poultry	Baked goods	Dairy products & eggs	Cereals & grains	Fruit	Roots & Tubers
Cucumber	Chicken	Bread	Eggs	Beans	Avocado	Carrots
Lettuce			Fresh cream	Pap flour	Granadilla	Onions
Tomato			Cheese	Cake flour	Apples	Potatoes
Mixed veggie				Spaghetti	Bananas	
Stir fry				Weetabix	Pomegranate	
Yellow pepper				Rice	Plums	
Cabbage				Green peas		
Button mushrooms						
Green pepper						

4.3.3 Middle-income household food types

The middle-income household sampled consumed foods from all the eight selected food groups. The total weight of foods consumed was 47,342g. The household consumed cereals and grains worth 15,273g, roots and tubers worth 9,332g, fruits worth 5,909g, vegetables worth 10,451g, meat and poultry worth 3,656g, dairy products and eggs worth 2,352g, fish and seafood worth 1,019g, baked goods worth 3,597g, and ready-made (already combined meals) meals worth 5,753g (Figure 25).

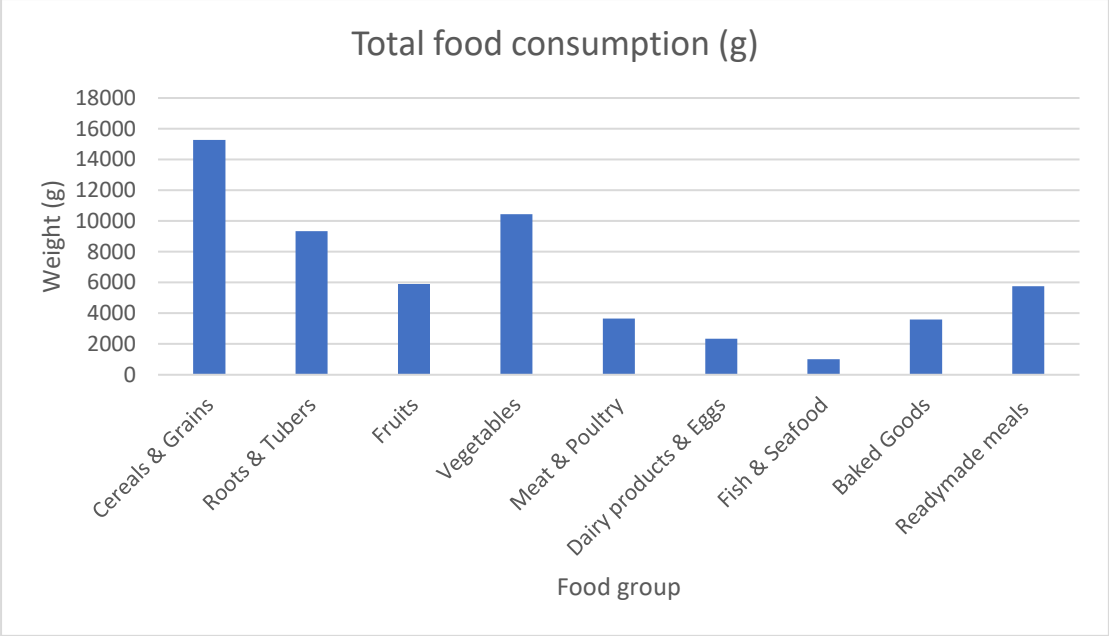

Figure 25: Middle income household total consumption

The household consumed approximately 1,578.06g of food per day for a period of 30 diary days. With a household size of two, this translated into 789.03g/person/day. The household spent a total of R3,382.26 on food purchases. With a total household income of between R25,601 – R51,200, the household is approximately spending between 13.21% and 6.60% of their total household income on food purchases.

The household consumed different types of foods. They consumed 15 types of cereals and grains, 10 types of vegetables, six types of roots and tubers, three types of baked goods, four types of fruits, three types of dairy products and eggs, three types of meat and poultry, and two types of fish and seafood (Table 15). The ready-made meals consisted of food types from these same food groups.

Table 15: Middle income household food types

Vegetables	Meat & Poultry	Baked goods	Dairy products & eggs	Cereals & grains	Fish & Seafood	Fruit	Roots & Tubers
Cucumber	Chicken	Bread	Eggs	Mixed seeds	Tuna	Banana	Carrots
Lettuce	Minced meat	Cracker bread	Cheese	Oats	Fish	Lemon	Potatoes
Tomato	Venison mince	Wraps	Cream	Tinned chickpeas		Avocado	Beetroot
Olives		Rusks	Feta cheese	Tinned black beans		Apple	Butternut
Spinach				Flour			Garlic
Veggie patties				Rice			Onion
Cauliflower				Couscous			
Baby gems				Frozen peas			
Green beans				Rice milk powder			
Mushrooms				Noodles			
				Popcorn			
				Pasta			
				Spaghetti			
				Nuts			
				Almonds			

The household consumed a wide variety of foods. By weight, foods in the cereals and grains, vegetables and roots and tubers food groups were consumed most. This was expected since the household reported that they mainly consumed a vegetarian diet. The household's diet of choice further explains the high variety and quantity of non-meat products consumed. It was observed that individual diet preferences such as taste can influence a household's food choices. For example, the household admitted to spending money on different cheese varieties because they like cheese.

Among the meat food types consumed by the household was venison mince. Venison commonly refers to any part of game meat, but in general it specifically refers to deer meat. Among the sampled households, the middle-income household was the only household that recorded consuming game meat. A possible explanation for this observation can be derived from the household's diary entries. The following quote was recorded:

"We try to buy healthy food - that's a big consideration for me (a bit less so for my husband, for example I like whole-wheat bread and he likes 'best-of-both' white bread!) This is both because we are health-conscious, and because I feel sick if I eat very oily, fatty or sugary food."

From this quote, the household may have opted for venison meat for the nutritional and health benefits that it offers. Venison meat is considered as a "low-fat, nutrient-dense alternative for the health conscious consumer" (Hoffman, 2007: 6) containing a higher protein and lower fat content than other meats (Radder & Le Roux, 2005).

4.3.4 Upper middle-income household food types

Household 4 consumed foods from seven food groups out of the eight food groups. They did not record any consumption of meat and poultry food types. The household consumed a total of 14,004g of food for a diary duration of 6 days. They consumed 2,623g worth of cereals and grains, 430g worth of roots and tubers, 3,639g worth of fruits, 1,335g worth of vegetables, 2,696g worth of dairy products and eggs, 488g worth of fish and seafood, 2,163g worth of baked goods, and 630g worth of ready-made meals (Figure 26).

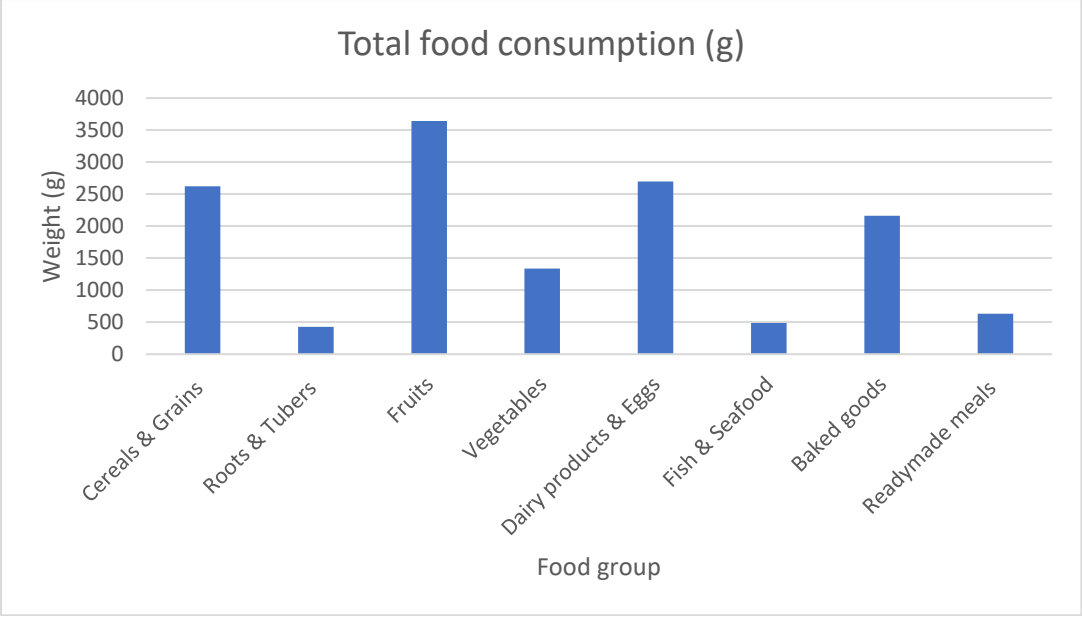

Figure 26: Upper middle-income household total food consumption (Household 4)

On average, the household consumed approximately 2,334g of food per day for six days. With a household size of four, this translated into 583.5g/person/day. The per capita consumption appears

to be smaller than expected, though there is a possible reason for this finding. The household composition consisted of two adults and two children in the age bracket 5-14 years. Generally, children do not consume as much food as matured adults, thus the household's composition may have affected the total weight of food consumed by the household. The household reported spending approximately R5,000 on food purchases per month. The total household income was between R51,201 – R102,400. This means that the household spends approximately 9.76% – 4.88% of their total household income on food purchases.

Household 4 consumed different types of foods. They consumed seven types of vegetables, five types of baked goods, six types of dairy products and eggs, ten types of cereals and grains, one type of fish and seafood, six types of fruit, and three types of roots and tubers (Table 16)

Table 16: Upper middle-income household food types (Household 4)

Vegetables	**Baked goods**	**Dairy products & eggs**	**Cereals & grains**	**Fish & Seafood**	**Fruit**	**Roots & Tubers**	**Meat & poultry**
Tomato	Bread	Feta	Popcorn	Fish fingers	Avocado	Carrot	Nil
Cucumber	Pretzel sticks	Yoghurt	Nachos		Dried pineapple	Garlic	
Salad leaves	Salticrax	Halloumi cheese	Dried red lentils		Apple	Potato chips	
Cabbage	Wrap	Eggs	Pasta		Banana		
Olives	Pizza base	Mozzarella cheese	Oats		Lemon		
Capers		Butter	Corn cakes		Pomegranate seeds		
Baby spinach			Corn on cob				
			Mixed nuts				
			Peanut butter				
			Peanut butter protein balls				

The household consumed several processed foods; for example, salticrax, pretzel sticks, potato chips, nachos, corn cakes, protein balls. The household mentioned that they bought a lot of snacks for their children:

HH 4: "*We also buy snacky foods (e.g, pretzels, crackers etc) for school lunch boxes*".

This could be a possible reason for the number of processed snack foods. Another possible explanation for the variety of processed foods is the household's expressed need for convenience:

HH 4: "*Price is a concern with some of the food we buy, but we either buy more expensive options (e.g. Woolworths or organic shop) either because the quality is sometimes better, or for convenience".*

Although the household noted that they are mostly a vegetarian household, they indicated that they occasionally purchased roasted chicken or processed fish for the children. This observation shows how the foods consumed by the household are a representation of the food preferences of individual household members.

Upper middle-income household total food consumption (Household 5)

There was no clear record of the quantity of food purchased by Household 5. This is because they did not make use of the weighing scale that was provided to take weight measurements of the foods that they consumed. This challenge was not captured early enough for the following reasons:

1. they began the diary exercise late in the month of March 2019;
2. they made diary entries on paper and transferred them to the electronic version later;
3. they started making diary entries before receiving the weighing scales, meaning that the initial days had approximated records of the weights of foods consumed.

Household 5 consumed foods from seven food groups from the selected eight food groups (Table 17). They consumed a variety of foods, just like the other middle-income households sampled. They consumed 11 types of vegetables, one type of baked good, four types of dairy products and eggs, seven types of cereals and grains, one type of fish and seafood, three types of fruit, and three types of roots and tubers

Table 17: Upper middle-income household food types (Household 5)

Vegetables	Baked goods	Dairy products & eggs	Cereals & grains	Fish & Seafood	Fruit	Roots & Tubers	Meat & Poultry
Broccoli	Wrap	Feta cheese	Oats	Snoek	Avocado	Sweet potato	Nil
Butter lettuce		Cream cheese	Risotto		Lemon		
Cucumber		Mozzarella cheese	Macaroni		Lime	Carrot	
Sun dried tomatoes		Yoghurt	Sweet corn			Butternut	
Samphire			Rice crackers				
Celery			Pasta				
Red cabbage			Chickpea				
Rocket							
Veggie sausages							
Gherkin							

It was found that out of the four types of dairy products consumed, three of them were different varieties of cheese: feta cheese, cream cheese and mozzarella cheese. The household is consuming different varieties of the same food type; this could be an indicator of the household preference for cheese and cheese products.

The household consumed a wide variety of vegetables. Among them, exotic vegetable food types such as samphire and gherkin. The household indicated that they liked to buy ‘unusual food’, which they described as food that they had never tried before. They added that they are likely to buy new foods even when they were not sure of how to use them best.

The household noted that they purchased a lot of snacks and ready-made foods because of their child. They also stated convenience as another reason for purchasing ready-made foods. They added that they would choose convenience over price. From this, the complex and varied circumstances that influence households’ food choices can be observed. For a working parent, such as the one in Household 5, their lifestyle directly influences the choice of the type of foods that they consume. Although the household considers eating a healthy diet a priority, their lifestyle does not always allow them to follow through with their desire to maintain a healthy diet.

Table 18: Summary of the different food consumption profiles of sampled households

Household (HH) characteristics	HH Size: 1 Period: 15 days	HH Size: 2 Period: 12 days	HH Size: 2 Period: 30 days	HH Size: 4 Period: 6 days	HH Size: 3 Period: 10 days
	Household type (Total HH income)				
Food group (g)	**Low-income**	**Lower-middle income**	**Middle-income**	**Upper-middle income (HH 4)**	**Upper-middle income (HH 5)**
Cereals & grains	5,748g	2,310g	15,273g	2,623g	**Nil**
Roots & tubers	7,145g	2,921g	9,332g	430g	**Nil**
Fruits	205g	4,233g	5,909g	3,639g	**Nil**
Vegetables	1,233g	4,185g	10,451g	1,335g	**Nil**
Meat & Poultry	6,962g	1,550g	3,656g	0g	**Nil**
Dairy products & eggs	1,483g	1,314g	2,352g	2,696g	**Nil**
Fish & seafood	987g	0g	1,019g	488g	**Nil**
Baked goods	3,206g	1,104g	3,597g	2,163g	**Nil**
Ready-made meals	2,754g	0g	5,753g	630g	**Nil**
Total food consumption	**28,823g**	**17,617g**	**47,342g**	**14,004g**	**N/A**

4.4 Household food waste generation

Sampled households produced an average of 52.6 litres of food waste per week. (Table 19). The evidence suggests that there is not much difference between the volume of food wasted by the different income groups. Households in the lower income groups appear to be producing similar volumes of waste as the higher income households. For example, households with no income generated 52.5 litres of food waste per week compared to households within the R25,601 – R51,200 income group who generated 51.9 litres of food waste per week, only 0.6 litres less than the no income households. Households within the income group R102, 401 – R204, 800 generated the highest volume of food waste, producing an average of 94.8 litres per week.

Table 19: Total volume of food waste produced weekly by sampled household

	Total food waste generated per week			
Effect	Level of factor (Income Group)	(N) Number of households	Food waste Litres (L) Mean	Food waste Litres (L) Standard Deviation
Total		396	52.6	75.1
Income	No income	6	52.5	43.5
Income	R 1 - R 1 600	22	37.2	73.9
Income	R 1 601 - R 3 200	34	52.7	67.6
Income	R 3 201 - R 6 400	59	55.1	75.2
Income	R 6 401 - R 12 800	52	39.3	56.8
Income	R 12 801 - R 25 600	75	52.8	71.9
Income	R 25 601 - R 51 200	87	51.9	68.2
Income	R 51 201 - R 102 400	40	63.9	118.2
Income	R 102 401 - R 204 800	14	94.8	78.3
Income	More than R 204 801	7	37.5	43.7

These findings were inconsistent with the literature that estimates that households produce an average of six kilograms (Kg), which is approximately six litres (L) in volume, of food waste per week (Ramukhwatho *et al.*, 2016). This finding can be attributed to the method used to calculate the average waste generated. It was assumed that refuse bag volume equivalents could be used to estimate the quantity of food waste that households produce. This was not the case; the refuse bag volume averages used over-estimated the quantities of food waste produced. None the less, the data was useful in revealing food waste quantities of different households. Further, the data was useful in determining the correlation between household food quantities and household income.

The relationship between total food waste generated and total household income of the sampled households is linear, meaning that as total household income increases, total food waste generated correspondingly increases or decreases. A Pearson correlation analysis was thus conducted to determine the extent to which these two variables are linearly related. The analysis was conducted on 396 households. It was found that there was no significant correlation (p=0.16) between the volume of food generated by households and total household income for the sampled households (Table 20).

Table 20: Correlation between total volume of food waste generated and total household income

Variable 1	Variable 2	Pearson	Pearson p-value	Number of cases
Total income	Food waste Litres (L)	0.07	0.16	396

4.5.1 Low-income household food waste generation

The low-income household sampled generated a total of 5,576g of food waste (Table 21). The avoidable food waste portion was 3,149g, the possibly avoidable food waste portion was 1,319g, and the unavoidable food waste portion was 1,108g. The household generated approximately 371g of waste/day over a period of 15 days. The household generated an average of 371g/capita/day. This is a relatively high waste generation rate for a single household. From the total food consumed by the household, approximately 19.34% of it is wasted.

Table 21: Low-income household food waste quantities

Waste Category	Wet weight (g)	% Proportion
Avoidable food waste	**3149**	**56.47%**
Possibly avoidable food waste	**1319**	**23.65%**
Unavoidable food waste	**1108**	**19.87%**
Total food waste generated	**5576**	
Proportion of food wasted (Total food wasted/Total food consumed)	**5576/28,823**	**19.34%**

4.5.2 Lower middle-income household food waste generation

The lower middle-income household sampled generated a total of 2,171g of food waste. The possibly avoidable food waste portion was 564g and the unavoidable food waste portion was 1,607g. The household did not have any avoidable food waste. On average, the household generated approximately 180.91g of food waste/day over a period of 12 days. When distributed along household size, the household generated approximately 90.45g/capita/day. The total food waste generated was approximately 12% of the total household food consumption (Table 20)

Table 22: Lower middle-income household food waste quantities

Waste Category	Wet weight (g)	% Proportion
Avoidable food waste	**0**	**0%**
Possibly avoidable food waste	**564**	**25.97%**
Unavoidable food waste	**1607**	**74.02%**
Total food waste generated	**2171**	
Proportion of food wasted (Total food wasted/Total food consumed)	**2171/17,671**	**12%**

Of the total 2,171g of food waste generated, 564g of it was partially avoidable food waste and 1,607g of it was unavoidable food waste. The unavoidable food waste category occupied the larger proportion with approximately 74% of the total food waste generated, while the possibly avoidable food waste occupied approximately 26% of the total food waste generated.

Among the three food waste categories, the lower middle-income household sampled generated waste that was either possibly avoidable or unavoidable. When the household characteristics were examined, none could sufficiently explain this finding. The only plausible explanation could be that the avoidable wastes that were generated had negligible weight that could not be measured on the weighing scales provided. The least weight that could be measured on the scales provided was 1g, and so any food waste below this weight could have been left out.

4.5.3 Middle-income household food waste generation

The middle-income household sampled generated a total of 3,032g of food waste over a period of 30 days. On average, the household generates 101.06g of food waste/day. With a household size of two, the household generates 50.53g/capita/day. The total food waste generated compared to the total food consumed accounted for approximately 6% of total food consumption. Of the 3,032g of food waste generated, avoidable food waste was 362g, possibly avoidable food waste was 926g, and unavoidable food waste was 1,744g (Table 21).

Table 23: Middle income household food waste quantities.

Waste Category	Wet weight (g)	% Proportion
Avoidable food waste	**362**	**11.93%**
Possibly avoidable food waste	**926**	**30.54%**
Unavoidable food waste	**1744**	**57.51%**
Total food waste	**3032**	
Proportion of food wasted (Total food wasted/Total food consumed)	**3032/57,342**	**5.28%**

The largest waste category was unavoidable food waste, taking up approximately 57% of the total food waste generated. This means that most of the food waste generated consisted of inedible food parts. Possibly avoidable food waste was the second largest waste category occupying

approximately 31% of the total food waste generated, while avoidable food waste was the smallest waste category representing approximately 12% of the total food waste generated by the middle-income household.

4.5.4 Upper middle-income household food waste generation

In this section, the results from only one household of the two upper middle-income households sampled for the study are presented. The results below are from Household 4. During the data cleaning process, it was noted that the waste quantities provided by Household 5 were not measured using a weighing scale but were instead approximations given by the household. For this reason, the households' data on the waste generation quantities were excluded from the results.

Household 4 generated a total of 1,640g of food waste over a period of 6 days. The avoidable food waste was 210g, possibly avoidable food waste was 91g, and the unavoidable food waste was 1,339g. (Table 22). On average, the household generated 273.33g of food waste/day. When distributed along household size, the household generated approximately 68.33g/capita/day. When compared to the total weight of food consumed, the total food waste generated was approximately 11.71% of the total food consumed.

Table 24: Upper middle-income household food waste quantities (Household 4)

Waste Category	Wet weight (g)	% Proportion
Avoidable food waste	**210**	**12.80%**
Possibly avoidable food waste	**91**	**5.54%**
Unavoidable food waste	**1339**	**81.64%**
Total food waste	**1640**	
Proportion of food wasted (Total food wasted/Total food consumed)	**1640/14,004**	**11.71%**

Approximately 82% of the food waste generated by the household was unavoidable food waste. This waste was made up of inedible parts of food such as peels and bones. Avoidable food wastes accounted for approximately 13% of the total food waste and possibly avoidable wastes accounted for the least proportion at approximately 5% of the total food waste generated by the household.

4.6 Summary

Sampled households made use of a variety of sources for their food provisioning needs. From these sources they were able to access a variety of foods whose choice was influenced by several reasons depending on the needs, references and economic access to purchase certain foods. The households sampled generated different quantities of food wastes but in general it can be concluded that the sampled households were not necessarily wasteful as a bigger proportion of food wasted was avoidable and possibly avoidable food waste types.

Chapter 5: Conclusion and Recommendations

5.1 Introduction

There are a limited number of food metabolism studies and an even smaller number that conduct metabolism assessments of disaggregated flows. This study sought out to fill this gap by collecting data on food sources (stocks) accessed by households and food types (flows) consumed. The data was supplemented with qualitative data on household food choices that sought to contextualise household food consumption by understanding how households make decisions on foods (flows) to consume. To measure the efficiency of food consumption in households, the study made use of food waste as the 'indicator substance' (Faist *et al.*, 2001). Data on quantities of food waste generated by households was collected to measure consumption efficiency. To further qualify the data, the food waste quantities were categorised to potentially distinguish different levels of efficiency. The overall objective of the study was to better understand the food consumption of urban households.

The following sections summarise the key methodological and empirical findings of the study and offer recommendations for future research from the lessons learned from the study.

5.2 Key methodological findings

It was found that sampled households consumed foods from almost all the nine selected food groups. There was no significant difference between the food groups that were selected by the different households of varying income, even though the literature indicates that dietary diversity increases with an increase in income. This could be because the foods were organised into food groups.

A rapid survey is useful in providing information on the types and sources of household foods from a large sample with a wide geographical distribution. It is however not an ideal tool for collecting detailed information on household food consumption and related practices. Online surveys may not be suitable for collecting qualitative data. Being self-completion questionnaires, respondents are left alone to answer questions. A misinterpretation of the question may lead to misinterpret results, affecting the data.

Using enumerators to administer the survey proved to be a useful strategy for collecting data in the low-income suburbs. Due to literacy challenges and language barriers, the enumerators were able to capture data from households that would have otherwise been left out of the survey process. The feedback that was gained from their field activities and interactions with different households was invaluable in refining the survey and the literature.

Using the number of shopping bags as a proxy for how much food households consume did not prove useful. Instead, it led to over-estimated quantities. This may have been in part due to the assumptions made in estimating the quantities; it was assumed that all bags were full at the time of purchase.

Similarly, using the number of refuse bags as a proxy for how much food waste households generated did not prove useful. Instead, it led to the overestimation of waste quantities generated. This may have been because of the assumptions made in estimating waste quantities. Although the fullness of the bag at the time of disposal was accounted for, the refuse bag size that was used was a calculated average of three residential wheelie bin capacities. It was assumed that a refuse bag used in a wheelie bin would be of the same capacity as the wheelie bin. This assumption may have contributed to the high food waste quantities recorded.

5.3 Key empirical findings

5.3.1 The research approach

The urban metabolism approach proved useful in assessing household food flows. It allowed the conceptualisation and identification of possible food flows and prompted the enquiry into the usefulness of having highly disaggregated flows. From the study findings, tracking individual food types does not necessarily offer much insight into food flows. Urban food metabolism assessments, using methods like the material flow analysis (MFA), often use weight measurements to quantify food flows. Even so, data from such assessments enable the comparison of food consumption of different households. Since food's main purpose is human nutrition, perhaps urban food metabolism assessments could make use of household calorie intakes to assess food flows.

To perform an urban metabolism assessment, a system's boundary must be defined. The boundary for the household is set as the physical space delimited by the outer perimeter walls surrounding a house structure. This would mean that any food consumed beyond the house boundary, even if it came from the household's stock, is not accounted for in the total household consumption. This excludes a significant portion of foods eaten by household members outside the house. Quantitative household consumption assessments might then underestimate the actual consumption of households.

5.3.2 Key findings

Sampled households consumed foods from at least seven food groups of the selected nine food groups used in the study. This finding indicates that the sampled households had a relatively high dietary diversity, which is defined as *the number of different foods or food groups consumed over a given reference period* (Hoddinott & Yisehac, 2002: 4).

It was found that there was a significant correlation ($p<0.01$) between the volume of food consumed by households and total household income, for the sampled households. This finding confirmed the literature that indicated the higher the household income, the higher the quantity of food purchased and consumed (Zezza *et al.*, 2017). This means that the quantities of foods consumed by a household varied with income.

Price, convenience, and food safety perceptions linked to nutrition and health were the three most frequently cited factors considered by households when making choices of what to consume.

It was found that the amounts of waste produced by sampled households were relatively significant when compared to the quantity of food consumed. Of the total food consumed by the household, the low-income household wasted 19.34% of their total consumption, the lower middle-income household wasted 12% of their total consumption, the middle-income household wasted 5.28% of their total consumption, and the upper middle-income household wasted 11.71% of their total consumption.

A larger proportion of the food wasted by the sampled households consisted of avoidable and partially avoidable food waste quantities. These were defined as:

1. **Avoidable food waste** is food that was edible at some point prior to disposal (e.g., a slice of bread, plate residues, etc.).
2. **Possibly avoidable food waste** is waste generated because of different consumer habits (e.g., bread crusts, apple skins, potato peels).
3. **Unavoidable food waste** is food that is not edible and derives from preparation and consumption (e.g., bones, eggshells, coffee grounds, etc.).

This indicates that the sampled household are not necessarily wasteful since a bigger proportion of the food waste that they generate is unavoidable.

It was found that there was no significant correlation ($p=0.16$) between the volume of food generated by households and total household income for the sampled households. This means that the quantities of food waste generated by households did not vary with income.

5.4 Limitations

The weight measurement taken by households was the wet weight of each food item. This gives the weight of both the material and its water content. Some foods such as fruits and vegetables have a significant water content. Not taking this into account may affect the weight recorded for foods wasted if they are not weighed immediately before losing their moisture content.

Due to limited time and resources, the study could only sample a limited number of households for the food diary. The initial sample size was 10 households of a mix of middle- and low-income households. The final sample size was five households after some participants dropped out of the study. Due to this, the results could not be generalised to Cape Town. Even though the sample was not representative, the insights learned from the data collection process did shed some light on some of the dynamics of household food flows and helped illuminate some of the findings from the online survey.

Being a household study, often the person who fills in the diary is the household member in charge of food in the house. This is done to capture a near-accurate account of household food practices. Even with this strategy, it was not possible for the responsible individual to keep track of all foods

eaten by everyone in the household, especially if the foods were taken from the household but eaten outside the household.

5.5 Recommendations for future research

The following recommendations are based on the key findings and limitations identified from the study. They can be used to inform future household food metabolism assessments and research in household food consumption.

Categorising food waste types can prove useful to the formulation of food waste reduction interventions. Future research could on report food waste quantities according to the waste categories avoidable, partially avoidable and unavoidable food waste.

To lower the number of respondent dropouts, food diaries should be conducted for a reasonable period. A 30-day diary is not an ideal duration. The households completed an average of 10 days in total and only one respondent managed to compete the whole 30 days without any incentive. It was observed that most of the respondents who gave detailed information, had interest in their nutrition and knowing more about their food consumption. This was also noted during the participant recruitment drive where households were recruited who were interested in other features that the diary offered, such as information on food expenditure. This offers some insight for future research. As a potential strategy to retain respondents, the researcher could recruit households that have some personal interest in the outcome of the research.

To get information on what households are consuming, it is better to use actual consumption data rather than sourcing data. During the diary period, households were asked to make a note of food types purchased every time they accessed a food source. They were also asked to note down the food types that they ate every day. When compared, it was noted that households were consuming foods that did not feature in their ‘foods purchased’ information. This is likely to be because the households already had some food in stock at the time of the study. This can also be attributed to the household’s shopping routine. For example, if the diary is competed after the household has already shopped, there will be no purchase data to use to estimate household food consumption.

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Appendices

Appendix A: Food consumption section of the online household survey

Appendix B: Household food diary

Appendix C: Household sources for cereals and grains food group

Appendix D: Household sources for fruit food group

Appendix E: Household sources for vegetables, roots & tubers food group

Appendix F: Household sources for dairy products & eggs food group

Appendix G: Household sources for fish & seafood food group

Appendix H: Household sources for meat & poultry food group

Appendix I: Household sources for baked goods food group

Appendix J: Household sources for canned/tinned meat food group

Appendix K: Household sources for canned/tinned fruit & vegetables food group

Appendix A: Food consumption section of the online household survey

Food Consumption Section of the Online Survey

48. In a typical week, how many **full shopping bags of food groceries** does your household **bring home**? (If you only shop once a month, please divide this number of bags by four)

- Less than 1 bag per week
- 1-2 bags
- 3-4 bags
- 5-6 bags
- 7-8 bags
- 9-10 bags
- 11-12 bags
- 13-14 bags
- 15-19 bags
- 20-24 bags
- 25+ bags

49. How much does your household typically **spend on groceries per month**?

- We don't spend money on food
- R1-R99 per month
- R100-R199 per month
- R200-R399 per month
- R400-R599 per month
- R600-R799 per month
- R800-R999 per month
- R1000-R1399 per month
- R1400-R1799 per month
- R1800-R2199 per month
- R2200-R2599 per month
- R2600-R2999per month
- R3000-R3999 per month
- R4000-R4999 per month
- R5000-R5999 per month
- R6000-R7999 per month
- R8000-R9999 per month
- R10,000-R14,999 per month
- R15,000-R19,999 per month
- R20,000 + per month

50. How much does your household typically **spend** on **food outside your home** per month? (restaurants, take-away, markets, street vendors, etc.)

- We don't spend money on food
- R1-R99 per month
- R100-R199 per month
- R200-R399 per month
- R400-R599 per month
- R600-R799 per month
- R800-R999 per month
- R1000-R1399 per month
- R1400-R1799 per month
- R1800-R2199 per month
- R2200-R2599 per month
- R2600-R2999per month
- R3000-R3999 per month
- R4000-R4999 per month
- R5000-R5999 per month
- R6000-R7999 per month
- R8000-R9999 per month
- R10,000-R14,999 per month
- R15,000-R19,999 per month
- R20,000 + per month

51. Where do you typically get your **groceries** from?

	Supermarket	Farmer's market	Local grocer	Street vendor	From Relatives	We grow our own	We don't eat this
Cereals & grains							
Fruit							
Vegetables, roots & tubers							
Dairy products & eggs							
Fish & seafood							
Meat & poultry							
Baked goods							
Canned/tinned meat							
Canned/tinned vegetables							

52. How much meat do you purchase in atypical month?

Red Meat (beef, lamb, ostrich, ...	**Kg or Cans**
White Meat (chicken, pork, ...)	
Fresh / Frozen Fish	
Canned Fish	
Canned Meat	

53. How often do you get your food from the following places?

	Never	Everyday	Several times a week	Once a week	Several times a month	Once a month	Every few months
Supermarket							
Farmer's market / Local market							
Local grocer							
Street vendor							
From relatives							
I grow my own							
Restaurant							
Other (e.g. food aid, in exchange for work)							

54. Please **select** your three most important factors **when choosing food?**

- Food price
- Organic foods
- GM-free foods
- Free range
- Source origin of food (e.g. local or imported)
- Physical appearance of the food
- Type & amount of packaging
- Shelf life of the food
- Storage instructions

55. Where do you usually store your food?

	Fridge/freezer	Pantry/food cupboard	Open counters (Kitchen & table)
Cereals & grains			
Roots & tubers			
Fruits			
Vegetables			
Meat & poultry			
Dairy products & eggs			
Fish & seafood			
Baked goods			
Canned / tinned meat			
Canned / tinned fruit/vegetables			

56. Please select the **2** most common reasons why you would **throw away food?**

- I bought too much food
- I did not store the food per instructions
- I cooked too much food
- Food goes off in the fridge/freezer/cupboard
- I don't label my packed foods
- I have scraps/peels from food preparation or cooking

57. What do you usually do with leftovers?

	We don't produce leftovers	We throw it in the trash	We store it away for later use	It is collected by someone	We compost it	We feed it to the pet (s)
During cooking / preparation						
After meals						

58. How many **black bags of garbage** do you produce in a typical week?

- Less than 1 bag
- 1 bag
- 2 bags
- 3 bags

- 4 bags
- 5+ bags

59. Typically, how **full** are you bags **when you replace them?**

- They are completely full
- They are ¾ full
- They are half full
- They are ¼ full
- They are less than ¼ full

60. How much of the following **wastes** do you produce in **a typical week?**

	none	**Less than ¼ bags**	**¼ bags**	**½ bags**	**¾ bags**	**Full bag**	**2 bags**	**3 bags**	**4+ bags**
Food waste									
Garden waste									
Paper & cardboard									
Glass									
Plastic									
Tin cans & other metals									

Appendix B: Household food diary

Household Food Diary

Instructions

This diary will be used for taking record of what foods your household buys, consumes and disposes off. It will involve 3 simple activities; **keeping track of money spent on food items and the types of foods consumed, weighing food waste items and lastly observing and taking notes on your daily food practices.**

What to do:

Activity 1: Keeping Track of amount spent on food

Once you get home from shopping, keep the receipt of the items purchased. If you bought some of your shopping from a local grocery or a spaza shop, write down the amount spent and then finally note down the total amount spent on all your shopping in the diary.

Activity 2: Weighing food and waste items

After every meal preparation (cooking) and meal, put all leftovers aside for weighing and note down their weight in the diary.

How To:

1. Weigh foods consumed

Before every meal, make sure to weigh the food before cooking or eating it. This includes the ingredients that you use to make your meals as well as the ready-made meals that you buy to eat at home e.g. takeaways eaten at home and any meals that you order in.

2. Weigh 'waste' items

Gather together all foods and leftovers meant for disposal. Ensure that the weighing scale reads "0" and that the unit is "g" (grams) for solids and "ml" (millilitres) for liquids. If it does not read "0", set it back to the "0" by pressing on the "Tare" button at the bottom of the weighing scale. If you are not sure what button this is, read the user manual that came with the scale. Once this is done place the items on the weighing scale and write down their weight in the food diary. Do this for all leftovers and all food before throwing it away.

Activity 3: Observing and Taking Notes

Once you have weighed all your foods and leftovers, write down the reasons for throwing them away.
Explain in detail:

1. **How did it end up being waste?**
2. **Under what circumstances and for what reasons did this happen?**
3. **Was there something you could have done to prevent this from happening? and if no, why not?**

Please Note: For this study, **we shall be tracking the following foods**. Kindly refer to the list below for reference.

Food Group	**Examples**
Cereals & Grains	e.g. Maize, rice, beans, lentils
Roots & Tubers	e.g. potatoes, carrots
Fruits	e.g. oranges, bananas
Vegetables	e.g. spinach, cabbage
Meat & Poultry	e.g. beef, chicken, corn beef
Dairy products & Eggs	e.g. eggs, yoghurt, cheese
Fish & Seafood	e.g. calamari, canned tuna
Baked Goods	e.g. bread, cake, pies

***Please Note**: The 3 activities above shall be carried out every day, for a period of **30 days**. As you fill in your diary every day, please try and be as honest and open as possible about your behaviour and perceptions. Also, try and **reflect about your daily actions and choices and what influences them**. **Try and avoid one-word explanations. Instead, treat this as a personal diary where you narrate every thought in detail.** This will be **a confidential study** and the information shared in these diaries will only be accessible to the researcher and her supervisor so your honesty and openness will be highly appreciated.*

An Example of a Filled Diary

Date: 21/02/2019

Sourcing & Storage

9. How much money do you typically spend on shopping in a month? R1500

10. What foods did you buy today? Fill in the details in the table below

Food Item/Food Group	**Source (where did you get the food from e.g. supermarket)**	**Where did you store it? (e.g. fridge, freezer, placed it on the dining table, etc.)**	**Comments (Any additional Information about why you chose this storage option)**
Fruits (A bunch of bananas, a bag of peaches and a watermelon)	Local grocer	On top of the fridge	Banana -I place them there so that i can remember to eat a fruit a day! Peaches & watermelon - I put in the fridge because i normally store my fruits in the fridge
A loaf of bread	Neighbour	In the bread bin on the kitchen counter	
A packet of milk	Spaza Shop	In the fridge	
A bag of Potatoes	Supermarket	Half in the fridge and half in my cupboard.	I stored half in the fridge to preserve it, and half in my cupboard because I ran out of space in the fridge.

11. How much money did you spend on food purchases today? R118

Consumption & Waste

12. What foods did you eat today and What ended up in the bin today? (Fill in the details in the table below)

As you think about and reflect on the reasons why you threw away food, ask yourself the following questions: **Why do I eat this food? How much of it did I buy? Was there a way I could have kept this food fresh for longer? What could I have done to prevent this food from going to waste?**

What did we eat today/ What did we use to make our meal today?	How much did it weigh?	What did we throw away? (E.g. which part was it?)	How much did it weigh?	Why was it thrown away? (The reason/s for disposal)	How did you dispose of it? (where did it end up?)
Boneless chicken breasts	408g	Partly eaten leftover pieces	193g	I came home hungry and ended up serving too much on my plate and what was left over was partly eaten and i don't see the need of keeping such food in the fridge. I am the only one who can eat it anyway since it was mine in the first place. So, it is just easier to dispose of it	Fed it to my pet
Chicken drumsticks	611g	The whole packet of uneaten drumsticks	611g	There was a promotion. The chicken pack price was marked down so to make a saving on this purchase i bought too many unfortunately. I did put them in the freezer but by the time we got to eating eat, it was way past its expiry date, so we just threw it away.	Trash Bin
Kale	56g	The stems	17g	I do not eat the stems. They are hard and tasteless so it's easier to just throw them away or compost them whenever I can.	Compost
3 Tomatoes	220g	Skin	27g	The skin has a tough texture. I prefer to blend my tomatoes to get a nice paste out of them.	Trash Bin
Tuna salad	150g	Leftovers	50g	In a rush to get into bed, I forgot to keep it in the fridge. By the time I woke up I wasn't sure if the salad was still fresh or not. To be safe I threw it away.	Trash Bin

Milk	400ml	None	None	None	None
4 Eggs	248g	Egg Shells	33g	The shells are not edible	Crushed them and spread them on my veggie patch
1 Cup of Rice	224g	None	None	None	None
5 Slices of Bread	143g	The crust	13g	I don't like eating the crust. It's hard and often tasteless.	Trash Bin

13. Was there a Special Occasion today? (e.g. My roommate had a birthday party, we had friends over for dinner, etc.) No

14. Total weight of food that we ate today 2051**g &** 400**ml**

15. Total weight of food that was thrown away for the day 944**g &** 0**ml**

Any Additional Comments About Today: ……

Diary Section

Demographics

1. In which Suburb do you live? ……

2. How many people of each age and gender are in your household?

Female	Number	Male	Number
0-4 years old		0-4 years old	
5-14 years old		5-14 years old	
15-24 years old		15-24 years old	
25-64 years old		25-64 years old	
65+ years old		65+ years old	

3. What is your household's total monthly gross income? (Tick the box the box that applies)

No Income		R12,801-R25,600	
R1-R1600		R25,601-R51,200	
R1601-R3200		R51,201-R102,400	
R3201-R6400		R102,401-R204,800	
R6401-R12,800		More than R204,801	

4. What is the highest education level in your household? (Tick the box the box that applies)

No Formal Education	
Primary School	
Secondary School	
Technical Certification	
Undergraduate Degree	
Postgraduate Degree	

Provisioning

5. How often do you go grocery shopping?

Every day	
Several times a week	
Once a week	
Several times a month	
Once a month	
Every few months	

5a) For any other routine, please specify: ……

6. Why do you opt for this shopping routine? Please give a short description *e.g. I prefer to buy and eat vegetables fresh on the same day so I buy them so I shop as often as I need a fresh meal*
……

For the next questions, have these foods in mind as you reflect on your responses.

Examples	**Food Group**
e.g. Maize, rice, beans, lentils	Cereals & Grains
e.g. potatoes, carrots	Roots & Tubers
e.g. oranges, bananas, canned pineapples	Fruits
e.g. spinach, cabbage	Vegetables
e.g. beef, chicken, corn beef	Meat & Poultry
e.g. milk, yoghurt, cheese	Dairy products & Eggs
e.g. calamari, canned tuna	Fish & Seafood
e.g. bread, cake, pies	Baked Goods

7. What influences your food choices? For this question, you are asked to reflect on your food choices. Ask yourself the following questions: Why do I eat this food? Why do I choose certain foods over others? What do I consider when I am making the choice on what to eat and what to buy? *E.g. I opt for organic foods because I am conscious about what I eat OR price is my main priority because I have a limited food budget, etc.*

……..

8. Once you have made the choice to buy a food item, how do you make the selection among the options available? *E.g. once you make the choice of buying bananas, how do you select the bananas you want from a pile of them on the shelf?*

…….

Day 1

Date: ……

Sourcing & Storage

9. How much money do you typically spend on shopping in a month?.....

10. What foods did you buy today? Fill in the details in the table below

Food Item/Food Group	Source (where did you get the food from e.g. supermarket)	Where did you store it? (e.g. fridge, freezer, placed it on the dining table, etc.)	Comments (Any additional Information about why you chose this storage option)

11. How much money did you spend on food purchases today? ……..

Consumption & Waste

12. What foods did we eat today? Which ones ended up as waste? (Fill in the details in the table below) As you think about and reflect on the reasons why you threw away food, ask yourself the following questions: **Why do I eat this food? How much of it did I buy? Was there a way I could have kept this food fresh for longer? What could I have done to prevent this food from going to waste?**

What did we eat today/ What did we use to make our meal today?	How much did it weigh?	What did we throw away? (E.g. which part was it?)	How much did it weigh?	Why was it thrown away? (The reason/s for disposal)	How did you dispose of it? (where did it end up?)

13. Was there a Special Occasion today? (e.g. My roommate had a birthday party, we had friends over for dinner, e.t.c.) .....

14. Total weight of food that we ate today…….grams & ……ml

15. Total weight of food that was thrown away for the day……g & ……..ml

Any Additional Comments About Today: ……

Appendix C: Household sources for Cereals and Grains food group

Row Totals		Superm arket	Farmer's Market	Local grocer	Street vendor	Relatives	We grow our own	We don't eat this
9	No income	5	0	3	1	0	1	0
	Row %	55.56 %	0.00%	33.33 %	11.11 %	0.00%	11.11 %	0.00%
25	R 1 - R 1 600	20	2	9	8	5	0	0
	Row %	80.00 %	8.00%	36.00 %	32.00 %	20.00%	0.00 %	0.00%
41	R 1 601 - R 3 200	34	1	16	10	1	0	0
	Row %	82.93 %	2.44%	39.02 %	24.39 %	2.44%	0.00 %	0.00%
63	R 3 201 - R 6 400	55	1	21	11	4	1	0
	Row %	87.30 %	1.59%	33.33 %	17.46 %	6.35%	1.59 %	0.00%
63	R 6 401 - R 12 800	49	7	23	15	0	0	1
	Row %	77.78 %	11.11%	36.51 %	23.81 %	0.00%	0.00 %	1.59%
96	R 12 801 - R 25 600	72	8	16	8	2	0	1
	Row %	75.00 %	8.33%	16.67 %	8.33%	2.08%	0.00 %	1.04%
124	R 25 601 - R 51 200	75	4	9	2	0	0	7
	Row %	60.48 %	3.23%	7.26%	1.61%	0.00%	0.00 %	5.65%
59	R 51 201 - R 102 400	36	0	4	0	0	0	2
	Row %	61.02 %	0.00%	6.78%	0.00%	0.00%	0.00 %	3.39%
21	R 102 401 - R 204 800	11	2	3	0	0	0	0
	Row %	52.38 %	9.52%	14.29 %	0.00%	0.00%	0.00 %	0.00%
9	More than R 204 801	7	0	1	0	0	0	0
	Row %	77.78 %	0.00%	11.11 %	0.00%	0.00%	0.00 %	0.00%
	Totals	364	25	105	55	12	2	11

Appendix D: Household sources for Fruit food group

Row Totals		Supermarket	Farmer's Market	Local grocer	Street vendor	Relatives	We grow our own	We don't eat this
9	No income	5	1	1	1	0	0	0
	Row %	55.56 %	11.11%	11.11 %	11.11 %	0.00%	0.00 %	0.00 %
25	R 1 - R 1 600	10	2	6	16	2	0	2
	Row %	40.00 %	8.00%	24.00 %	64.00 %	8.00%	0.00 %	8.00 %
41	R 1 601 - R 3 200	18	3	8	21	1	0	2
	Row %	43.90 %	7.32%	19.51 %	51.22 %	2.44%	0.00 %	4.88 %
63	R 3 201 - R 6 400	41	6	17	35	2	0	0
	Row %	65.08 %	9.52%	26.98 %	55.56 %	3.17%	0.00 %	0.00 %
63	R 6 401 - R 12 800	45	9	22	25	3	1	0
	Row %	71.43 %	14.29%	34.92 %	39.68 %	4.76%	1.59 %	0.00 %
96	R 12 801 - R 25 600	58	21	17	19	0	2	0
	Row %	60.42 %	21.88%	17.71 %	19.79 %	0.00%	2.08 %	0.00 %
124	R 25 601 - R 51 200	72	16	16	10	2	1	0
	Row %	58.06 %	12.90%	12.90 %	8.06%	1.61%	0.81 %	0.00 %
59	R 51 201 - R 102 400	36	8	6	4	1	1	0
	Row %	61.02 %	13.56%	10.17 %	6.78%	1.69%	1.69 %	0.00 %
21	R 102 401 - R 204 800	10	2	6	0	0	0	0
	Row %	47.62 %	9.52%	28.57 %	0.00%	0.00%	0.00 %	0.00 %
9	More than R 204 801	5	1	1	2	0	0	0
	Row %	55.56 %	11.11%	11.11 %	22.22 %	0.00%	0.00 %	0.00 %
	Totals	300	69	100	133	11	5	4

Appendix E: Household sources for Vegetables, Roots & Tubers food group

Row Totals		Superm arket	Farmer's Market	Local grocer	Street vendor	Relatives	We grow our own	We don't eat this
9	No income	4	1	1	1	0	0	No variance
	Row %	44.44 %	11.11%	11.11 %	11.11%	0.00%	0.00%	
25	R 1 - R 1 600	12	3	6	15	5	0	
	Row %	48.00 %	12.00%	24.00 %	60.00%	20.00%	0.00%	
41	R 1 601 - R 3 200	21	4	10	23	1	0	
	Row %	51.22 %	9.76%	24.39 %	56.10%	2.44%	0.00%	
63	R 3 201 - R 6 400	44	6	17	33	2	1	
	Row %	69.84 %	9.52%	26.98 %	52.38%	3.17%	1.59%	
63	R 6 401 - R 12 800	47	10	23	24	2	3	
	Row %	74.60 %	15.87%	36.51 %	38.10%	3.17%	4.76%	
96	R 12 801 - R 25 600	58	22	14	21	1	1	
	Row %	60.42 %	22.92%	14.58 %	21.88%	1.04%	1.04%	
124	R 25 601 - R 51 200	71	18	15	9	2	7	
	Row %	57.26 %	14.52%	12.10 %	7.26%	1.61%	5.65%	
59	R 51 201 - R 102 400	38	10	7	3	0	6	
	Row %	64.41 %	16.95%	11.86 %	5.08%	0.00%	10.17%	
21	R 102 401 - R 204 800	9	3	5	0	0	2	
	Row %	42.86 %	14.29%	23.81 %	0.00%	0.00%	9.52%	
9	More than R 204 801	5	2	0	3	0	0	
	Row %	55.56 %	22.22%	0.00%	33.33%	0.00%	0.00%	
	Totals	309	79	98	132	13	20	

Appendix F: Household sources for Dairy Products & Eggs food group

Row Totals		Supermarket	Farmer's Market	Local grocer	Street vendor	Relatives	We grow our own	We don't eat this
9	No income	5	0	2	0	0	0	0
	Row %	55.56 %	0.00%	22.22%	0.00%	0.00%	0.00 %	0.00%
25	R 1 - R 1 600	19	2	7	3	3	0	1
	Row %	76.00 %	8.00%	28.00%	12.00%	12.00%	0.00 %	4.00%
41	R 1 601 - R 3 200	31	2	15	4	0	0	0
	Row %	75.61 %	4.88%	36.59%	9.76%	0.00%	0.00 %	0.00%
63	R 3 201 - R 6 400	52	4	26	9	2	0	0
	Row %	82.54 %	6.35%	41.27%	14.29%	3.17%	0.00 %	0.00%
63	R 6 401 - R 12 800	49	6	24	13	1	0	0
	Row %	77.78 %	9.52%	38.10%	20.63%	1.59%	0.00 %	0.00%
96	R 12 801 - R 25 600	67	9	23	1	0	1	2
	Row %	69.79 %	9.38%	23.96%	1.04%	0.00%	1.04 %	2.08%
124	R 25 601 - R 51 200	77	11	9	2	1	0	1
	Row %	62.10 %	8.87%	7.26%	1.61%	0.81%	0.00 %	0.81%
59	R 51 201 - R 102 400	39	4	4	0	0	1	1
	Row %	66.10 %	6.78%	6.78%	0.00%	0.00%	1.69 %	1.69%
21	R 102 401 - R 204 800	9	3	4	0	0	0	0
	Row %	42.86 %	14.29%	19.05%	0.00%	0.00%	0.00 %	0.00%
9	More than R 204 801	6	0	1	1	0	0	0
	Row %	66.67 %	0.00%	11.11%	11.11%	0.00%	0.00 %	0.00%
	Totals	354	41	115	33	7	2	5

Appendix G: Household sources for Fish & Seafood food group

Row Totals		Superm arket	Farmer's Market	Local grocer	Street vendor	Relatives	We grow our own	We don't eat this
9	No income	3	0	0	0	0	0	3
	Row %	33.33 %	0.00%	0.00%	0.00%	0.00%	0.00%	33.33 %
25	R 1 - R 1 600	12	3	0	5	0	0	6
	Row %	48.00 %	12.00%	0.00%	20.00%	0.00%	0.00%	24.00 %
41	R 1 601 - R 3 200	28	2	6	7	0	0	2
	Row %	68.29 %	4.88%	14.63%	17.07%	0.00%	0.00%	4.88%
63	R 3 201 - R 6 400	40	3	14	9	1	0	8
	Row %	63.49 %	4.76%	22.22%	14.29%	1.59%	0.00%	12.70 %
63	R 6 401 - R 12 800	41	5	8	7	1	1	8
	Row %	65.08 %	7.94%	12.70%	11.11%	1.59%	1.59%	12.70 %
96	R 12 801 - R 25 600	59	2	9	3	1	0	10
	Row %	61.46 %	2.08%	9.38%	3.13%	1.04%	0.00%	10.42 %
124	R 25 601 - R 51 200	67	5	6	2	2	2	12
	Row %	54.03 %	4.03%	4.84%	1.61%	1.61%	1.61%	9.68%
59	R 51 201 - R 102 400	31	2	4	0	2	0	6
	Row %	52.54 %	3.39%	6.78%	0.00%	3.39%	0.00%	10.17 %
21	R 102 401 - R 204 800	8	2	4	0	0	0	0
	Row %	38.10 %	9.52%	19.05%	0.00%	0.00%	0.00%	0.00%
9	More than R 204 801	8	0	0	1	0	0	0
	Row %	88.89 %	0.00%	0.00%	11.11%	0.00%	0.00%	0.00%
	Totals	297	24	51	34	7	3	55

Appendix H: Household sources for Meat & Poultry food group

Row Totals		Superm arket	Farmer's Market	Local grocer	Street vendor	Relatives	We grow our own	We don't eat this
9	No income	5	1	1	0	0	0	0
	Row %	55.56 %	11.11%	11.11%	0.00%	0.00%	0.00%	0.00%
25	R 1 - R 1 600	20	4	6	3	1	0	0
	Row %	80.00 %	16.00%	24.00%	12.00 %	4.00%	0.00%	0.00%
41	R 1 601 - R 3 200	32	3	9	6	2	0	1
	Row %	78.05 %	7.32%	21.95%	14.63 %	4.88%	0.00%	2.44%
63	R 3 201 - R 6 400	55	3	17	8	2	0	1
	Row %	87.30 %	4.76%	26.98%	12.70 %	3.17%	0.00%	1.59%
63	R 6 401 - R 12 800	51	8	15	11	3	0	2
	Row %	80.95 %	12.70%	23.81%	17.46 %	4.76%	0.00%	3.17%
96	R 12 801 - R 25 600	61	12	9	1	1	1	5
	Row %	63.54 %	12.50%	9.38%	1.04%	1.04%	1.04%	5.21%
124	R 25 601 - R 51 200	69	7	13	0	2	0	5
	Row %	55.65 %	5.65%	10.48%	0.00%	1.61%	0.00%	4.03%
59	R 51 201 - R 102 400	36	5	7	0	1	1	0
	Row %	61.02 %	8.47%	11.86%	0.00%	1.69%	1.69%	0.00%
21	R 102 401 - R 204 800	10	1	5	0	0	0	1
	Row %	47.62 %	4.76%	23.81%	0.00%	0.00%	0.00%	4.76%
9	More than R 204 801	7	1	1	0	0	0	0
	Row %	77.78 %	11.11%	11.11%	0.00%	0.00%	0.00%	0.00%
	Totals	346	45	83	29	12	2	15

Appendix I: Household sources for Baked Goods food group

Row Totals		Super market	Farmer's Market	Local grocer	Street vendor	Relatives	We grow our own	We don't eat this
9	No income	5	0	1	0	0	0	1
	Row %	55.56 %	0.00%	11.11 %	0.00%	0.00 %	0.00%	11.11 %
25	R 1 - R 1 600	13	2	9	2	1	0	2
	Row %	52.00 %	8.00%	36.00 %	8.00%	4.00 %	0.00%	8.00 %
41	R 1 601 - R 3 200	27	2	17	5	0	1	0
	Row %	65.85 %	4.88%	41.46 %	12.20 %	0.00 %	2.44%	0.00 %
63	R 3 201 - R 6 400	44	1	31	6	4	0	1
	Row %	69.84 %	1.59%	49.21 %	9.52%	6.35 %	0.00%	1.59 %
63	R 6 401 - R 12 800	47	3	18	9	1	1	1
	Row %	74.60 %	4.76%	28.57 %	14.29 %	1.59 %	1.59%	1.59 %
96	R 12 801 - R 25 600	55	4	23	5	1	4	6
	Row %	57.29 %	4.17%	23.96 %	5.21%	1.04 %	4.17%	6.25 %
124	R 25 601 - R 51 200	67	7	19	3	2	4	7
	Row %	54.03 %	5.65%	15.32 %	2.42%	1.61 %	3.23%	5.65 %
59	R 51 201 - R 102 400	32	2	8	0	0	1	3
	Row %	54.24 %	3.39%	13.56 %	0.00%	0.00 %	1.69%	5.08 %
21	R 102 401 - R 204 800	9	2	4	0	0	0	3
	Row %	42.86 %	9.52%	19.05 %	0.00%	0.00 %	0.00%	14.29 %
9	More than R 204 801	6	1	2	1	0	0	0
	Row %	66.67 %	11.11%	22.22 %	11.11 %	0.00 %	0.00%	0.00 %
	Totals	305	24	132	31	9	11	24

Appendix J: Household sources for Canned/tinned Meat food group

Row Totals		Super market	Farmer's Market	Local grocer	Street vendor	Relatives	We grow our own	We don't eat this
9	No income	4	0	1	0	0	0	2
	Row %	44.44 %	0.00%	11.11 %	0.00%	0.00 %	0.00 %	22.22 %
25	R 1 - R 1 600	14	2	4	5	1	0	5
	Row %	56.00 %	8.00%	16.00 %	20.00 %	4.00 %	0.00 %	20.00 %
41	R 1 601 - R 3 200	27	1	8	3	1	0	7
	Row %	65.85 %	2.44%	19.51 %	7.32%	2.44 %	0.00 %	17.07 %
63	R 3 201 - R 6 400	48	2	19	7	4	1	5
	Row %	76.19 %	3.17%	30.16 %	11.11 %	6.35 %	1.59 %	7.94 %
63	R 6 401 - R 12 800	45	4	15	4	0	0	6
	Row %	71.43 %	6.35%	23.81 %	6.35%	0.00 %	0.00 %	9.52 %
96	R 12 801 - R 25 600	55	1	10	2	0	1	18
	Row %	57.29 %	1.04%	10.42 %	2.08%	0.00 %	1.04 %	18.75 %
124	R 25 601 - R 51 200	64	2	8	1	0	0	21
	Row %	51.61 %	1.61%	6.45 %	0.81%	0.00 %	0.00 %	16.94 %
59	R 51 201 - R 102 400	25	1	1	0	0	0	16
	Row %	42.37 %	1.69%	1.69 %	0.00%	0.00 %	0.00 %	27.12 %
21	R 102 401 - R 204 800	8	0	0	0	0	0	6
	Row %	38.10 %	0.00%	0.00 %	0.00%	0.00 %	0.00 %	28.57 %
9	More than R 204 801	6	0	0	0	0	0	2
	Row %	66.67 %	0.00%	0.00 %	0.00%	0.00 %	0.00 %	22.22 %
	Totals	296	13	66	22	6	2	88

Appendix K: Household sources for Canned/tinned Fruit & Vegetable food group

Row Totals		Superm arket	Farmer's Market	Local grocer	Street vendor	Relatives	We grow our own	We don't eat this
9	No income	3	0	0	0	0	0	3
	Row %	33.33 %	0.00%	0.00%	0.00%	0.00%	0.00%	33.33 %
25	R 1 - R 1 600	13	2	4	4	2	0	4
	Row %	52.00 %	8.00%	16.00%	16.00%	8.00%	0.00%	16.00 %
41	R 1 601 - R 3 200	29	2	6	5	0	0	5
	Row %	70.73 %	4.88%	14.63%	12.20%	0.00%	0.00%	12.20 %
63	R 3 201 - R 6 400	47	5	19	8	3	1	4
	Row %	74.60 %	7.94%	30.16%	12.70%	4.76%	1.59%	6.35%
63	R 6 401 - R 12 800	50	4	13	7	2	0	2
	Row %	79.37 %	6.35%	20.63%	11.11%	3.17%	0.00%	3.17%
96	R 12 801 - R 25 600	60	1	14	3	0	1	13
	Row %	62.50 %	1.04%	14.58%	3.13%	0.00%	1.04%	13.54 %
124	R 25 601 - R 51 200	66	2	8	2	1	0	18
	Row %	53.23 %	1.61%	6.45%	1.61%	0.81%	0.00%	14.52 %
59	R 51 201 - R 102 400	30	0	1	0	0	0	11
	Row %	50.85 %	0.00%	1.69%	0.00%	0.00%	0.00%	18.64 %
21	R 102 401 - R 204 800	8	0	1	0	0	0	5
	Row %	38.10 %	0.00%	4.76%	0.00%	0.00%	0.00%	23.81 %
9	More than R 204 801	5	0	0	0	0	0	3
	Row %	55.56 %	0.00%	0.00%	0.00%	0.00%	0.00%	33.33 %
	Totals	311	16	66	29	8	2	68