BEHAVIOURAL ANALYSIS IN MANAGEMENT AND COMMERCIALISATION OF AGRO-FOOD WASTE AMONG URBAN AGRO-PRODUCER HOUSEHOLDS IN KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Doctor of Philosophy Degree in Agribusiness Management of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented in this university or any other for the award of a degree.

Sign…………………………………………………… Date…25/10/2021…..……………….

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Recommendation

This thesis has been submitted with our approval as University supervisors.

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DEDICATION

Dedicated to my family (Carol, Ray and Ritah) for their unconditional support during the entire period of my studies.

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ABSTRACT

In Kenya, most of the waste generated in the urban supply chains end up in dumpsites. Agro-food waste is no different although there are indications that a portion of it is utilised as input in urban agriculture. Despite this, there is limited empirical evidence on agro-food waste management and commercial utilisation behaviour among urban agro-producer households. The study (i) assessed the drivers of agro-food waste typologies generation, (ii) assessed the role of contextual factors in the choice of agro-food waste management practices, (iii) determined factors influencing agro-food waste commercial utilisation behaviour and (iv) evaluated the determinants of demand for agro-food waste among urban agro-producer households. The study sample constituted 456 agro-producer households and 48 key informant interviews drawn from Nairobi City County. Fractional response, multivariate probit, structural equation and linear almost ideal demand system models were used to assess waste generation, choice of management practices, commercial utilization behaviour and waste demand respectively. Findings indicated that the daily per capita agro-food waste generated was 11.42kg (food waste 0.67kg and agricultural waste 10.75kg). Household agricultural inputs budget showed a higher allocation towards conventional inputs (0.73) compared to agro-food waste (0.27). Furthermore, other households constituted the most preferred source (30.85%) of agro-food waste utilised whereas waste emanating from processors had the highest budget allocation of 26.60% in agro-producer households. Fractional Response model output indicated that age, number of enterprises, perceived behavioural control and attitude were among the most important drivers of agro-food waste generation. Knowledge variables (waste sorting and urban agriculture knowledge) largely had influence on agro-food waste management options and safety practices in Multivariate probit model. Structural equation model indicated that commercial utilisation intention, risk perceptions and perceived behavioural control had significant influence on the commercial utilisation behaviour which implied that intention largely transitioned to behaviour. The model could explain 79.1% of the commercial utilisation behaviour variance. Based on the Linear Approximation of Almost Ideal Demand System, expenditure elasticities for agro-food waste sourced from restaurants (0.6998), agro-markets (1.1988), processors (1.7481), own (0.8640) and other (0.8970) households were normal goods whereas dumpsite (-0.0769) waste was an inferior commodity. Although uncoordinated, the demand aspects implied that waste market was in existence and developing. Overall, participatory tailor-made education programs would likely enhance agro-food waste management and supply chain coordination as such streamlining the waste market in Kenya.

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LIST OF ABBREVIATIONS AND ACRONYMS

ETPB	Extended Theory of Planned Behaviour
FAO	Food and Agriculture Organization of the United Nations
ISWA	International Solid Waste Management Association
KNBS	Kenya National Bureau of Statistics
LA-AIDS	Linear Approximation of an Almost Ideal Demand System
MNL	Multinomial Logit
MVP	Multivariate Probit
NACOSTI	National Commission for Science, Technology and Innovation
NEMA	National Environment Management Authority
OLS	Ordinary Least Squares
QUAIDS	Quadratic Almost Ideal Demand System
RoK	Republic of Kenya
SDG	Sustainable Development Goal
SEM	Structural Equation Modelling
UNEP	United Nations Environmental Programme
UNSD	United Nations Statistics Division

CHAPTER ONE
INTRODUCTION

1.1 Background information

Waste is largely an issue of global importance. Since it affects public health and environment, it is a societal issue that concerns every individual. More so, waste has a direct relationship to the societal behaviour on production and consumption (Wilson *et al.*, 2015). Recently, its global perspective has fundamentally transitioned from waste disposal to waste management and perception as waste to a resource as such requiring resource management approach. In essence, there is increasingly a paradigm shift from 'waste as a problem' to 'waste as an opportunity,' resulting to a circular economy (Malinauskaite *et al.*, 2017; Wilson *et al.*, 2015). According to UNSD and UNEP (2010), waste refers to "materials that are not prime products for which the generator has no further use for his own purpose of production, transformation or consumption, and which he discards, or intends or is required to discard." However, upon recovery, re-use or recycling at the source of generation, these materials cease to be waste (UNSD & UNEP, 2010). Based on the International Standard Industrial Classification of all Economic Activities, UNSD and UNEP (2010) classified waste into household, manufacturing, and agriculture, forestry and fishing among others.

Notwithstanding the UNSD and UNEP (2010) classification, agricultural-related waste emanating from the urban food system (households, markets, industries, and restaurants) can be categorized into agricultural and food waste. Essentially, agricultural waste arises from agricultural related activities including production (crop residue and animal waste), distribution (market) and processing (agro-industrial by-products) of agriculture, forestry and fishery resources (Agamuthu, 2009; Nagendran, 2011). Closely related to agricultural waste, food waste encompass food that is acquired for human consumption but drawn out from the food supply chain with the intention of disposal or for recovery and may include edible and inedible parts of food (Östergren *et al.*, 2014). However, there is no consensus on food waste definition since what may be considered as waste by an individual or in each setting may not be waste to other individuals, settings or regions.

Annual global agricultural waste has been estimated at 998 million tonnes (Obi *et al.*, 2016) and it has been rapidly increasing (Xue *et al.*, 2016). The United Nations Sustainable Development Goal (SDG) 12 advocates for responsible production and consumption. Proper management practises of agricultural and food waste (agro-food waste) generated in food supply chains are a basis for resource use efficiency (Dri *et al.*, 2018; UN, 2017a).

Conspicuously, as 821 million people are food insecure across the world (FAO *et al.*, 2018), a third of global food supply goes to waste annually; an estimated 1.3-1.6 billion tonnes (Elks, 2018; Gustavsson *et al.*, 2011). This amount of food could be enough to feed 2 billion people if it was not wasted (Huber, 2017) and could reduce greenhouse gas emissions by 9% (Wilson *et al.*, 2015). An increase in global population from 7.6 billion in 2017 to 8.6 billion by 2030 (UN, 2017b) and urban population rise from 55 to 60 per cent in 2018 to 2030 respectively (UN, 2018a, 2018b) is expected to result to higher food waste. According to Elks (2018), food waste is projected to rise by approximately a third annually to 2.1 billion tonnes by 2030.

High- and medium-income countries are the highest contributors of food waste compared to low-income countries. Notably however, food waste in high and medium economies mainly happens in the consumption stage whereas in low-income economies it occurs in earlier stages of the food supply chain (Gustavsson *et al.*, 2011). This scenario is an indicator that most Sub-Saharan Africa countries which are mostly in the low-income bracket experience agro-food waste in the pre- and post-harvest stages in the food supply chain. This waste is associated with management practises, weather, pest and diseases, seed quality, distribution, storage and handling (Emana *et al.*, 2017). Indeed, considering agro-producers have production and consumption aspects, their waste may even be higher, *ceteris paribus*. However, with the changing population structure in terms of urbanization, globalization, economic growth, industrialization and per capita income, food waste is increasingly happening in developing countries' food supply chains (Singhal & Lipinski, 2015; Thyberg & Tonjes, 2016). This could be the case with Kenya which has recently been re-classified as a lower medium-income country (Index Mundi, 2017; World Bank Group, 2017). Similarly, an effort to supply the growing urban population with sufficient food, agricultural waste mostly originating from rural areas is on the rise in urban areas (Tefft *et al.*, 2017; Winfield, 1973). For instance, over 70 per cent of urban waste in Nairobi City is organic, an indicator that it is mostly of agro-food type (Ayaga *et al.*, 2004).

Presently, the legality of urban agriculture is not clear due to contradicting existing laws (Owuor *et al.*, 2017) but already over 20 per cent of Nairobi households practise smallholder crop production (Lee-smith, 2010). The devolved nature of agriculture in Kenya, a change from the past, may contribute to improved attention to urban agriculture in a way it suits specific Counties, unlike the general agriculture act. For instance, the enactment of Nairobi City County Urban Agriculture Promotion and Regulation Act, 2015 is an indicator that the County government has the intention of streamlining urban agriculture. Among the objectives of the

Act is the institutionalisation of procedures for accessing agricultural resources such as organic waste and capacity building through extension services (RoK, 2015). This aspect would potentially address the waste segregation challenge that developing countries (Kassaye, 2018) such as Kenya continue to face. Additionally, the Act aims at monitoring the social, economic and environmental effects of urban agriculture. This points to government intention to promote best practise and recognition of urban agriculture as an alternative source of income for the urban population (RoK, 2015). In creating awareness and perhaps an indicator of urban agriculture legality, the City government has gone further to launching agricultural projects in its sub-counties (Mathai, 2016). This effort may further be strengthened by the Nairobi City County Integrated Development Plan 2018-2022 which listed urban agriculture as a priority area (RoK, 2018) as well as the proposed national Sustainable Waste Management Act, 2019 (RoK, 2019).

A significant portion of the urban population in Kenya is food poor; 24 per cent in core-urban and 29 per cent in peri-urban areas). On overall, poverty levels of core-urban and peri-urban dwellers are 29 and 28 per cent, respectively, an indicator of likely resource constrained status (KNBS, 2015). Although food waste is higher in urban settings, agricultural waste emanating from rural areas is also on the rise. This presents agro-food waste as an opportunity, that is as a factor of production that may have a lower average cost (Zu Ermgassen *et al.*, 2016) and thus, more accessible among low-income category households than conventional inputs (ETC-UA, 2006). Arguably, one man's waste is another man's treasure (Nygren, 2014). In this respect, low-chemical-input urban and peri-urban agriculture may offer an alternative source of food and income for the unemployed and underemployed urban population categories, a coping strategy. Urban agriculture is also flaunted as an avenue for managing agro-food waste associated with distribution since shorter distances are made in the urban food system, improved recycling and reduced greenhouse gas emissions. Utilisation of agro-food waste in urban agriculture leaves lesser organic waste for urban residents and authorities to deal with, which translates to reduced cost of management (ETC-UA, 2006; Lanarc, 2013) while benefiting the users (Anastasiou *et al.*, 2014). Though with limited documentation, in Kenya there are indications of informal commercial utilisation of agro-food waste as animal feed and compost (FAO, 2012; Karanja *et al.*, 2010). Elsewhere in Asia (India, South Korea, China, Sri-Lanka) waste is regarded as important and is industrially processed for use as animal feeds and fertilizer (Bakshi *et al.*, 2016; Dubbeling *et al.*, 2016; Nandan *et al.*, 2017; Nygren, 2014; Salemdeeb *et al.*, 2017).

Most often waste has been considered useless but economically it represents lost time, effort and other productive resources (Ghosh *et al.*, 2016). Waste has been used in insults such as "*takataka*" meaning "absence of values," an indicator of the low appeal of waste. Provision of credible information on agro-food waste regarding the already existing practises provides leeway in understanding household agro-food waste management and commercial utilisation behaviour. Furthermore, agro-food waste accessibility presents an opportunity for urban households to commercialise urban agriculture. This may probably change the narrative of "*takataka*" to "resource" regarding the role of agro-food waste in the urban food system.

1.2 Statement of the problem

Idiomatically, it has been said that "one man's waste is another man's treasure." Whereas the statement is endowed with potential economic benefits from waste, inadequate attention has been directed towards the agro-food waste cycle particularly in developing countries where most of the waste generated in urban areas end up being dumped. Currently, research is more inclined towards environmental effects of waste. In the Kenyan context, there are indications that a portion of agro-food waste in urban areas is utilised as input in urban agriculture, waste to wealth transformation. As much as waste management in urban Kenya is a public service, there is dearth of knowledge on waste management efforts at the household level. The generation, safety risk practices, demand dynamics and utilisation of agro-food waste in relation to urban agriculture remain unclear. Therefore, by understanding these perspectives, urban agriculture commercial inclinations would be revealed as a basis for improvement of the livelihoods of the urban households. As such, the study sought to document the knowledge gap regarding management and commercial utilisation behaviour towards agro-food waste among urban agro-producer households in Kenya.

1.3 Objectives

The overall objective of the study is to contribute to enhanced management and commercialisation of agro-food waste through behavioural analysis for improved livelihoods among urban agro-producer households in Kenya.

1.3.1 Specific objectives

i. To assess the drivers of agro-food waste typologies generation among urban agro-producer households in Kenya.

ii. To assess the role of contextual factors in the choice of agro-food waste management practises among urban agro-producer households in Kenya.

iii. To determine factors influencing agro-food waste commercial utilisation behaviour among urban agro-producer households in Kenya.

iv. To evaluate the determinants of demand for agro-food waste among urban agro-producer households in Kenya.

1.4 Research questions

i. What are the drivers of agro-food waste typologies generation among urban agro-producer households in Kenya?

ii. What is the role of contextual factors in the choice of agro-food waste management practises among urban agro-producer households in Kenya?

iii. What factors influence agro-food waste commercial utilisation behaviour among urban agro-producer households in Kenya?

iv. What factors determine demand for agro-food waste among urban agro-producer households in Kenya?

1.5 Justification of the study

Through the provision of requisite information on agro-food waste management and commercial utilisation, households especially those that are resource-constrained and/or environmentally conscious can exploit the agro-food waste benefits. Moreover, the study findings provide an important basis for commercialisation of agro-food waste and as a result improved livelihood. This would be a step towards supporting the resource cycle globally (Dubbeling *et al.*, 2016; Malinauskaite *et al.*, 2017; Wilson *et al.*, 2015).

The findings of this study are expected to contribute to increased appeal for informed policy in exploitation and sustainable agro-food waste management in urban areas. The study findings have brought to the fore and likely popularized agro-food waste safety risk management practises meant to improve food safety in the urban food system. The study has contributed to agro-food waste literature (which is still scarce) especially in developing countries (Chauhan *et al.*, 2018; Geislar, 2018; Setti *et al.*, 2016; Singhal & Lipinski, 2015).

Furthermore, SDG 12 seeks to improve data on food wastage which makes this study a small step towards it (UN, 2017a). The likely beneficiaries of this research would be the urban food supply chain actors such as County governments, private entities, opinion shapers, policymakers, processors, urban residents, producers and consumers.

1.6 Scope and limitation of the study

The study encompassed cross-sectional data collection on agro-food waste management and commercial utilisation by urban agro-producer households. Crop, livestock and mixed farming practitioners were considered. A fourteen day and three months' recall periods were adopted for agro-food waste generated within the household, and urban agriculture practices and waste acquired externally, respectively. To eliminate the likely inconsistency, the data was converted to daily and monthly equivalents as required. A household was considered as an agro-producer household if it had its own agricultural produce market orientation. Since other agro-food waste chain actors are critical in food supply chain, their contribution was assessed from agro-producers' facilitation and or sources of waste aspects. The study was conducted at the end of main rainy season (June-July) and onset of dry season (August) to reduce adverse seasonal effects.

1.7 Definition of terms

Agro-food waste refers to agricultural and food waste; materials that are non-prime and arises from agriculture, forestry and fishery supply chains, and food that is intended for human consumption but for varying reasons not used as such. Excluding liquid waste.

Agro-producer an urban household that is involved in urban agriculture and at least sells part or all the urban produced agricultural products from one or more enterprises it practises.

Commercialisation refers to urban household's agri-enterprise utilisation of agro-food waste input with an output market objective.

Contextual factors refer to factors that characterize the settings in which urban households operate in, that is socioeconomic and institutional factors.

Inedible food waste refers to residue emanating from food preparation and parts of food that are generally accepted as inedible by humans such as peels, shells, meat bone, beverage residue, some fruit seeds, vegetable covers and hard stalks. Otherwise, edible food waste.

Management refers to deliberate action by agro-producer households in getting rid of agro-food waste and ensuring safety in utilisation in urban areas.

Participants refers to households that were involved in the crop, livestock and mixed farming systems among the sampled agro-producers. Otherwise, those who did not participate in either of the systems were considered non-participants.

Waste management practices refers to activities carried out by an urban agro-producer household in relation to minimizing, putting to use, giving out or selling and getting rid of agro-food waste generated as well as activities aimed at minimizing or eliminating likely harm arising from use of agro-food waste through sorting, cleaning, heating, composting, mixing with dry feeds and salt, and specific sourcing.

Waste utilisation refers to recovery, reuse and recycling of waste in urban agriculture related activities such as animal feeding and composting.

CHAPTER TWO

LITERATURE REVIEW

2.1 Drivers of agro-food waste generation in households

Whereas research and policy discourses discourage food waste, its generation continue to soar in both developed and developing countries (Elks, 2018; FAO *et al.*, 2018; Huber, 2017). This trend continues even in cases where food waste has been associated with economic loss (Ghosh, 2016; Koivupuro *et al.*, 2012;). For instance, Yaqub (2016) indicated that an estimated 120-170 kg/year per capita of food waste is generated in sub-Saharan Africa compared to 280-300 kg/year per capita generated in Europe and North America. In this regard, numerous studies on minimizing food waste have been conducted (Annunziata *et al.*, 2020; Cecere *et al.*, 2014; Geislar, 2018; Mu'azu *et al.*, 2018). Over the last decade, food waste generation in consumer households has been studied in both developed and developing countries. The common aspects of research has been the cause of food waste generation irrespective of the typology (Grasso *et al.*, 2019; Irani *et al.*, 2018; Wegedie, 2018). Perhaps, the existing waste management challenges especially in developing countries are contributed by failure to understand waste typologies generated by various actors.

Although large amount of resources are allocated to waste collection, most urban areas in developing countries are faced with solid waste management challenges (Guerrero *et al.*, 2013). The waste management situation is worsened by absence of reliable data on waste generation and composition which would enable formulation of optimal waste management strategic plans (Bing *et al.*, 2016; Guerrero *et al.*, 2013; Zia *et al.*, 2017). This implies that waste characterization which is critical in waste management is largely absent. Understanding of waste characteristics presents an opportunity in reduction of pollution related to air, soil and water (Zia *et al.*, 2017) which are associated to climate change (FAO, 2015). Furthermore, waste characterization is a basis for lifecycle assessment approaches in better waste management (Maalouf & El-fadel, 2019) through just-in-time management.

Waste typologies have often been used as a basis for characterizing waste generated. Like food waste characterization, agricultural waste is increasingly gaining a global appeal and concern especially regarding its value and environmental impact. Even so, there are few studies on agricultural waste in developing countries more so in urban areas in quest to satisfy the food needs of the increasing urban population (Anastasiou *et al.*, 2014; Nigussie *et al.*, 2015; Menyuka *et al.*, 2020). In an attempt to fill the void in literature, Wang *et al.* (2016) identified straw and livestock waste as the major types of agricultural wastes in China. Ghosh *et al.* (2016) argued that attaching a definition to food waste was an abstract affair due to the subjective nature of edible and inedible parts of food depending on culture and norms. Naturally, production and consumption processes are expected to result to some level of unavoidable waste as such contributing to non-edible portions of food. Buzby and Hyman (2012), and Redlingshöfer and Soyeux (2012) were of the view that inedible parts of food included eggshells, bones, fruit seeds and citrus fruit zest. However, Ghosh *et al.* (2016) indicated that inedible parts are diverse and may extend to peels, meat fat and bread crusts among others depending on the geographical and cultural setting of a household.

In exploring avoidable food and drink waste in the United Kingdom, Quested and Luzecka (2014) established an influence of respondent's age, employment status, household size and structure on food wastage. In explaining waste generation at household level, sociodemographic characteristics have often been used. For instance, in Denmark and Spain, household size, gender, age and employment characteristics were associated with food waste prediction in households (Grasso *et al.*, 2019). The findings of a solid waste generation study conducted in Ethiopia indicated that household size and income were the most relevant drivers which meant that higher incomes and bigger families generated more waste (Wegedie, 2018). According to Mattar *et al.* (2018), education, household size, income and employment status were the main variables that explained the food waste volumes generated in households of Lebanon. Moreover, Astane and Hajilo (2017) pointed that age of the household head, household income and assets were important in explaining generation of waste. Similarly, in China, Xiao *et al.* (2015) although using urban communities stratification approach (work-unit, transitional and commercial) concluded that household size, family structure, residential area and frequency of eating at home were correlated to waste generation in households.

2.2 Choice of agro-food waste management practices in households

Traditionally, waste disposal has been considered as a method of waste management (Heller & Catapreta, 2003). It has been a means to get rid of unwanted and unusable materials or to transfer the responsibility of waste management to the next actor in the waste supply chain. Although organic waste usability and value may be compromised by disposal through decay and mixture with impurities, the method offers a platform for access of waste by other actors for supporting their livelihoods. Disposal is increasingly loosing popularity especially in landfills with increasing shift in embracing waste as a resource (Wilson *et al.*, 2015). Waste disposal is not considered as an optimal way of waste management since when improperly disposed it constitutes threat to air, water, soil, animals and humans (Awomeso *et al.*, 2010). As such health and environment impacts may arise. However, at the household level, waste disposal remains a popular means of waste management (Brown, 2015; Nthambi, 2013; Yoada *et al.*, 2014). Ferrara and Missios (2016) flaunted consumption reduction, reuse and recycling as alternative avenues of waste management meant to reduce waste offloaded to landfills from households. Similarly, Erich (2018) identified waste management options as prevention, minimization/reduction, reuse, recycle, recovery and disposal.

Food waste affect monetary, environmental and social spheres in a society (Werf *et al.*, 2019b). In line with this, waste reduction has been flaunted as among the most promising strategies (Mu'azu *et al.*, 2018) in countering the current waste trends. Whereas there has been effort to explore ways of reducing waste (Annunziata *et al.*, 2020; Aschemann-witzel *et al.*, 2015), the resultant effect has been mainly short term. In some instances, households that intend to reduce their food waste ended up wasting more (Russell *et al.*, 2017). As such it becomes important to understand the 'who,' 'why,' behaviour and motivators of waste reduction. Waste reduction perspective has been shown to be aided by physical and/or technological enablers through intelligent refrigerators, using inform and remind aspects (Ganglbauer *et al.*, 2013). Further, modification of packages for preservation (Verghese *et al.*, 2015) and resizing packages into sizes that may appeal better to consumers (Evans, 2011) have also been used.

Although on one aspect urban agriculture is perceived as pro-poor, good for food security and livelihoods, it is also argued to be a harbour for pathogenic diseases (Hamilton *et al.*, 2014). Notwithstanding the view, urban agriculture is associated with products that are organic, healthy, fresh, local, quality, safe, convenient, natural and varietal among others (Grebitus *et al.*, 2017). This view is further strengthened by Polimeni *et al.* (2018) who assessed urban agriculture from local farming support, healthy environment, community building and economic support aspects. However, utilisation of waste in urban agriculture has in some instances overshadowed the benefits arising owing to insistent negative perception towards waste (Amoah, 2006) especially in developing economies. Therefore, safety risk concern arises in the management and utilisation of agro-food waste.

Composting has been touted as one of the most effective methods for management of pathogens and weed seeds through heat generated (Santosh *et al.*, 2018). However, Taylor *et al.* (2010) associated processed organic waste with utilisation difficulty due to inadequate biological stability which have necessitated consideration of vermicomposting in some instances. The traditional method of composting involves heaping wet organic related matter such as agricultural and food waste which is eventually converted into humus. However, water, air, carbon and nitrogen endowed organic materials are usually included in composting to enhance the breakdown process thus reducing solid waste heaps and likely pollution.

Vermicomposting which involves use of earthworms has been used to accelerate the breakdown process (Lim *et al.*, 2015). During the process, bacteria and fungi also accelerate the process. The resultant humus is used as fertilizer (Santosh *et al.*, 2018). Composting as a form of organic waste management (Ayilara *et al.*, 2020) is improved by the quality of waste which means that removal of non-biodegradable materials from household waste is a prerequisite to producing quality compost. Nsimbe *et al.* (2018) findings indicated that peri-urban agricultural practitioners were likely to develop composting behaviour compared to their core-urban counterparts as explained by the land space availability.

There are indications that households which conduct separation of waste upon generation are likely to develop actual waste utilisation behaviour (Aprilia *et al.*, 2012; Nsimbe *et al.*, 2018). Segregation is considered a prerequisite in utilisation of waste (Chen *et al.*, 2017) especially if it is meant for feed or compost material. Generally, waste segregation increases the utilisation appeal of waste (Jamal *et al.*, 2019) which may imply value improvement. According to Miao (2015), psychological aspects are important predictors in waste management and utilisation. She was of the view that the usual norms, motivation, identity issues, retention of status quo and inadequate understanding were associated with composting participation bottlenecks. Additionally, cognitive capability, self-control, time allocation and absence of salience influenced the composting participation behaviour. Mbeng *et al.* (2009) studied public behaviour towards domestic waste management and found out that concern, education, information and awareness are key drivers in behavioural change but, similar to Miao (2015) noted that economic incentives or motivations could intervene in the behavioural process.

For long, conversion of agro-food waste to animal feed has been considered as a viable option in addressing current global challenges of landfilling, food insecurity and environmental sustainability (Dou *et al.*, 2018). Although waste may have lost appeal in developed regions such as the European Union due to safety issues over the years, developing countries in Asia and Africa where policy restrictions are lesser continue to use these resources. Heating has been advocated in sterilizing of agro-food waste thus making it safe for animals. Non-standardized heating procedures have been adopted across studies. For instance, García *et al.* (2005) homogenized and heated agro-food waste for 10-60 minutes at 65-80˚C, Westendorf *et al.* (1996) at 100°C, Paek *et al.* (2005) at 110-120°C and Moon *et al.* (2004) at 140°C. Combination of heating with other methods such as cleaning, rinsing, grinding, shredding and dehydration as well as fermenting have also been adopted towards promoting safety effectiveness in utilisation of waste (Kim & Kim, 2010; Moon *et al.*, 2004).

2.3 Determinants of agro-food waste utilisation behaviour in households

Food waste has increasingly become a sustainability and economic problem thus impacting on the overall profitability of food supply chains. Ghosh *et al.* (2016) argued that the consumers are likely to bear the economic burden associated with food waste. However, supply chain actors are affected throughout the food supply chain which necessitates beneficial utilisation of waste resources to counter the associated losses. Reportedly, an average of 22% of generated waste in OECD countries is recycled compared to 1-3% in developing countries (Johansson, 2016). Behavioural motivation aspects of recycling that included physical and psychological factors were considered key.

Quantification of behaviour is possible. Bollen and Noble (2011) explained that behaviour is often measured using latent variables in social and behavioural sciences. This attempt of quantifying latent variables may encompass measurement errors. The eventual establishment of relationships among these variables may be a challenge but necessary in achieving adequate interpretation of such issues as behaviour. More so, intention has been closely associated with behaviour while in some cases intention behaviour versus actual behaviour have been considered (Amini *et al.*, 2014). Notwithstanding the perspective, intention is an indication of likely transition from a plan to actualization. However, intention-behaviour gap is a reality in practice.

Velagi (2012) explored influence of waste recycling from a motivational push, concerns, attitudes, knowledge and local public communication drives. The findings established the importance of these factors in forming a waste recycling behaviour in households. Using a model of home composting behaviour in Vietnam, Loan *et al.* (2019) findings indicated that motivational factors in terms of knowledge on composting, attitude and garden ownership were the basis for composting behaviour. Moreover, a general pro-environmental behaviour by a household was indicated to be a likely influence on composting. However, although training in composting was important in explaining participation decision, it did not determine the level of participation. Thi *et al.* (2018) findings indicated that environmental awareness, attitude, social-pressure, regulations and laws, recycling cost and inconvenience had significant prediction on e-waste recycling intention. In studying agricultural waste demand in China, Wang *et al.* (2016) was of the view that recycling and utilisation was influenced by cost, technological innovation, passion and environmental appeal.

In a study of the role of social factors in reuse of waste in developing countries, Furedy and Pitot (2011) captured societal values and religious factors in waste utilisation behaviour. Most often in developing countries, waste is dissociated with and affect hygiene behaviour and eventually health outcomes. However, in some communities, such as in India, waste is recognized as a resource and proverbial saying "waste is food" is common, which then influence household and societal behaviour towards waste. Contrastingly, Geislar (2018) employed a metabolism conceptual framework in understanding food flows and interconnected flows of energy and materials into, via and out of urban areas in regard to waste reduction, recovery, reuse and redistribution. The study indicated that transformation of food waste to organic soil amendments ensures reclamation and redirecting of nutrients towards supporting the food system through growing of new food, water conservation and reduction in synthetic fertilizer utilisation. The study identified storage of uneaten food to pantry, giving uneaten food to others, sorting waste, composting, bin maintenance and replacement, and adopting appropriate food storage methods were the main determinants in the redistribution and reuse of household food waste.

2.4 Determinants of source-based agro-food waste demand

Surprisingly, some few decades ago agro-food waste was not considered from economic loss of natural resources perspective. However, because of increasing public concern in its relation to food security, environmental issues and socioeconomic contexts, agro-food waste research especially in the food front has been enhanced. In this regard, researchers have increasingly explored and encouraged waste utilisation as a basis for promoting sustainable use of resources (Ghosh *et al.*, 2016). Emanating from this push, waste has been considered as an ingredient for energy, fertilizer, food, and feed (Jouhara *et al.*, 2017; Lin *et al.*, 2013; Malinauskaite *et al.*, 2017; World Energy Council, 2016). The increasing diverse uses of waste may imply demand and supply forces which constitute a market are in existence. These aspects have enhanced recovery, reuse and recycling of waste.

Over the last few decades, the general perception that waste may have no intrinsic value has increasingly shifted towards its resourcefulness. As such when put to use it implies it is valuable; presence of demand. Nigussie *et al.* (2015) explored the demand and utilisation for agricultural waste in urban areas of Ethiopia. Agricultural waste (and compost) was used as animal feeds and soil amendment. Labour availability for composting processes was identified as a major impediment in enhancing the demand for compost. In addition, there exist competing demand between use of agricultural waste as soil amendment and feed and sometimes as fuel (Nigussie *et al.*, 2015; Valbuena *et al.*, 2014).

Organic waste as soil amendment has been shown to be more effective than inorganic fertilizer (Ngome *et al.*, 2011). Research shows excessive use of inorganic fertilizer contribute to physical and chemical deterioration as well as pollution of environment. Effects such as low microbial activity, leaching of nutrients and plant stress emanating from salinity have been cited. These aspects may affect the economy as well as water contamination yet organic waste can reverse them (Lim *et al.*, 2015). This perspective offers a basis for agro-food waste demand as a supplement to conventional input.

Apart from animals and food crops, urban agriculture involves tree and flower propagation which also encompasses plant potting. Peat being a popular soilless growth media in plant potting, its sustainability is under threat due to its high cost and non-renewable nature. Zhang *et al.* (2013) argued that composted green waste could serve as a substitute to peat since it contributed to acceptable level of improved soil physical and chemical properties. As such this facilitates tree and flower gardening and nursery management.

Sadh *et al.* (2018) findings indicated that agricultural waste resource contains bioactive compounds which could be useful in biofuel, biogas, mushroom and tempeh production. Embracing waste has been touted to reduce production cost and contribute to environmental sustainability. Agricultural waste that constitute field and process residues are valuable resources that are often underutilised (Sadh *et al.*, 2018). Field waste have been used for soil moisture and erosion management. Apart from the common uses of agro-food waste, it has been transformed to and utilised as charcoal briquettes especially in developing countries (Sabiiti, 2011). However, the common use of agricultural waste has been as fertilizer and animal feeds (Dou *et al.*, 2018; Menyuka *et al.*, 2018; Saravanan *et al.*, 2013; Wadhwa & Bakshi, 2013). Truong *et al.* (2019) indicated that with the increasing diversion of corn from animal feed ingredient to biofuel, there will be increased demand for animal feeds which the vast amount of agro-food waste could bridge. This incorporation of waste in animal feeds is projected to decrease greenhouse gas emissions by 3.7 million metric tonnes of carbon dioxide.

Source and accessibility of agro-food waste are important factors in estimating its demand. Agro-food waste sourcing (supply side) is mostly associated with residential, industrial, commercial (hotels, stores, restaurants, markets and offices), institutional (schools, hospitals, prisons, government centres), municipal services and agriculture (farming households) (UN, 2000; World Bank, 1999). This makes transaction cost an expected aspect in acquisition of agro-food waste which translates to likely hindrance to its utilisation (Asian Development Bank, 2011).

2.5 Empirical review of literature

Generation of waste studies have increasingly transitioned from general socioeconomic factors to also include behavioural aspects (Aktas *et al.*, 2018; Diaz-ruiz, 2018; Fu, 2018; Stancu *et al.*, 2016). The change is argued to make robust waste generation frameworks in availing a better understanding of the problem in the food supply chain. In strengthening the generation of waste models further, typologies of waste have also been considered as a basis for devising better waste management strategies. There is rich literature on generation (Id *et al.*, 2019; Mattar *et al.*, 2018; Xiao *et al.*, 2015) although total waste has largely been considered rather than by type or portions (Afroz *et al.*, 2011; Astane & Hajilo, 2017; Kumar & Samadder, 2017; Wadhwa & Bakshi, 2013). This inclination limits a deeper understanding of waste typologies and potential usability (Kumar & Samadder, 2017; Obi *et al.*, 2016; Wegedie, 2018). In such cases, ordinary least squares methodology has been adopted (Kumar & Samadder, 2017; Wegedie, 2018). Departing from this methodology, Visschers *et al.* (2016) employed a combination of the Theory of planned behaviour and Tobit models to study six food groups. This approach acts as a basis for identifying specific food waste predictors.

The multiple avenues through which waste could be managed presents choice for generators of waste. Adu-boahen *et al.* (2014) and Mensah (2020) assessed waste management practices in Ghana using descriptive and waste hierarchy models. Disposal, prevention and reduction of waste practices were more pronounced in small hotels whereas disposal was more dominant in households. Molem and Enjema (2017) employed a Multinomial Logit (MNL) model to explore households' choice in waste management practices where frequency of trash emptying, education, age and participation in neighbourhood cleaning programs had significant role in choosing waste management practices. Similarly, through MNL, Nthambi (2013) findings indicated that years of schooling, family size, contractual arrangement, waste segregation, gardening and livestock rearing were important drivers in the choice of waste management practices. However, the MNL model does not capture the non-exclusivity of the waste management practices (Bel & Paap, 2014).

Although with numerous modifications from the original constructs (behaviour, intention, attitude, subjective norm and perceived behavioural control), the Theory of Planned Behaviour (TPB) has been largely accepted as a robust theory for behavioural assessment (Ajzen, 1985; Philippsen, 2015; Stancu *et al.*, 2016; Stefan *et al.*, 2013; Zhang, 2014). The basis was to show how intentions transition to actions under influence of specific behavioural constructs. Food waste behaviour tendencies have also been explored (Stancu *et al.*, 2016; Werf *et al.*, 2019b) using TPB. Largely, the study of recycling behaviour of waste is an indicator of utilisation of waste (Akenji *et al.*, 2015; Basev, 2016; Ioannou *et al.*, 2011; Johansson, 2016; Nguyen *et al.*, 2018; Wang *et al.*, 2016) notwithstanding its commercial inclination. In addition, TPB rides on structural equation modelling in prediction and explanation of behavioural constructs interrelationships (Diaz-ruiz, 2018; Grasso *et al.*, 2019; Shabanali *et al.*, 2019). Whereas TPB is based on Ajzen (1985, 1991) its flexible nature promotes adaptability in research thus contributing to behavioural theory advancement. Over time, various constructs have been developed in explaining and understanding behaviour aspects; perceived moral obligation (Chu & Chiu, 2003; Philippsen, 2015), environmental awareness (Nguyen *et al.*, 2018), motivation (Johansson, 2016) and contextual factors (Zhang, 2014).

Latent demand model has been applied in assessing agricultural waste supply and demand at the farm level in China (Zhou *et al.*, 2018). Livestock and kitchen waste demand in Cameroon using logit models showed the relevance of socioeconomic factors in its utilisation (Parrot *et al.*, 2009). Callan and Thomas (2006) also employed logit models to assess disposal and recycling services demand. However, Callan and Thomas (2006), Parrot *et al.* (2009) and Zhou *et al.* (2018) failed to factor-in the value of waste as such adopting latent variables and dummies to estimate demand. This limits the model's capability in explaining the actual demand for waste. However, Callan and Thomas (2006) also adopted Contingency Valuation Method in urban waste demand. The model considered the value of waste unlike for the Logit and latent demand models. Using OLS, Rashmika and Edirisinghe (2016) indicated that the demand for compost through transition from mineral fertilizers was dependent on the market response in Kurunegala. The study established the significant influence of household and head of the household characteristics. Considering the diversity of agro-food waste sourcing in food supply chain, this aspect is evidently absent in literature.

2.6 Theoretical framework

The theoretical framework for the study was be based on two major theories: Theory of Planned Behaviour and Choice Theory. The theories are based on value expectation where households are driven by the utility, they were likely to derive from a given aspect.

2.6.1 Theory of planned behaviour

Earlier works on Theory of Reasoned Action informed the development of TPB (Ajzen, 1991; Ajzen & Fishbein, 1970; Hill *et al.*, 1977) which is essentially an extension of the former (Fu, 2018). TPB is expected value-based such that it provides pointers of motivation towards the performance of behaviour. TPB has widely been used in waste generation and management behaviour studies (Diaz-ruiz, 2018; Ioannou *et al.*, 2011; Tonglet *et al.*, 2004; Zhang *et al.*, 2015). Therefore, TPB provides a theoretical basis in understanding generation, management and commercial utilisation behaviour of agro-food waste in urban areas. Unlike other traditional models, TPB does not thrive on revealed preferences in the deduction of the unobserved decision process but involves direct evaluation of theoretical constructs. The evaluation is based on specific behaviour unlike the traditional approach of overall evaluation. TPB holds that household's behaviour is a function of intention (readiness to perform the behaviour under consideration), where the intention is based on the household's attitude (AT), subjective norm (SN) and the perceived behavioural control (PBC) regarding the behaviour. Accordingly, these constructs (AT, SN and PBC) are determined by behaviour, norms and control beliefs respectively (Ajzen, 2015; Tonglet *et al.*, 2004; Zhang *et al.*, 2015).

2.6.2 Theory of choice

According to Ajzen (2015), every behaviour constitutes a choice. This implies that a choice involves an act of choosing, irrespective of the number of options. However, in TPB every option provides a behaviour based on the influence of the belief on performing or not performing the behaviour. Therefore, every alternative in a choice would involve measuring the TPB constructs separately. Considering that the network of relationships involving one behaviour in a TPB can be generally complex in nature, the contemplation of constructing TPB networks for all the alternatives in making a choice would even be more complicated; cognitive load. As much as the TPB approach in making choices would be more informative, it is infeasible under the proposed study. This makes choice theory more appropriate in the provision of precise and synthesised information on aspects of the study that involved choice making.

Like TPB, choice theory is expected value based. As such, the choice that a household makes in choosing agro-food waste management practise is dependent on the expected value from such a choice. Although the process is mostly unobservable, it involves weighing the costs and benefits of every choice and deciding from this. Therefore, it is assumed under the proposed study that a household decided on whether to reduce agro-food waste generation, dispose, utilise or give out/sell depending on the expected value from implementing the practise(s). Additionally, agro-producer households made an additional decision on safety risk management practise they would employ to ensure improved waste safety in its utilisation. As a result, the study assumed that they had to choose whether to sort, clean, heat, compost, mix or do specific sourcing. Realistically, a household would choose one or more management practises from among the available alternatives. Based on this, household i had a set of alternatives j in the form $(j = 1,2, \ldots, K)$ each with expected value (that is utility) U_{ij} but since the utilities were unobserved, the utility derivable was in the form (Launio *et al.*, 2014);

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (1)$$

Where; U_{ij}= utility of a choice, V_{ij} = deterministic component of the expected value, and ε_{ij} = stochastic component.

The probability that household i chose alternative j from the set of management practises k would then be:

$$\text{Prob (j)} = \text{Prob} \left(V_j + \varepsilon_j\right) \quad (2)$$

Where; prob = probability of making a choice.

Similarly, urban households were faced with choice decisions on the avenues to acquire agro-food waste from. As such, in forming a choice set regarding acquisition of agro-food waste, it involved choosing from own household, other households, restaurants, agro-markets, processors and/or dumpsites. Therefore, theory of choice drove the demand theory in assessment of the determinants of agro-food waste demand in urban households.

2.7 Conceptual framework

The analysis of management and commercial utilisation behaviour is grounded in the TPB and choice theory. It was assumed that an urban agro-producer household generates various types of agro-food waste; animal, crop, edible and inedible food waste. In explaining the agro-food waste typologies (Figure 2-1), the study assumed that this assessment could be done for each of the waste typologies. The contextual factors and the Extended Theory of Behaviour constructs were presumed to be the drivers for agro-food waste generation in such a household. In the process and/or upon agro-food waste generation, an urban household was postulated to opt for several agro-food waste management practises (general management options and safety risk management practises) with varying expected value depending on the context they operated in. Therefore, the study assumed that Extended Theory of Planned Behaviour (ETPB) constructs, contextual factors and commercial utilisation intention and behaviour related to the respondent households had a stake in the choice of a management practise. It is further assumed that the management practise alternatives were not mutually exclusive; they were interdependent.

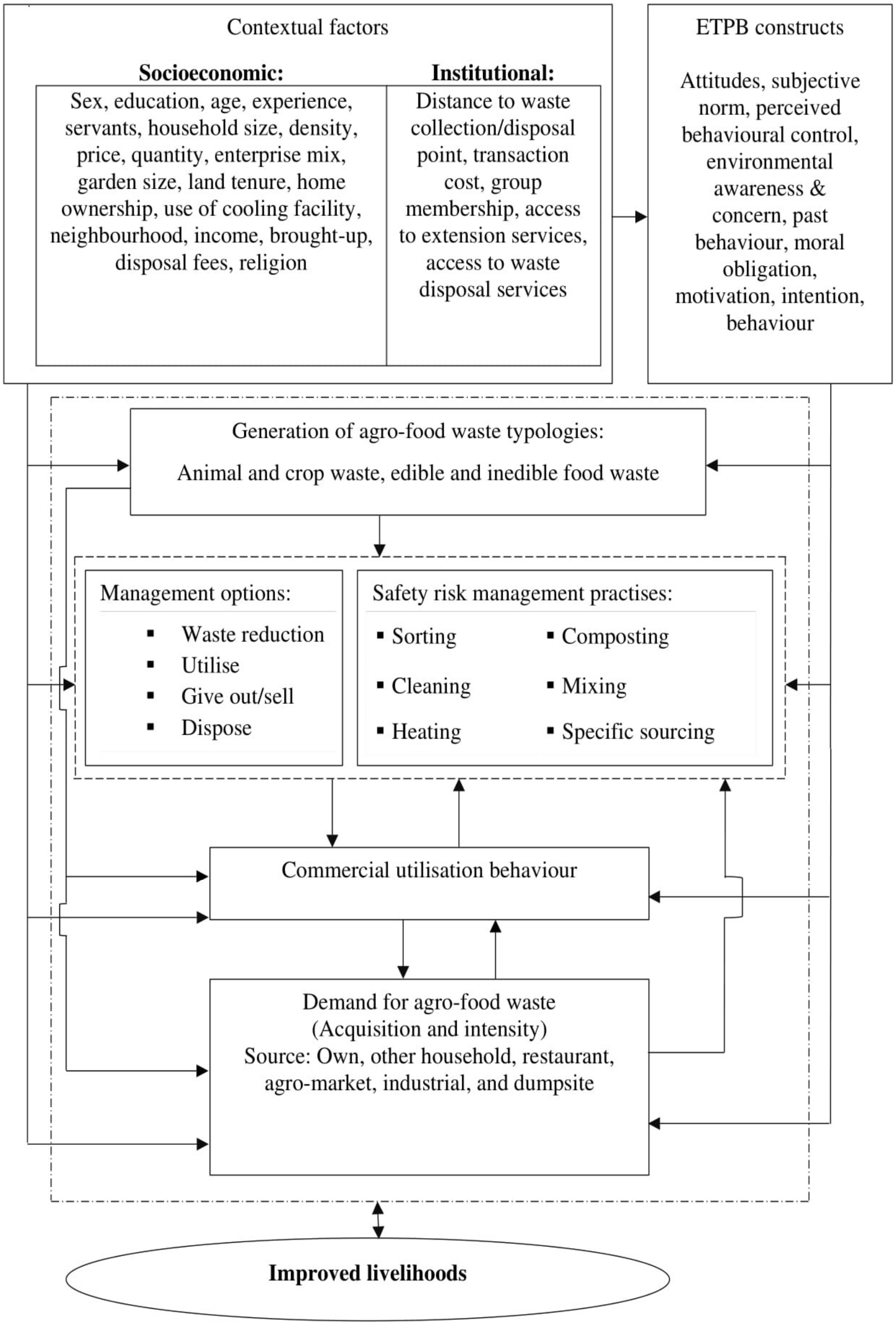

Figure 2-1: Conceptual framework for management and commercialisation of agro-food waste

In consideration of agro-food waste management practises, utilisation may have arisen as a management practise. Notwithstanding whether utilisation was identified as a management practise, a household may still have exhibited agro-food waste commercial utilisation intention. If a household had been utilising agro-food waste and or intended to use or to continue using, this was projected to result to commercial utilisation intention and behaviour. In this case, the behaviour was assumed to be determined by the TPB constructs; AT, SN, PBC and intention. In addition, the proposed study adopted an extended TPB by including moral obligation (MO), environmental awareness and concern (EAC), motivation (MT) and contextual factors (CF) to boost the expected value and the predictive power of the TPB. The CF were assumed to influence the ETPB constructs as portrayed in SEM.

The agro-food waste commercial utilisation intention and behaviour is assumed to transition to demand among the urban agro-producers. Depending on the commercial utilisation behaviour, the study assumed that the agro-food waste demand by agro-producers would be source oriented. Given the various alternative sources of agro-food waste that were available including own, other households, restaurants, agro-markets, industrial and dumpsites, agro-producer households would choose their preferred waste source. Like the choice of agro-food waste management practises, an agro-producer may demand agro-food waste from one or more sources. Under this perspective, it means that agro-producers would demand either some agro-food waste or none from a given source. The ETPB constructs, commercial utilisation intention and behaviour as well as contextual factors were assumed to influence source demand. The study also postulates that the realization of improved livelihoods emanating from management and commercialisation had a feedback effect on agro-food waste generation, management, commercial utilisation behaviour and demand.

2.8 Literature research gaps summary

Whereas identifying and assessing the drivers for generation of specific agro-food waste components in households would provide insights in management of waste, most empirical studies on household agro-food related waste have largely ignored waste typologies. In most cases, aggregated waste has been considered.

A common practise in choice of waste management practises has been the assumption of mutually exclusiveness of alternatives. However, given the numerous alternatives available for agro-food waste management, urban households can adopt different options, an indication that the assumption is misleading. As a result, the common methodological application of MNL in the assessment of choice of waste management practises is inappropriate.

There has been generally incomprehensive approach in the assessment of waste utilisation behaviour in literature, the trend has mostly been piece meal. Therefore, the study departs from the usual practice of analysing single aspects of waste utilisation behaviour to wholesome approach with respect to agro-food waste.

Whereas there are indications of use of agro-food waste in urban agriculture in developing countries such as Kenya, empirical evidence on acquisition and expenditure allocation has not been forthcoming. The sources of agro-food waste that is used in urban agriculture has remained elusive and yet to be concretely identified as well. Moreover, source-based demand for agro-food waste by urban agro-producer households is absent in literature.

CHAPTER THREE

WHAT DRIVES GENERATION OF AGRO-FOOD WASTE TYPOLOGIES AMONG URBAN AGRO-PRODUCER HOUSEHOLDS? INSIGHTS FROM A DEVELOPING COUNTRY

Abstract

The aim of this study was to evaluate the drivers of agro-food waste typologies generation among urban agro-producer households in Kenya. To accomplish this, an electronically structured questionnaire was administered to 456 agro-producer households to collect disaggregated self-reported data. Descriptive and Fractional Response models were employed for data analysis. The results revealed significant disparities of waste generation profiles among livestock and mixed agro-producers; age of the household head, number of enterprises, inability to sell produce frequency, home ownership and market guarantee. The daily per capita food waste generated was 0.67kg while the daily per capita agricultural waste was 10.75kg. The regression results indicated both socioeconomic (age and number of enterprises) and behavioural attributes (perceived behavioural control and attitude) were among the most important drivers in agro-food waste typologies generation. Number of mature agri-enterprises were consistently the highest contributor of predicted marginal changes in agricultural, food, edible, inedible, crop and animal waste portions generated among urban households. Results implied that agricultural education and behavioural interventions meant to foster enterprise specialization and adoption of effective methodologies in exploitation of benefits associated with agro-food waste meant to support the urban food system are urgently required. Findings could instil micro-level self-awareness in generation and self-regulation in management of agro-food waste for betterment of the urban agroecology.

Keywords: Agro-food waste, Fractional response, marginal changes, short-run, self-awareness, self-regulation

3.1 Introduction

Waste generation is on the rise globally (Elks, 2018; Kaza *et al.*, 2018). Estimates indicate that 2.01 billion tonnes of solid waste were generated in 2016. The quantity is expected to grow by 70 percent to 3.40 billion tonnes by 2050, accelerated by population growth and urbanization (Kaza *et al.*, 2018). Waste generated globally emanate from households, restaurants, shops, healthcare outlets, offices, academic institutions, industries and markets among others. Whereas literature does not expressly indicate the contribution of waste generated globally from each of these sources, households are potentially the major contributors. Quantities and typologies of waste differ from one household, neighbourhood, region or nation to another (UN, 2000). This being the case, it is argued then that understanding and prediction of typologies and quantities of waste that households generate is crucial in devising effective management practises (Kumar & Samadder, 2017).

Across the globe, the overall and urban areas daily per capita waste generated is estimated to be 0.46(0.74)[1], 0.52(1.5), 1.18(1.28), 2.21(3.13), and 0.81(1.38) kg in sub-Saharan Africa, South Asia, Europe and Central Asia, North America, Middle East and North Africa respectively. The estimates are against a global daily per capita rate of 0.74kg. Further to these, dry recyclables (metal, glass, plastic, paper and cardboard) constitute approximately 38 percent of waste generated globally while food and green waste forms the major global waste composition at 44 percent. This is an indication that most of the waste generated globally is organic waste of the agricultural and food types (Kaza *et al.*, 2018). In developing countries, the agricultural and food waste (agro-food waste) portions may be higher compared to other waste since household budget share for food related items is comparably higher (Kavanagh, 2019). Moreover, food waste in these countries occurs in distribution, processing and preparation stages (Huang *et al.*, 2020; Lithuanian Consumer Institute, 2018) whereas agricultural waste arises during production (Alexander *et al.*, 2017) but with overlaps.

In an effort to understand agro-food waste, for instance, Agamuthu (2009), Nagendran (2011) and Obi *et al.* (2016) categorized agricultural waste into production (crop and animal waste) and processing (industrial) waste. Sharma and Garg (2019) classified agricultural waste as livestock waste, crop residue, forest waste, weeds, leaf litter and saw dust. They further narrowed the categorization to agricultural, domestic and industrial waste. Further, Drechsel *et al.* (2015) considered agricultural waste as garden rubbish, leaf litter, cut grass, tree pruning waste, weeds, livestock dung, crop residues and public parks waste. This is an indication that mostly crop and livestock/animal waste is mostly generated at the household level. In regard to food waste, Glanz (2008) classified it into packaged (unopen), packaged (partially used), inedible and leftovers whereas Werf *et al.* (2018) categorized food waste into avoidable and unavoidable. Visschers *et al.* (2016) considered food waste as avoidable, possibly avoidable, and unavoidable but classified them as fruits and vegetables, proteins, bakery, ready to eat, starches and dairy waste products. Still, Lin *et al.* (2013) classified food waste into organic crop, animal non-prime products, domestic, catering, packaging and mixed food waste.

[1] Figures in parentheses represent the daily per capita waste in urban areas for respective regions

Nonetheless, Östergren *et al.* (2014) perceived food waste as a composition of edible and inedible components, emanating from mature crop and animals which may be domestic or wild.

Whereas literature shows that use of sociodemographic factors on their own may have considerably weak predictive power of waste generation in households (Stancu *et al.*, 2016; Falasconi *et al.*, 2019), they are critical in capturing the context thus unavoidable. To address the weakness, researchers have often incorporated attitude and behaviour aspects in waste studies (Visschers *et al.*, 2016; Falasconi *et al.*, 2019), an approach that could strengthen the assessment of agro-food waste generation in urban households. For instance, Astane and Hajilo (2017) findings showed personal attitude was of significance in understanding waste generation. Stancu *et al.* (2016) findings indicated that perceived behavioural control and associated routines on shopping and reuse were key in explaining self-reported household waste. The frequency of eating away from home, purchases of offers and guilt associated with food wastage have also been shown to influence food waste generation (Mattar *et al.*, 2018). Particularly, most studies on drivers of household waste generation have assessed it from an aggregated perspective. Therefore, there is dearth of knowledge on what drives agro-food waste typologies generation in households (Visschers *et al.*, 2016) which if assessed would avail a more informative picture on waste generation.

To cease the opportunities in the urban food supply chains, urban agro-producers have taken it upon themselves to produce food for their consumption and supplying the surplus to the market. These trends are crucial in influencing the transition of any urban area. During the agricultural production and consumption process at the household, agro-producers are likely to generate waste such as animal, crop, edible and inedible waste types, among others. These may in turn be tapped as resources in the agricultural production process. In Nairobi, Kenya's capital city, this is no exception. However, agro-food waste generation especially among urban agro-producers remains an area with limited empirical information. Whereas literature is much clearer on food waste aspects in consumer households, the food and agricultural waste aspects require an exploratory approach in agro-producer households to establish the socioeconomic and behaviour inclinations. Therefore, intuition played a critical role in the study. So, (1) Are there characteristic disparities among crop, livestock and mixed production participants and non-participants? (2) What drives generation of agro-food waste typologies among urban agro-producer households?

Table 3-1: Indicative drivers of household food related waste generation

Variables	Relevant literature
Sex and gender	Cecere *et al.* (2014); Secondi *et al.* (2015); Grasso *et al.* (2019)
Age	Astane and Hajilo (2017); Grasso *et al.* (2019)
Education of household head	Cecere *et al.* (2014); Neff *et al.* (2015); Mattar *et al.* (2018)
Education of woman of the household	Kim *et al.* (2000)
Household size	Xiao *et al.* (2015); Han *et al.* (2018); Mattar *et al.* (2018); Wegedie (2018); Grasso *et al.* (2019)
Employment of household head	Mattar *et al.* (2018); Grasso *et al.* (2019)
Employment of woman of the household	Kim *et al.* (2000)
Income	Xiao *et al.* (2015); Astane and Hajilo (2017); Mattar *et al.* (2018); Wegedie (2018)
Knowledge	Visschers *et al.* (2016); The National Academies of Sciences (2019)
Prepare excess food	Chakona and Shackleton (2017)
Refrigeration/storage	van Geffen *et al.* (2016); Chakona and Shackleton (2017); van Geffen *et al.* (2017); van Holsteijn and Kemna (2018); Romani *et al.* (2018)
Plan food purchase	Stefan *et al.* (2013); Mondéjar-Jiménez *et al.* (2016); Annunziata *et al.* (2020); Bravi *et al.* (2020)
Buy food in large quantities (excess/in bulk/on offer)	Romani *et al.* (2018)
Frequency of eating away from home	Xiao *et al.* (2015); Mattar *et al.* (2018)
Market access	Tielens and Candel (2014); Irani *et al.* (2018)
Attitude	Visschers *et al.* (2016); Astane and Hajilo (2017); Soorani and Ahmadvand (2019)
Personal/subjective norm	Visschers *et al.* (2016); Aktas *et al.* (2018); Soorani and Ahmadvand (2019)
Perceived behavioural control	Stancu *et al.* (2016); Visschers *et al.* (2016); Soorani and Ahmadvand (2019); Werf *et al.* (2019a)

3.1.1 Drivers of agro-food waste generation

Without re-inventing the wheel, in-depth literature exists on household waste from which numerous household characteristics and behaviours have been established to be correlated to food related waste as shown in Table 3-1.

3.2 Methodology

3.2.1 Study area

Kenya is a developing lower middle-income country located in Eastern Africa (Index Mundi, 2017; World Bank Group, 2017). The country has a rapidly growing population (at 2.3 percent), urbanization stands at 27 percent (growth was 4.29 percent from 2010-2020) as well as increasing urban poverty (Soezer, 2016; World Bank, 2016). With the expanding urban population, the county governments who are responsible in management for solid waste are becoming overwhelmed. The daily per capita waste generated in major urban municipalities across Kenya is approximately 0.46kg. The situation is far much worse for Nairobi City County (see Appendix 1) compared to other 46 counties since it is the administrative capital and its 99.8 percent urbanized. The daily per capita waste generated in Nairobi City is estimated at 0.75kg (Soezer, 2016).

Nairobi City County and its environs is an important centre in understanding the general socio-economic trends within Kenya. The diversity of population in terms of income, culture, food consumption behaviour, ethnicity, religion and residential neighbourhoods among other characteristics gave the area an appeal for the current study suitability. Based on these projected diversities, the agro-producer households within the study area were expected to provide insights into agro-food waste typologies generation and what drives them. Additionally, over 20 percent of Nairobi city households are involved in either subsistence or for-market surplus agriculture (Lee-smith, 2010). The study was based in Nairobi City county's ten administrative wards; Kahawa West, Mwiki, Ruai, Githurai, Njiru, Karura, Mugumo-ini, Karen, Uthiru/Ruthimitu and Waithaka. The selection of the wards was informed by their relatively visible involvement in agricultural activities and generation of agro-food waste.

3.2.2 Research instrument and data collection

The study involved collecting self-reported data on socio-economic and behavioural characteristics as well as animal[2], crop[3], edible[4] and inedible[5] waste generated by households. The study targeted crop, livestock and mixed agro-producers. The agro-producer inclusion criteria were orientation to the market; an agro-producer had to have surplus produce and offloaded it to the market over the past 3 month's period prior to the study. Since one aspect of the study involved structural equation modelling, a total sample of 456 instead of the proposed 356 urban agro-producer households was considered based on Wolf *et al.* (2013) findings in order to strengthen the association of sample size and parameters. The sample size was distributed equally among the ten ward clusters; approximately 46 respondents each. The ten wards were selected purposively based on their existing agricultural activities. A mix of systematic random sampling (where respondents were pre-identified) and referral sampling (where respondents had not been pre-identified) were used in identifying agro-producer households. Local administrators (village elders) and agricultural extension officers were involved in aiding the tracing of potential respondent households. This was also used as a strategy for increasing the response rate where in some instances the locals were talked into participating by the facilitators.

An electronically structured questionnaire (Appendix 7) designed in Kobo Toolbox was used for data collection. The questionnaire was administered by duly trained enumerators using Kobo Collect mobile application. Therefore, prior to data collection, enumerators underwent a two-day classroom training as well as two days pretesting of the questionnaire to prepare them in conducting the survey. Both paper and electronic format questionnaire were used for training enumerators with the aim of providing safeguard for instances of mobile gadgets failure during data collection. In cases where the paper questionnaire was used in data collection, the resultant data was fed into the Kobo Collect application once the concerned enumerator completed their day's allocation. To enrich the study, additional notes (to capture observations) were made in notebooks that were provided for the enumerators during the survey.

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[2] Animal waste include manure, semi-solid sludge, carcasses, leftover feeds and animal slaughter waste.
[3] Crop waste refers to crop residue from harvest and destruction by weather, pests and diseases.
[4] Edible food waste refers to unused raw food, burnt/ sticking food in cooking pans, food with cosmetic defects especially fruits and vegetables, uneaten and expired food for disposal.
[5] Inedible food waste include residue emanating from food preparation and parts of food that are generally considered as inedible by humans such as peels, shells, meat bone, beverage residue, some fruit seeds, vegetable covers and hard stalks. Otherwise, edible food waste.

3.2.3 Analytical framework

Explanation and prediction of waste volumes generated from households is important in devising requisite changes at micro level. Kumar and Samadder (2017) and Wegedie (2018) applied Ordinary Least Squares (OLS) approach where rate of generation and quantity of waste generated in a household were the dependent variables respectively. Similar to Wegedie (2018), Grasso *et al.* (2019) used OLS but went further to incorporate structural equation modelling. Mattar *et al.* (2018) employed logistic regression by dichotomizing "eat everything prepared" variable based on its frequency where "more frequent or regular" aspects scored one (1) while the "sometimes" responses scored zero (0). Using a Likert scale to measure the self-reported waste, Falasconi *et al.* (2019) dichotomized the responses in order to use a logistic regression. From a different perspective, Visschers *et al.* (2016) used Tobit analysis due to the substantial zero-inflated quantities of waste recorded to assess food waste typologies generation. However, Wooldridge (2002) explained that heteroscedasticity and non-normality in Tobit results to its estimator β^ being inconsistent for β. He went further to explain that the inconsistency arises since the derived density of y given x is established on $y \ |x\sim Normal(x\beta,\sigma^2)$; an indicator of non-robustness of Tobit estimator.

In assessing the drivers for agro-food waste typologies generation, an urban agro-producer household may generate zero or greater than zero quantity of waste of a given agro-food type, that is ≥0. This implies that the quantities of waste for various agro-food types may be viewed from the actual quantity perspective (Wegedie, 2018) or a monthly or per capita equivalent like in the case of Kumar and Samadder (2017). This implies OLS may be applied alongside another model. Alternatively, by considering the proportion of various agro-food waste types (food, agricultural, animal, crop, edible and inedible waste) generated in a household, this implies the dependent variable is a fraction, in which case Fractional Response Model (FRM) applies. In addressing the shortcomings associated with Tobit model, Papke and Wooldridge (1993) and Gallani *et al.* (2015) adopted FRM. Unlike Tobit, FRM does not require beforehand to know the distribution of the response, only correct specification of the conditional mean is required. FRM uses a quasi-likelihood estimator which is consistent and asymptotically normal notwithstanding the dependent variable (y_i) distribution which can take either discrete, continuous or both discrete and continuous variable characteristics (Gallani *et al.*, 2015). Based on the FRM strengths, it was adopted for the study.

The basic assumption of FRM is defined as;

$$\mathrm{E(y/x) = G(x_i\beta)\forall i} \quad (1)$$

Where y = dependent variable, x = explanatory variables, $G(z)$ = known function with $0 < G(z) < 1 \forall z \in$ (a representation of a unit interval condition), $\forall z$ and $\forall i$ = for all cases of z and i, and = real value of continuous number.

According to StataCorp (n.d.), the log-likelihood for FRM is of the form;

$$\text{InL} = \sum_{i=1}^{N} w_i y_i \text{In}\{G(x_i'\beta)\} + w_i(1 \quad y_i)\text{In}\{1 \quad G(x_i'\beta)\} \tag{2}$$

Where N = sample size, w_i = optional weights, β = parameter to be estimated, and y_i = dependent variable.

Since FRM can be a probit, logit or heteroscedastic probit model then $G(.)$ can take the respective functional forms depending on the model. Considering probit structure fractional model, then;

$$\text{Probit} = \Phi(x_i'\beta) \tag{3}$$

Where x_i = covariates for household i, and Φ = cumulative density function (cdf), standard normal.

Gallani *et al.* (2015) defined the Fractional Response variable as:

$$y \quad = \alpha + f(x) + u \tag{4}$$

Where u = unobserved heterogeneity and x = the explanatory variables, and y = proportion of agro-food waste type j generated in household i.

Since y will have positive values exclusively, then $y \quad = y$.

$$y = \frac{\text{Daily per capita of agro} \quad \text{food waste type j}}{\text{daily per capita of all agro} \quad \text{food waste generated in household i}} \tag{5}$$

Where j = animal, crop, edible or inedible food waste.

3.2.4 Description of variables used to assess the drivers of agro-food waste typologies

Whereas food waste literature is plenty and diverse, agricultural waste has had minimal focus on its drivers. Based on this, the choice of some variables used to assess the agricultural waste perspective were largely exploratory, derivative and intuitive. The Theory of Planned Behaviour constructs such as attitude, subjective norm and perceived behavioural control were measured using five-point Likert scale average scores (Aktas *et al.*, 2018; Fu, 2018; Taylor & Todd, 1995). The measure also applied to urban agriculture knowledge. Table 3-2 presents variables that were considered for assessing the drivers of agro-food waste generated by households after requisite pre-estimation tests (multicollinearity and cross-correlations) as shown in Appendix 1. Post-estimation tests (marginal effects) were also computed as shown in

Table 3-2: Description of drivers of agro-food waste typologies generation

Variables	Measurement
Dependent variables	
Pc food waste share, pc agricultural waste share, pc edible food waste share, pc inedible food waste share, pc crop waste share and pc animal waste share (FRM)	Equation 5 above
Socioeconomic variables	
Sex of household head	Dummy (Female=1; Male=0)
Age of household head	Number of years
Education level of household head	Number of schooling years
Education level of wife or household woman	Number of schooling years
Household size	Number of people in a household
≤5 years	Number of people in a household aged ≤5 years
≥70 years	Number of people in a household ≥70 years
Employment status of household head	Dummy (Salaried=1; Otherwise=0)
Employment status of woman of household	Dummy (Salaried=1; Otherwise=0)
Daily per capita disposable income	Amount (Kes)
Daily per capita urban agriculture income	Amount (Kes)
Home ownership status	Dummy (own=1; otherwise=0)
Urban agriculture knowledge	Ordinal scale (1-5)
Guaranteed market	Dummy (Yes=1; No=0)
Unable sell frequency	Number of times
Access to extension service	Dummy (Yes=1; No=0)
Group membership	Dummy (Yes=1; No=0)
Regular servant	Dummy (Yes=1; No=0)
Religion	Dummy (Islam=1; otherwise=0)
Mature crop enterprises	Number of mature crop enterprises (*harvest)
Number of agri-enterprises	Number of agri-enterprises (crop and livestock)

Behavioural variables	
Prepare excess food during meals	Dummy (Yes=1; No=0)
Refrigerator use	Dummy (Yes=1; No=0)
Plan food purchase/produce harvest	Dummy (Yes=1; No=0)
Buy large food quantities	Dummy (Yes=1; No=0)
Monthly per capita frequency eats out-of-home	Frequency (number of times)
Attitude	Ordinal scale (1-5)
Subjective norm	Ordinal scale (1-5)
Perceived behavioural control	Ordinal scale (1-5)

*pc refers to per capita; *harvest refers to enterprises that have been harvested at least once

Table 3-5 to 3-7. In this regard, the average marginal effects for FRM were dy/ex instead of dy/dx since the dependent variables (y) were already fractions. Therefore, its change was required rather than its percentage change (StataCorp, n.d.-a).

3.3 Results and discussion

3.3.1 Descriptive analysis

Descriptive comparative statistics were disaggregated by crop, livestock and mixed farming systems with focus on participants and non-participants in the three groups as presented in Table 3-3 and Appendix 1. Majority of urban agro-producers practiced crop farming (99.78 percent) whereas 75.88 and 70.18 percent were livestock and mixed farmers respectively. Mean age for livestock production participants (52.07 years) was higher than for non-participants (44.52 years). Mixed production participants and non-participants had a mean age of 52.07 and 45.95 years correspondingly. Livestock and mixed production participation (participants vis-à-vis non-participants) indicated significant differences at $p \leq 0.01$. As such, livestock and mixed farming systems participants were much older than their respective non-participating counterparts. The findings correspond to Guendel (2002) findings that most of livestock keepers in urban areas of East African were middle aged. Similarly, Wilson (2018) findings indicated an average age of 55 years for livestock producers in Addis Ababa.

Mean household size of livestock participants and non-participants were 4.97 and 4.35 persons respectively. Similarly, mixed agro-production participants' (5.02) and non-participants' (4.34) mean household size. Both were significantly different at $p \leq 0.05$. However, Owour (2018) findings indicated household size mean of 3.71 persons in a food security status study in Nairobi, Kenya. In contradiction of the findings, Kenya's population census of 2019 indicated an average household size of 2.9 persons in Nairobi City County and a national average of 3.9 persons (KNBS, 2019a). The difference between the findings and the literature could be explained by the age structure nature of the urban agro-producer household heads who were more likely to have sired children unlike the numerous young, one person and no children households in urban areas. Comparably, in other parts of the world Strom *et al.* (2017) findings indicated the household size average of 5 persons and adjusted household size was 4 in urban family-based pig rearing in Cambodia. Akinlade *et al.* (2016) reported an average of 6 persons in urban agriculture practising households of Nigeria.

Number of children who were ≤5 years for participating and non-participating livestock producer households were 0.5 and 0.72 respectively. Likewise, the mean number of children for mixed production participant and non-participant households were 0.49 and 0.70 consecutively. Both were significantly different at $p \leq 0.05$. This implies that livestock and mixed production non-participating households had higher number of ≤5-year-olds. Due to their fussy eating habits, children have been shown to be important indicators in generation of waste in households (Giboreau *et al.*, 2019).

Number of mature crop enterprises and overall number of agri-enterprises for livestock participants and non-participants were significantly different at $p \leq 0.01$. The mean number of mature crop enterprises were 7.26 and 4.71 for livestock production participants and non-participants consecutively. On the other hand, the mean of all agri-enterprises was 10.7 and 9.17 for livestock production participants and non-participants respectively. Further, the mean number of mature crops agri-enterprises per household for mixed agricultural production practitioners and non- practitioners were 7.28 and 5.17 whereas the mean of agri-enterprises for the same producers were 9.17 and 5.58 for participants and non-participants. This implied that crop and overall number of agri-enterprises for both livestock and mixed production participation were consistently higher for participants than for non-participants. This is also an indication of higher diversity in agricultural production by the former than the later.

Non-livestock producers had significantly higher frequency of inability to sell their produce whenever they availed it to the market than livestock producers at $p \leq 0.01$. This coincided with significantly higher daily per capita crop waste for non-livestock producers compared to livestock producers. Similarly, non-mixed agricultural producers had significantly higher mean inability to sell their produce than their mixed agricultural producer counterparts.

Table 3-3: Characteristics of agro-producers participating in urban agriculture in Kenya

	All producers	Crop producers			Livestock producers			Mixed producers		
Variables	Mean	participant	non-participant	t-value	participant	non-participant	t-value	participant	non-participant	t-value
Age of head	50.25	50.27	38	0.89	52.07	44.52	5.13**	52.07	45.95	4.42**
Education level of head	12.64	12.65	12	0.15	12.46	13.22	-1.58	12.49	13	-1.13
Education level of wife	11.44	11.44	12	-0.12	11.45	11.41	0.08	11.42	11.5	-0.17
Household size	4.82	4.82	5	-0.07	4.97	4.35	2.29*	5.02	4.34	2.74*
Children aged ≤5 years	0.54	0.54	1	-0.56	0.5	0.72	-2.33*	0.49	0.7	-2.42*
Adults aged ≥70 years	0.33	0.33	0	0.1	0.37	0.19	0.5	0.39	0.18	0.68
Agriculture knowledge	3.31	3.31	3	0.32	3.32	3.28	0.38	3.31	3.32	-0.04
Mature crop enterprises	6.65	6.66	0.00	1.83	7.26	4.71	6.7**	7.28	5.17	5.84**
Number of enterprises	8.10	8.11	2.00	1.43	9.17	4.71	10.7**	9.17	5.58	8.9**
Unable sell frequency	2.41	2.42	0	0.37	1.78	4.39	-3.68**	1.86	3.71	2.78**
Monthly per capita eat away	19.51	19.47	34.07	-0.34	17.81	24.84	-1.52	18.02	23.01	-1.15
Attitude	3.68	3.68	3.43	0.6	3.7	3.61	1.94*	3.7	3.64	1.44
Subjective norm	3.32	3.32	5	-1.68	3.34	3.27	0.68	3.35	3.27	0.78

Perceived behavioural control	3.38	3.37	4.33	-1.08	3.44	2.85	2.85**	3.43	3.25	1.9
Per capita agro-food waste	11.42	11.42	7.93	0.06	14.02	3.22	1.7	13.30	6.98	1.06
Per capita inedible quantity	0.46	0.45	2.14	-2.22*	0.48	0.39	1.03	0.47	0.41	0.81
Per capita edible quantity	0.21	0.21	0.07	0.15	0.22	0.17	0.53	0.23	0.15	0.85
Per capita crop residue quantity	1.55	1.56	0.00	0.28	2.52	1.25	-2.1*	1.28	2.20	-1.63
Per capita animal waste quantity	9.20	9.21	5.71	0.06	12.08	0.00	1.89	11.32	4.22	1.2
Per capita food waste	0.67	0.66	2.21	-1.08	0.70	0.56	0.87	0.70	0.56	0.95
Per capita agricultural waste	10.75	10.77	5.71	0.09	14.60	1.25	1.68	12.60	6.42	1.04
Per capita disposable income	149.97	150.25	25.04	0.37	129.75	214.76	-2.3*	129.26	199.44	-2.04*
Per capita agriculture income	316.13	372.91	255.56	0.14	344.58	460.97	-1.3	327.39	479.16	-1.81

Measurement units in Table 3-2; *significance at 5% and **significance at 1%

The implication of inability to sell produce when availed to the market was likely to increase agricultural produce rejects and eventually to agro-food waste.

On overall, the daily per capita food waste was established to be 0.67 kg compared to agricultural waste which was 10.75 kg. The study revealed the unconscious nature in which households generated agro-food waste. Respondents admitted of not having thought about how much they generated as waste until they were engaged by enumerators to estimate. Comparably, daily per capita food waste findings by Soezer (2016) was 0.75kg among Nairobi City dwellers. The food waste findings were consistent with those of Kaza *et al.* (2018) that in sub-Saharan Africa the urban areas daily per capita waste was 0.74kg. In urban areas, waste generation was influenced by higher income compared to rural dwellers whose waste was 0.46kg daily per capita.

Daily per capita inedible waste generation for crop producers and non-producers had significantly different quantities at $p \leq 0.05$. Furthermore, livestock producers had significantly higher daily per capita quantities of crop waste compared to non-producers at $p \leq 0.05$. This implies that livestock producers were likely to use animal waste as a fertilizer in their crop enterprises thereby increasing produce which in turn contributed to cumulatively higher crop waste compared to non-livestock producers.

Daily per capita disposable income for livestock producers (Kes 129.75) and non-producers (Kes 214.76) were significantly different at $p \leq 0.05$. Similarly, the daily per capita disposable income between mixed (Kes 126.26) and non-mixed (Kes 199.44) producers was also significantly different at $p \leq 0.05$. This was consistent with the daily per capita urban agriculture income which was higher for non-livestock and non-mixed producers compared to livestock and mixed producers as shown in Table 3-3. This implied that non-participants in both livestock and mixed production had consistently higher daily per capita disposable income than their participating counterparts. Surprisingly, the daily per capita urban agriculture income was consistently higher than the daily per capita disposable income for all the participating and non-participating producer categories. This may imply that for most agro-producers, urban agriculture was their chief source of income. Alternatively, it implies that the reported urban agriculture income was likely the gross rather than net income.

In Table 3-4, the results of home ownership among urban agro-producer households disclosed that 86 percent owned a home. Livestock keepers had 93.35 percent home ownership compared to 60.91 percent of non-livestock keepers who owned a home. The livestock keepers and non-keepers home ownership were significantly different at $p \leq 0.01$. On the other hand, agro-producers who participated in mixed production had home ownership of 92.81 percent

Table 3-4: Urban agro-producers percentage (%) of participation in urban agriculture

	All producers	Crop producers			Livestock producers			Mixed producers		
Variables	% overall participation	participant	non-participant	χ^2 value	Participant	non-participant	χ^2 value	participant	non-participant	χ^2 value
Female	29	28.57	0	0.40	28.03	30	0.16	27.19	31.62	0.92
Male	71	71.43	100		71.97	70		71.81	68.38	
Employed head	25	25.27	0	0.34	23.12	31.82	3.35	24.06	27.94	0.76
Non-employed head	75	74.73	100		76.88	68.18		75.94	72.06	
Employed wife	17	17	0	0.20	18.32	22.82	2.79	15.31	20.9	2.09
Non-employed wife	83	83	100		81.68	77.78		84.69	79.1	
Own home	86	85.49	100	0.17	93.35	60.91	70.97**	92.81	68.38	46.01**
Don't own home	14	14.51	0		6.65	39.09		6.19	31.62	
Prepare excess food	44	44.18	100	1.26	44.51	43.64	0.03	44.06	44.85	0.02
Don't prepare excess food	56	55.82	0		55.49	56.36		55.94	55.15	
Refrigerate	44	44.18	0	0.79	46.53	36.36	3.50	47.19	36.76	4.21*
Do not refrigerate	56	55.82	100		53.47	63.64		52.81	63.24	
Plan food purchase	59	59.34	100	0.68	58.38	62.73	0.65	57.81	63.24	1.16
Do not plan	41	40.66	0		41.62	37.27		42.19	26.76	

Buy large food quantities	49	49.23	100	1.03	49.71	48.18	0.08	49.38	49.26	0.00
Do not buy large quantities	51	50.77	0		50.29	51.82		50.62	50.74	
Guaranteed market	70	70.33	0	2.36	73.7	59.09	8.51**	73.44	62.5	5.46*
No guaranteed market	30	29.67	100		26.3	40.91		26.56	37.5	
Access to extension	28	27.69	100	2.60	29.19	23.64	1.28	28.44	26.47	0.18
No access to extension	72	72.31	0		70.81	76.36		71.56	73.53	
Group membership	16	15.6	0	0.18	17.34	10	3.42	16.56	13.24	0.80
No group membership	84	84.4	100		82.66	90		83.44	86.76	
Regular servant	28	27.91	0	0.39	36.36	25.14	5.23*	31.62	26.25	1.37
No regular servant	72	72.09	100		75.86	63.64		73.75	68.38	
Islam religion	1	1.1	0	0.01	0.87	1.82	0.70	0.94	1.47	0.25
Non-Islam	99	98.9	100		99.13	98.18		99.06	98.53	

Measurement units in Table 3-2; *significance at 5% and **significance at 1%

compared to non-mixed producers whose ownership was at 68.38 percent. Participant and non-participant mixed producers' home ownership was significantly different at $p \leq 0.01$. The results implied that livestock producers were likely to own a home compared to non-livestock producers. Similarly, mixed producers were likely to own a home compared to non-mixed producers. This further implies that homeowners were likely to make long-term decisions regarding urban agriculture on their pieces of land compared to those who leased, used public space or were gifted land to use.

Whereas 44 percent of the agro-producer respondents refrigerated some of their food, only mixed producers compared to non-mixed producers had significantly different levels of refrigeration at $p \leq 0.05$; that is 47.19 and 36.76 percent respectively. This implied that mixed producers were more likely to store food for longer and possibly reduce food waste generated in their households compared to non-mixed producers.

The results among livestock production participants indicated higher guaranteed market linkages compared non-livestock producers that is at 73.7 and 59.09 percent respectively. The two were significantly different at $p \leq 0.01$. This could have been influenced by milk, pork and chicken meat guaranteed markets that the agro-producers had highlighted during the survey. In addition, 73.44 percent of mixed producers and 62.5 percent of non-mixed producers had guaranteed market access for their produce. Like livestock and non-livestock producers, mixed and non-mixed producers had significantly different guaranteed access to the market at $p \leq 0.05$. These implied that livestock producers and mixed producers had higher likelihood of having access to the market guarantees compared to non-livestock and non-mixed producers.

Notably, the results of the study revealed that livestock producers and non-producers had significantly different proportions in seeking regular servants' labour services in their households, at $p \leq 0.01$. An estimated 36.36 percent of livestock producers used labour from regular servants compared to 25.14 percent of non-livestock producers. This implied that beyond the labour provided by the agro-producer household members, livestock producers required additional labour services compared to non-livestock producers. This may be explained by the regular nature (day-to-day) requirement of labour in livestock enterprises compared to other enterprises.

3.3.2 Drivers of agricultural and food waste generation among agro-producer households

The food and agricultural waste FRM model results revealed that they were significant at $p \leq 0.01$ thus indicating goodness of fit. Their Wald chi-square statistics (Wald χ^2 (23) = 275.41, Prob> χ^2=0.0000; Wald χ^2 (19) = 340.62, Prob> χ^2=0.0000) implied that the explanatory variables used in the models jointly predicted food and agricultural waste share generation as shown on Table 3-5.

Advancement in age of the household head was likely to reduce the daily per capita food waste proportion but increase the daily per capita agricultural waste share. The food waste findings were consistent with Ishangulyyev *et al.* (2019) that older people were less wasteful. The agricultural waste findings were consistent with the observations made during the survey that older producers portrayed almost unplanned feeding behaviour for livestock. They regularly fed livestock if feeds were available which in turn made the animals picky. Probably, this contributed to generation of large quantities of livestock waste thereby increasing agricultural waste share.

A higher number of crop enterprises was likely to increase the daily per capita food waste and agricultural waste portion, in the short term. Similarly, higher number of total agri-enterprises would increase the daily per capita food waste and agricultural waste shares, *ceteris paribus*. This implies that the cumulative waste generated from additional enterprises would potentially contribute to the daily per capita food and agricultural waste shares. The higher the number of mature enterprises implies increased availability of food. As a result, households with more food available were likely to waste more than their counterparts with less. In addition, larger quantities of agricultural waste may mean that as the number of enterprises increase in a household, the varying managerial needs arises. As a result, the agro-producer may be unable to meet the managerial requirements of each enterprise efficiently and effectively thus contributing to increased waste. This implies that agro-producers with fewer number of enterprises were able to manage them better compared to those with large number of enterprises, specialization.

Improved urban agriculture knowledge was associated with a likely decline in the per capita food waste fraction, holding other factors constant. Probably, an understanding that waste represent lost time, labour and other productive resources in agriculture enabled agricultural

Table 3-5: Drivers of agricultural and food waste generation among agro-producer households

	Food waste		Agricultural waste	
Variables	Coefficient	dy/ex	Coefficient	dy/ex
Sex of household head	-0.0666(0.0704)	-0.0050	0.0161 (0.0714)	0.0013
Age of household head	-0.0062(0.0029)*	-0.0860	0.0103(0.0024)**	0.1403
Education level of household head	-0.0005(0.0116)	-0.0018	0.0039(0.0109)	0.0139
Education level of wife	0.0148(0.0095)	0.0502	-0.0165(0.0097)	-0.0540
Agriculture knowledge	-0.1023(0.0341)**	-0.0951	0.0614 (0.0370)	0.0565
Guaranteed market	-0.1586(0.0800)*	-0.0312	0.0994(0.0754)	0.0193
Regular servant	0.0041 (0.0843)	0.0003	-0.0206(0.0770)	-0.0016
Plan purchase/harvest	-0.1226(0.0805)	-0.0203	-0.1384 (0.0661)*	-0.0226
Crop enterprises	0.3393 (0.0389)**	0.6107	0.1454(0.04158)**	0.2561
Number of enterprises	0.3349(0.0339)**	0.7155	0.1505(0.0367)**	0.3151
Attitude	-0.0964 (0.0828)	-0.1012	-0.0338(0.0799)	-0.0351
Subjective norm	0.1433 (0.0423)**	0.1367	-0.0509(0.0362)	-0.0481
Household size	0.0072 (0.0195)	0.0105	-0.0084 (0.0158)	-0.0115
≤5 years	0.0981 (0.0450)*	0.0168	-	-
≥70 years	-0.0156 (0.0051)**	-0.0010	-	-
Prepare excess food	0.0942(0.0752)	0.0126	-	-
Refrigeration	0.0249(0.0807)	0.0030	-	-
Buy large quantities	0.0250 (0.0872)	0.0035	-	-
Per capita eat away	0.0007 (0.0008)	0.0038	-	-
Home ownership	0.3115(0.1100)**	0.0744	-	-
Islam religion	-0.3101 (0.2003)	-0.0007	-	-
Perceived behavioural control	-0.1212(0.0436)**	-0.1160	-	-

Lnpc disposable income	0.1580(0.0510)**	0.4614	-	-
Lnpc Agriculture income	-	-	-0.1318(0.0266)**	-0.3863
Employment of household head	-	-	-0.0071(0.0783)	-0.0006
Unable to sell frequency	-	-	0.0078(0.0034)**	0.0062
Extension access	-	-	-0.0394 (0.0761)	-0.0030
Group membership	-	-	-0.0365 (0.0904)	-0.0015
Livestock production	-	-	0.4795(0.1032)**	0.0920
_Cons	2.4557(0.6358)	-	-1.6489(0.3836)	-
	Wald χ^2 (23)=275.41; Prob > χ^2 =0.0000		Wald χ^2 (19)=340.62; Prob > χ^2 =0.0000	

Standard errors are in the parenthesis, *significance at 5% and **significance at 1%

households to reduce the likely food waste ratio. RUAF (2017) highlights the importance of agricultural knowledge in building sustainable urban agroecology.

Guaranteed market for produce harvested in the urban areas indicated that market access would be associated with a decline in the per capita food waste share. The implication of the association is that with access, the surplus produce would not go to waste. This notion is supported by negative significant association between making plans to harvest and agricultural waste portion. Planning of harvest timelines was associated with a likely decrease in the agricultural waste proportion. Consistently, a rise out in frequency of inability to sell harvested produce when availed to the market would prospectively increase the agricultural waste portion, holding other variables constant. This cements the descriptive finding that guaranteed market access showed reduced food waste portion. This implies that market access is a critical strategy in managing food and agricultural waste. The findings coincide with those of Irani *et al.* (2018) that food waste reduction could be achieved through market access interventions.

Higher score of subjective norms was associated with rise in the food waste fraction, *ceteris paribus*. This implies that a household's behaviour towards food waste is influenced by others that they look up to within the social circles and the society in general. Thus, a household was likely to adopt societal behaviours even in cases where they led to increased food waste.

This contradicts with Aktas *et al.* (2018) that subjective norm had a positive relationship with intention to reduce food waste. The disparities could be explained by the likely situational negative or positive nature of societal norms on behaviour. Conversely, the results indicated that a higher ability in perceived behavioural control was associated with likely decline in food waste ratio, in the short run. This suggest that a household's strong perception on ability to control food waste generation enabled reduction of the overall food waste at the household level. Similar findings were arrived at by Werf *et al.* (2019a) where perceived behavioural control contributed to reduced food wasting behaviour.

Number of children who were ≤5 years within a household were likely to increase food waste portion. On the contrary, the more the number of people with ≥70 years in a household, the lesser the food waste portion, in the short run. The relationship implies that children are on average higher contributors to the food waste basket compared to older people. The results may be explained by children's low comprehension vis-à-vis higher knowledge by adults on the amount each needs per meal. Whereas children's food is mostly prepared and served by adults or older children, they may not know with certainty how much a child will consume at a given time. This contributes to overestimation in most cases which in turn contribute to food waste. On the contrary, older people have much control over the quantities they prepare and serve. Furthermore, older people were associated with a higher understanding of the effort that goes towards putting food on the table unlike younger people who are mostly dependents in households. Porpino (2016) and Werf *et al.* (2019b) reported similar findings where children were associated with higher food wasting tendencies.

Rise in food waste portion was likely to be triggered by home ownership among agro-producer households. Home ownership as a proxy of wealth implies it has influence on household income (Id *et al.*, 2019; Matheson, 2019). The results showed an increase in the daily per capita disposable income was associated with a positive change in the food waste share. Similarly, a change of the daily per capita urban agriculture income was likely to contribute to a decline in agricultural waste portion in a household, in the short run. Home ownership is to an extent an indicator of household income status therefore it may signify food purchasing power compared to non-owners. As the daily per capita disposable income increases, households may have extra amount of money to spend on food which in turn contribute to increased food waste. Correspondingly, increase in urban agriculture income may influence the farmers' management behaviour to reduce agricultural waste to maximize on resource usage as well as monetary returns.

3.3.3 Drivers of edible and inedible food waste among urban agro-producer households

The disaggregated food waste (into inedible and edible food waste) FRMs are as presented on Table 3-6. The results revealed that the models were significant at p≤0.01 and had a good fit, Wald χ^2 (24) = 243.23; Prob > χ^2 =0.0000 and Wald χ^2 (24) = 139.12; Prob > $\chi 2$ =0.0000 for inedible and edible food waste respectively. This implies that the adopted explanatory variables were able to jointly predict the edible and inedible food waste share generation in urban households. In the short run, the number of crop enterprises and overall number of enterprises were associated with likely increase of daily per capita inedible and edible food waste ratio. The relationship implies that the higher the number of mature enterprises, the higher the availability of food. As a result, urban agro-producer households were likely to be choosier on the characteristics of food they consume. This would likely result to increased daily per capita edible and inedible food waste ratio in households.

Advanced age of the household head was more likely to contribute to reduced inedible food waste share, *ceteris paribus*. This implies that older people have a higher likelihood to consume what is generally considered inedible unlike younger people who may be picky. Alternatively, it may indicate that older people consume lesser amounts of food thereby generating lesser amount of inedible food waste thus smaller waste portion. Likewise, the number of household members who had age of ≥70 years had a negative relationship with the inedible food waste ratio. The higher the number of elderly persons in a household the lower the per capita inedible food waste ratio, in the short run. However, the number of ≤5-year-olds had positive influence on the daily per capita edible food waste fraction. An additional ≤5-year-old child in a household would likely increase the per capita edible food waste ratio, in the short-term. The association may be explained by the common practice where the food for the very young children in a household is prepared separately from the other members' food. In addition, food for young children is usually consumed fresh to minimize their higher susceptibility to food poisoning risk. In case of leftovers, it may go to waste. There is an associated guilt of not caring enough by parents that is linked to feeding children with leftovers (Cecere *et al.*, 2014; Schanes *et al.*, 2018) as such households are likely to avoid the practice. Furthermore, children are generally considered as picky eaters (Trofholz *et al.*, 2017) who contributes toward the increased overall edible food waste basket.

Table 3-6: Drivers of edible and inedible food waste among urban agro-producer households

	Inedible food waste		Edible food waste	
Variables	Coefficient	dy/ex	Coefficient	dy/ex
Sex of household head	-0.0401 (0.0680)	-0.0026	-0.1092(0.0850)	-0.0034
Age of household head	-0.0062 (0.0030)*	-0.0728	-0.0021 (0.0029)	-0.0131
Education level of household head	-0.0020(0.0127)	-0.0061	-0.0016 (0.0132)	-0.0029
Education level of wife	0.0074(0.0109)	0.0208	0.0212(0.0115)	0.0355
Household size	0.0040 (0.0198)	0.0049	0.0029 (0.0235)	0.0020
≤5 years	0.0200 (0.0468)	0.0028	0.1551(0.0507)**	0.0147
≥70 years	-0.0229(0.0093)*	-0.0010	0.0017 (0.0047)	0.0001
Employment of wife	-0.1493(0.0811)	-0.0056	0.2090 (0.1169)	0.0069
Lnpc disposable income	0.1736 (0.0502)**	0.4238	0.0474 (0.0602)	0.0642
Agriculture knowledge	-0.0920(0.0347)**	-0.0714	-0.0463 (0.0375)	-0.0199
Prepare excess food	-0.0333 (0.0744)	-0.0035	0.2638 (0.0930)**	0.0198
Refrigeration	0.0124 (0.0797)	0.0012	0.0557(0.0943)	0.0036
Plan food purchase	-0.1890(0.0795)*	-0.0250	0.0807(0.0947)	0.0069
Buy large quantities	0.0325 (0.0839)	0.0036	0.0279(0.1054)	0.0021
Pc eat away	0.0007(0.0008)	0.0029	0.0007 (0.0009)	0.0019
Guaranteed market	-0.1425(0.0807)	-0.0231	-0.0943 (0.1012)	-0.0084
Regular servant	0.0049 (0.0754)	0.0003	-0.0244 (0.1231)	-0.0009
Home ownership	0.2305(0.1031)*	0.0459	0.2207 (0.1366)	0.0234
Islam religion	-0.6199(0.2614)*	-0.0006	0.1597(0.2173)	0.0003
Crops	0.2915(0.0405)**	0.4391	0.2377(0.0458)**	0.1894

Number of enterprises	0.2867 (0.0353)**	0.5114	0.2316(0.0408)**	0.2153
Attitude	-0.0359(0.0831)	-0.0318	-0.1409 (0.1179)	-0.0669
Subjective norm	0.1155(0.0423)**	0.0934	0.0885 (0.0476)	0.0378
Perceived behavioural control	-0.0810(0.0438)	-0.0656	-0.1144(0.0552)*	-0.0487
_Cons	2.1822 (0.6612)		-0.1848(0.8510)	
	Wald χ^2 (24)= 243.23; Prob > χ^2=0.0000		Wald χ^2 (24)= 139.12; Prob > χ^2=0.0000	

Standard errors are in the parenthesis, *significance at 5% and **significance at 1%

Higher amounts of daily per capita disposable income were associated with a rise in inedible food waste generated per person per day. This implies that higher household earnings enhanced food access through higher purchasing power. This may have contributed to increased inedible waste, ceteris paribus. Similarly, homeowners were more likely to generate a higher fraction of daily per capita inedible waste compared to non-owners, in the short run. Ownership of high value assets such as a home is an indicator of social status (wealth) which is closely linked to income status in the society. The common notion in the society is that wealthier households are associated with higher affordability (purchasing power) to own more than they can consume as a result generating more food waste than their less wealthy counterparts. Concurrently, Id *et al.* (2019) revealed that home ownership correlate with high food expenditure and higher food waste generated. However, Matheson (2019) argued that although property ownership is an indicator of wealth and income, it is a poor proxy for consumption since it may not correlate to food waste generation.

A likely reduction of the inedible food waste ratio was associated with food purchase planning by households, in the short-term. This implies that impulse buying of food was likely to cause increased inedible food waste generated by an urban agro-producer household. On the contrary, preparation of excess food during meals was a positive driver of edible waste. The results indicated a probable increase of edible waste portion for rise in preparation of excess food in households, holding other variables constant. In practice, preparation of excess food is likely to contribute to food leftovers which may eventually not be consumed. Bravi *et al.* (2019) findings indicated that avoidable food waste could arise due to preparation of excess food during meals as well as purchasing larger quantities of food than required in a household.

Islam practicing household heads were associated with reduction in edible food waste, *ceteris paribus*. This may be explained by strict advice against extravagance in the Islamic faith as cited in the Holy Quran;

'It is He Who produceth gardens, with trellises and without, and dates, and tilth with produce of all kinds, and olives and pomegranates, similar (in kind) and different (in variety): eat of their fruit in their season but render the dues that are proper on the day that the harvest is gathered. But waste not by excess: for Allah loveth not the wasters.' (Qur'an 6:141, n.d.).

'O children of Adam, take your adornment at every masjid, and eat and drink, but be not excessive. Indeed, He likes not those who commit excess.' (Qur'an 7:31, n.d.).

Similarly, Abdelradi (2018), Abiad and Meho (2018) and Baig *et al.* (2018) reiterates the critical role of Islamic teachings in guiding use of food resources in the Islam practicing households.

Subjective norm was a positive driver in inedible food waste generation. This implied that households were likely to behave in a similar manner like those within their social network or those they looked up to. Therefore, that which is considered as inedible parts of food are regarded as such even if they could be edible. Higher score of subjective norms was likely to contribute to rise of inedible waste portion generated among the urban agro-producer households, in the short run. On the other hand, perceived behavioural control was associated with decline in the daily per capita edible food waste ratio. This implies that increased perceived ability to manage edible food waste was likely to result to reduced daily per capita edible food waste ratio among urban households. This also implies that the belief in oneself in managing food waste is associated with its reduction. Wilson *et al.* (2015) argued that waste emanating from households was linked to production and consumption behaviour. Werf *et al.* (2019a) indicated that subjective norm was important in explaining the intention to reduce food waste thus has a stake in determining food waste portions.

3.3.4 Drivers of crop and animal waste generation among urban agro-producer households

The FRM model statistics for crop and animal waste shares in agro-producer households were significant at $p \leq 0.01$; Wald χ^2 (20) = 197.90, Prob> χ^2=0.0000 and Wald χ^2 (20) = 275.99, Prob> χ^2=0.0000 respectively. The statistics implied a good model fit. As a result, the selected explanatory variables were satisfactorily able to predict crop and animal waste shares in urban agro-producer households as presented in Table 3-7.

Table 3-7: Drivers of crop and animal waste generation among urban agro-producer households

	Crop waste		Animal waste	
Variables	Coefficient	dy/ex	Coefficient	dy/ex
Sex of household head	0.0301(0.0820)	0.0026	-0.0419(0.0895)	-0.0034
Age of household head	0.0026(0.0027)	0.0376	0.0069(0.0029)*	0.1030
Education of household head	0.0118(0.0128)	0.0428	-0.0110(0.0127)	-0.0404
Education level of household head	-0.0267(0.0125)*	-0.0861	0.0160(0.0123)	0.0538
Household size	-0.0295(0.0169)	-0.0392	0.0206(0.0160)	0.0295
Employment of household head	-0.0214(0.0943)	-0.0016	-0.0266(0.0919)	-0.0019
Employment of wife	0.0043(0.1069)	0.0002	0.0688(0.1139)	0.0033
Lnpc Agriculture income	-0.0059(0.0293)	-0.0179	0.1457(0.0301)**	0.4546
Agriculture knowledge	0.0053(0.0424)	0.0051	0.0732(0.0451)	0.0713
Guaranteed market	0.1216(0.0893)	0.0248	0.0362(0.0949)	0.0078
Access to extension	-0.0541(0.0822)	-0.0043	-0.0115 (0.0862)	-0.0010
Group membership	0.0663(0.0964)	0.0030	-0.0839(0.1066)	-0.0040
Regular servant	-0.0332(0.0870)	-0.0026	0.0582(0.0900)	0.0044
Plan harvest	-0.0038(0.0874)	-0.0007	-0.1268(0.0947)	-0.0248
Livestock	0.5873(0.1154)**	0.1150	1.5848(0.1924)**	0.4260
Crops	0.2061(0.0422)**	0.3968	0.2372(0.0435)**	0.4908
Unable to sell	0.0068(0.0048)	0.0054	-0.0136(0.0091)	-0.0081
Number of enterprises	0.1729(0.0383)**	0.3937	0.2147(0.0384)**	0.5494
Attitude	-0.1039(0.1068)	-0.1095	0.0586(0.0991)	0.0636
Subjective norm	0.0542(0.0395)	0.0520	-0.0842(0.0419)*	-0.0828
_cons	0.0629(0.4326)		-3.6192 (0.5316)**	
	Wald $\chi^2(20)$= 197.90; Prob > χ^2 =0.0000		Wald $\chi^2(20)$= 275.99; Prob > χ^2 =0.0000	

Standard errors are in the parenthesis, *significance at 5% and **significance at 1%

Participation in livestock production by a household was a positive driver on crop waste ratio. This implies that livestock producers generate larger quantities of crop waste compared to non-producers. Livestock producers may have used livestock waste as a factor of crop production, which translates to likely higher productivity thus generating more waste in the process. On the other hand, livestock production was also a positive driver of daily per capita animal waste ratio. The findings support the influence of livestock production on agriculture waste in Table 3-5. This may seem obvious since in livestock production, waste emanating from animals arises in the process. However, differences may set in due to disparities in livestock management regimes.

Larger crop and animal waste shares in agro-producer households were associated with additional mature market-oriented crop enterprises. An increase in the number of overall agri-enterprises (with produce surplus) was projected to contribute to increment on the daily per capita crop and animal waste shares. This implies that as the magnitude of involvement in agricultural production increases, the higher the agricultural waste (crop and animal waste) quantities that were likely to be generated at the household level.

Education of the household woman was associated with a likely decline in per capita crop waste ratio, holding other variables constant. This is supported by the descriptive results that female spouses were less likely to be formally employed than their male counterparts. As a result, the female spouses were more likely to be directly responsible on urban agriculture in a household setup. Moreover, in the African culture, women (especially housewives) are traditionally bestowed with the responsibility of looking after the home and its resources whether the husband works outside the home or not. Higher education level may imply higher comprehension, as such they may be able to manage pests and diseases thereby reducing likely crop waste in the production process. However, this notion is increasingly changing with the changing gender roles (Kim *et al.*, 2000) influenced by the increasing education attainment among women.

Higher daily per capital animal waste ratio in households was associated with progress in age of the household head, *ceteris paribus*. Observations from the study portrayed mostly unplanned livestock feeding regime by older people. They were also observed to feed livestock on materials such as weeds, tree and fence waste that are likely to result to higher quantity of waste than younger people who opted to feed livestock on commercial feeds, preserved and fresh fodder (hay and napier grass among others). This behaviour was likely to result to cumulatively higher animal waste generated in older-people-headed households.

Higher subjective norm score was associated with lower portion of animal waste generated in a household. This implied that if adopted by an urban agro-producer household, the societal behaviour seemed to enable them to manage animal waste. This also implies that lesser participation in livestock production and or more efficient livestock feeding habits may result to reduced animal waste.

3.4 Conclusion and managerial implications

The study set out to assess the drivers of agro-food waste generation typologies among agro-producer households using self-reported data. The study results indicate that the daily per capita quantities for agro-food waste generated by urban households were 0.67kg (edible 0.21kg and inedible 0.46kg) food waste and 10.75kg (1.55kg crop waste and 9.20kg animal waste). This is an indication that the livestock farming system is the highest generator of agro-food waste at the household level whereas the crop system is the largest consumer. In other words, the mixed farming system ensured that the livestock and crop systems utilised the agro-food waste arising. As such they were interdependent.

Socioeconomic (age of the household head, number of household members aged ≥70 years, daily per capita disposable income, home ownership, urban agriculture knowledge, number of mature crop enterprises, number of agri-enterprises and market guarantee) and behavioural (subjective norm and perceived behavioural control) agro-producer characteristics are the drivers for food waste generation. In comparison, socioeconomic (age of the household head, number of crop enterprises, number of agri-enterprises, per capita urban agriculture income, inability to sell harvested produce and livestock production) and behavioural (planning to harvest produce) attributes are the drivers for agricultural waste generation. Notwithstanding the apparent disparities, common drivers of agricultural and food waste were revealed; age, number of mature crop enterprises, number of agri-enterprises, per capita income and market access. The number of agri-enterprises had the highest predicted marginal effect on both agricultural and food waste portions generated among households at 0.32 and 0.72 respectively. Whereas the socioeconomic attributes seemed to carry more weight in determining agro-food waste generation, they were responsible for forming the household behavioural dimensions. This implies that agricultural educational programs aimed at informing the behavioural perspective of agro-producers may be required. Furthermore, the agro-producer household are largely not keen in waste generation, as such contributing to increment of the quantities of agro-food waste generated. To minimize agro-food waste emanating from numerous agri-enterprises, specialization on fewer enterprises may be more appealing to agro-producers such that they manage them more efficiently. The program can target agro-producer households in raising self-awareness aimed at self-regulation in agro-food waste generation.

3.5 Limitations and suggestions for future research

As self-reported cross-sectional approach was used to gather data, there might be a likelihood of seasonal effect and misrepresentation of actual agro-food waste generated by urban households. Nevertheless, the study results provide important indications of the urban agro-food waste generation situation that need to be amended by devising appropriate self-regulation and community efforts at the household level. However, building on this study, a longitudinal study may be more critical in boosting the accuracy of data generated.

CHAPTER FOUR

AGRO-FOOD WASTE MANAGEMENT AND SAFETY PRACTISES AMONG SMALL-URBAN FARM BUSINESSES: MICRO-LEVEL INSIGHTS

Abstract

The study aimed to avail crucial information on the largely informal management of agro-food waste that is practiced in low- and lower middle-income countries. Insights of safety measures adopted in the utilisation of agro-food waste among urban agro-producers were explored empirically. An electronically structured questionnaire was administered on a sample of 456 urban agro-producer households for data collection. Descriptive as well as Multivariate Probit models were employed for analysis. The results indicated significant disparities in management options and safety risk management practices between the participating and non-participating livestock and mixed producers. Whereas the regression models showed disparities in the contextual factors influencing agro-food waste management options and safety risk measures, the knowledge variables (waste sorting and urban agriculture knowledge) largely had influence across these agro-food waste aspects. This implies that implementation of education programs in agro-food waste management and safety risk management practices among urban agro-producer households by urban authorities would enhance sustainable food safety in urban food supply chains. The findings could inform self-management efforts of agro-food waste in small-urban agribusinesses thus increasing economic benefits and improving environmental wellbeing.

Keywords: Waste utilisation, micro-level, urban agriculture, safety risk, self-management, Kenya

4.1 Introduction

Environmental and health-related risks makes management of waste an issue of global concern (Ferronato & Torreta, 2019; Wilson *et al.*, 2015). Perhaps in order to make its management efficient, waste is generally handled as a public service (Abrate *et al.*, 2014; Beigl *et al.*, 2008). However, this has not translated to admirable results is some countries. In provision of waste collection services, urban authorities are often non-streamlined and corruption may influence the provision of services (Breukelman *et al.*, 2019; Gumisiriza & Kugonza, 2020). In most countries, waste management service in urban areas is a monopoly run by those who are in power (Abrate *et al.*, 2014; Abrate *et al.*, 2018) thus affected by accountability, corruption and efficiency shortcomings. In cases where city authorities are unable to address waste issues in a feasible way, they contract private service providers under public-private partnership. However, these contracts may be riddled by "under-the-table dealings" which bear more weight, eventually compromising waste management. Some countries even go a step further to privatise waste collection services to ensure accountability and quality of services (Kaza *et al.*, 2018).

Waste management in developing countries is regarded as inefficient, narrow and may involve improper disposal of waste (Kassaye, 2018) with weak capacity systems. According to Henry (2006), and Zohoori and Ghani (2017), urban centres of developing countries face the same municipal solid waste problems; illegal dumping, limited services, non-structured neighbourhoods and poor waste infrastructure. An estimated 52 and 74 percent of waste in urban and rural areas of low-income countries remain uncollected compared to lower- and upper middle-income countries whose urban and rural uncollected waste range between 15-29 and 55-67 percent respectively. High-income economies' urban and rural uncollected waste is even lower at zero and two percent respectively (Kaza *et al.*, 2018). As noted by Kassaye (2018), waste is generated from our ways of life especially in quest for satisfaction of development needs and wants through supply chain activities. In response, understanding the processes that lead to rise of waste and adopting requisite management practises is fundamental.

From a public perspective, the wheels of transition from viewing waste as a problem to considering and tapping its value are turning rather slowly in developing countries. Some urban authorities across the world have put in place appropriate mechanisms for recovery, reuse and recycling waste into other forms such as energy and compost (Dubbeling *et al.*, 2016; World Energy Council, 2016) in furtherance of the right to clean and healthy environment and economic empowerment for the population. However, according to Kaza *et al.* (2018), in low- and lower-middle income countries, public waste collection services do not reach the whole population. In response, households often make own arrangements to manage the waste they generate. The waste management efforts embraced at micro-level may have a significant impact on the overall waste management in urban areas by spinning and steering the wheels of waste perception transition. As a result, a resource management approach in dealing with waste has been increasingly adopted especially at the household level. Although not risk-free, initiatives such as composting and utilisation of waste in urban agriculture have often been adopted. Urban agriculture as an alternative avenue for managing organic waste departs from the traditional methods such as dumping and landfilling. This illustrates a transition of waste from a burden to value; revealing the value of resources concealed in waste (Menyuka *et al.*, 2020).

In Nairobi, Kenya, over 2,400 tons of waste are generated daily. About 30-40 percent of the waste is not collected since only about 50 percent of urban population are served with waste collection services (Kaza *et al.*, 2018; NEMA, 2015). An estimated 68 percent of waste generated is domestic while food waste constitutes 57 percent (Ondiba, 2016). In taking advantage of the existing national feed and waste management policy gaps, some of the waste is recovered (NEMA, 2015). There is evidence of informal agro-food waste[6] management efforts at the household level, although it is limited (FAO, 2012; Karanja *et al.*, 2010). As an alternative to conventional agricultural inputs, enhanced management of agro-food waste forms a support system for small-urban farm businesses. Therefore, the study sought to assess (1) contextual factors influencing choice of agro-food waste management options for waste generated within urban agro-producer households who had agricultural output market orientation and (2) safety risk management practices devised among urban agro-producer households for agro-food waste generated within the households and that which is acquired elsewhere. The findings of the study would be of interest to urban centre managers and governments in formulation of a requisite framework for safe use of agro-food waste. It is also expected to invoke interest in agro-food waste commercialisation by small-urban farm businesses. On overall, the study is expected to contribute to the research and development in agro-food waste management through improved data, models, and concepts in relation to safety risk practices.

4.1.1 Waste management options

In Bahir Dar City, Ethiopia, Wegedie (2018) established that households' waste management practises included burning, burying and or dumping generated waste within their compounds. Dumping waste in undesignated places such as roadsides, riverbanks, and/or vacant lands was also common. Some household adopted these practises notwithstanding that they received local authority services but were either considered undependable or inefficient. Notably, some households utilised waste for composting and as animal feed. Similarly, Brown (2015) indicated that in Tanzania, households managed waste through improper disposal (throwing on road and drainage channels), designated place within their compounds, taking to public landfill, and/or handing to waste pickers. In Ghana, Adu-boahen *et al.*, (2014) findings

[6] Agro-food waste refers to agricultural and food waste; materials that are non-prime and arises from agriculture, forestry and fishery supply chains, and food that is intended for human consumption but for varying reasons not used as such. Agro-food waste emanating from own household, other households, restaurants, agro-markets, processors and dumpsites was considered. Liquid waste was not included in the study.

on waste management practises study indicated that burning was the most prominent choice although recycling and burying were practised to a lesser extent. Waste management practises in Kenya were found to be similar to those in Ethiopia, Ghana and Tanzania, where dumping was dominant though reuse, recycling and burning were practised (Nthambi, 2013). Nigussie *et al.* (2015) brought in a perspective of selling agro-food waste as a management practise. Further, Jouhara *et al.* (2017) in the assessment of municipal waste management for home use showed that households could benefit from adopting segregation, composting, anaerobic digestion, combustion and sterilization management practises.

Mu'azu *et al.* (2018) in their study of food waste summarized waste management practices to include reduction at source, feeding the needy, use as animal feeds, energy recovery, anaerobic digestion, composting, incineration and landfilling. The study indicated that in Saudi Arabia, although incineration and landfilling could be considered as waste management strategies, they represented the least preferable avenues since they were least beneficial. Source reduction was argued to be the most desirable option since it fulfils a religious obligation of judicious resource utilisation and the value of food is not lost in the process unlike all the other practices. From a different angle, Kassaye (2018) categorized waste management approaches as conventional practices (top-down approach). In this case, public participation is not key, command and control practices where the public is expected to follow bylaws and public-private partnership where there is medium- or long-term arrangement of sharing or transferring responsibilities. Kassaye (2018) arguments were more of local authority approaches but are key in the direction in which households may choose to manage their waste especially as groups, for instance in gated neighbourhoods.

In a study on household solid waste management in Tanzania, Brown (2015) findings showed that knowledge on local authority waste management regulations was a key driver in the choice of waste management practices. However, even though most of the households knew the related health dangers, majority (four-fifths) practiced illegal waste disposal. Surprisingly, almost a fifth of the sampled households had no knowledge of the solid waste management services that the local authority offered. Similarly, Alemayehu *et al.* (2017) cited rampant unauthorized dumping of waste in Ethiopia. Almost three-quarters of households practiced improper waste disposal. Equally, Ezebilo and Animasaun (2011), and Kassaye (2018) reiterates the problem of inefficiency in waste collection by local authorities and the likely resultant emergence of private waste collectors and illegal dumping in Ethiopia and Nigeria.

Mamady (2016) identified dumpsite, private and local authority collectors as the major waste management practices in Guinea which were either good or poor management practices.

The findings indicated that gender, education level, marital status, residential neighbourhood, household earnings and access to permitted dumpsite (distance) were significant factors in choice of good and poor management practices. Comparably, the Malaysian waste management by local authorities was characterized by poor management though controlled, resulting to inadequate application of pollution mitigation measures. In a choice experiment for hypothetical assessment of waste disposal technology options (control, landfill and incineration), Pek and Jamal (2011) estimated the non-market prices of waste management options with anxiety, air pollution, land utilisation and water quality (river) attributes. Varying choice sets of the technology attributes were used in labelling of disposal technologies. The findings showed that implicit prices were higher for technology specific options and distance from the current and proposed waste management facility were significant in determination of waste management fee. The approach of dichotomizing all management practices into good or poor aspects led to limitation of information whereas choice experimentation may have caused fatigue due to the size of choice set. This may have translated to low validity of information generated.

4.1.2 Safety risk management practices

Literature shows that waste management practises can help to mitigate the likely negative effects of waste or possibly amplify them (Mamady, 2016). It was also evident that in utilisation of waste resulting from human activities, it would be critical to consider the safety risk arising and therefore adopt appropriate risk mitigation measures. For instance, though becoming popular in some developing countries (Jouhara *et al.*, 2017), waste segregation practises at source have been minimal in most developing countries' waste management systems (Ferronato & Torreta, 2019; Kassaye, 2018). However, where practised it is either not encouraged or is done poorly (Mu'azu *et al.*, 2018). This is a major oversight on the likely economic benefits from reusable and recyclable materials as highlighted by Wegedie (2018) and may become a potential safety risk source. When the environmental quality and health (human, livestock, soil and plants) is threatened, safety risk issues arise.

In recognition of the risks associated with use of waste in urban agriculture, Drechsel *et al.* (2015) suggested health-based objectives such as health-outcome, water-quality, performance and specified technology application target measures to manage associated risks. Moreover, in considering the ease of implementation of the foresaid strategies especially in developing countries, Drechsel *et al.* (2015) recommended use of basic strategies at farmer level. These included at least some level of wastewater treatment and drip irrigation preference to cut down pathogen load in waste application and washing produce after harvest. Overnight storage of produce after harvest, disinfection, peeling and cooking were also cited as cost friendly on-farm interventions.

Mamady (2016) conducted analysis of safety behaviour (hygiene, proper disposal and childcare) in waste management. Gender, age and education of the head as well as income and residential location of the household were significant in explaining household safety risk management behaviour. Likewise, past studies have expressed agro-food waste safety risk concerns especially in their utilisation in farming activities. Salemdeeb *et al.* (2017) cited that European Union guidelines permits preferential use of food waste as animal feeds. However, use of most food waste as animal feeds is illegal owing to potential disease risk but nevertheless the practise is growing. Contrastingly, in East Asia, heat is used to treat food waste to meet feed safety standards. Similarly, Rivin *et al.* (2014) and Bakshi *et al.* (2016) noted that size and high moisture content is a safety risk for use waste as animal feed but chopping, drying, ensiling, mineral and common salt mixing can be employed as risk management practises. Salemdeeb *et al.* (2017) further indicated that wet and dry pig feed technologies used in South Korea as well as anaerobic digestion and composting could be readily used in boosting safety of agro-food waste utilisation. According to Zu Ermgassen *et al.* (2016), food waste processing as pig feed could translate to reduced land under pork production and safety risk of greenhouse emissions yet providing a low-cost animal feed.

In 'food waste to animal feed,' Westendorf (2000) outlined food waste that has been used as animal feed such as maize remains, wheat middling, distiller's residue, hotel waste and generally garbage. He further indicated that there were risk concerns associated with using food waste as feed. In pig feeding, producers employed safety risk management practises on food waste such as cooking, mixing garbage with grains and forage. Drechsel *et al.* (2015) stresses the need for nutrient recovery in organic waste utilisation in urban agriculture and in the process managing the likely safety risk of waste. Alike, Sabiiti (2011) delved on utilisation of agricultural waste in urban Uganda for improving the organic matter and fertility of soil as well as animal feed as a way of managing the likely risk arising. Waste segregation, composting and energy generation from agro-food waste were identified as critical in safety risk management (Ferronato & Torreta, 2019; Jouhara *et al.*, 2017; Kassaye, 2018; Mamady, 2016; Mu'azu *et al.*, 2018; Saravanan *et al.*, 2013; Wegedie, 2018). Whereas addressing safety risk issues in the utilisation of agro-food waste may contribute to improved food safety in the urban food supply chain, the assessment of choice of safety risk management practises is remarkably scarce in literature.

4.2 Methodology

4.2.1 Study area

The study was conducted in Nairobi City County (see Appendix 2), the administrative capital of Kenya. The choice of the study area was informed by the city authority's effort towards streamlining urban agriculture through Nairobi City County Urban Agriculture Promotion and Regulation Act, 2015 (RoK, 2015). The area is an important centre for agricultural trade (local, imports and exports), processing, distribution and consumption thereby agro-food waste arising as a result. In addition, over 20 percent of households in the City are involved in agriculture (Lee-smith, 2010). Land under urban agriculture is estimated to be 13.9 percent of the Nairobi City County surface area (RoK, 2018). Having the highest population of over 4,397,073 people (KNBS, 2019a) compared to other major Kenya's urban areas, the area was projected to portray a higher diversity of agro-food waste management practices.

4.2.2 Sampling and survey instrument

The study sample involved a cross-sectional survey of urban agro-producer households who (a) had been involved in one or more agricultural enterprises, (b) produced agricultural output and sold some or all of it during the three months preceding the survey and (c) freely consented to participate in the survey. Small-urban farm businesses run by households were the respondents per se. The selection of respondent households was through a multi-stage sampling procedure. The first stage involved clustering the study area to 85 clusters as per the existing administrative wards. Purposive sampling of ten clusters based on past and present agricultural activities in the areas was used in the second stage. Given that structural equation modelling was used in one aspect of the study, a sample size of 456 instead of 356 was arrived at in order to establish meaningful association of parameters and sample size as cautioned by Wolf *et al.* (2013). Since the population of agro-producers in the respective wards was unknown during the survey, the total sample size of 456 for the study was distributed equally among the selected clusters; approximately 46 households. However, requisite adjustments were done later centred on the agricultural situation that was found in the specific wards. In the third stage, the cluster specific sample was selected through systematic random sampling in areas where a list of agro-producers was available. Lists of potential respondents were developed through pre-identification by field facilitators who were engaged during the study. In addition, the last stage involved referral sampling in clusters where a list of potential respondents was not available. The requisite ethical approvals were granted by National

Commission for Science, Technology and Innovation (NACOSTI) vide License No. NACOSTI/P/20/4406 before commencing the survey.

An electronic-structured questionnaire (Appendix 7) designed in the Kobo Humanitarian platform under Kobo Toolbox was implemented in the Kobo Collect mobile application in offline-online mode. Prior to data collection, requisite training of research assistants on how to execute the research questionnaire was conducted for two days using the Kobo mobile app and printed out questionnaire. This was followed by two days of pilot survey to test the research assistant's familiarity with the questionnaire, likely gaps, flow and adequacy of the instrument. Upon conclusion of the pre-testing phase, the principal investigator and the research assistants' shared experiences during the execution of the questionnaire. These views were assessed and where found compelling they were incorporated into the questionnaire. The research assistants that portrayed difficulties during the pilot study were dropped while the rest were involved in the survey. The research assistants were required to share an agro-food waste brochure (Appendix 10) with potential respondents that had a summary of what the research sought. In addition, the assistants informed potential respondents on their rights regarding their involvement in the study and subsequently consent to participate was obtained (Appendix 6). The data collected were downloaded from Kobo Toolbox in Microsoft Excel and exported to Stata 15 for cleaning and analysis. Data were subjected to requisite multicollinearity and correlation tests and corrections, after which were run for analysis.

4.2.3 Analytical framework

Influenced by literature, experience and intuition, the identified agro-food waste management practices that were likely to be practiced by urban agro-producers were waste reduction, utilising, giving out or selling, and disposing. In managing agro-food waste through utilisation, it was projected that small-urban farm businesses were likely to encounter safety risks which were likely to affect soil, air, water, crops, animals and humans. These risk perceptions necessitated sorting or segregation, cleaning (using water), heat treatment (cooking/boiling/steaming and or drying), composting, mixing (with dry feeds and or salt) and specific sourcing (sourcing only from self-vetted outlets) of agro-food waste as safety risk management measures in utilisation.

In literature, a common practise in choice of waste management practises has been the assumption of mutually exclusiveness of waste management alternatives where Multinomial Logit (MNL) has been applied (Launio *et al.*, 2014; Molem & Enjema, 2017; Nthambi, 2013). However, given the numerous alternatives available for agro-food waste management and safety risk management, urban households could adopt several options concurrently, an indication that the assumption of mutual exclusiveness is misleading. MNL is suited for studies where the individual under observation can only make a single choice amongst various options at their disposal; it assumes exclusivity in choices (Bel & Paap, 2014). In real-life situations such as in waste management, an individual can make simultaneous choices which are correlated and therefore not mutually exclusive. Equally, the Multinomial Probit is challenged in that it requires a structural-error covariance matrix that is arbitrary up to a fixed element and therefore constrained beyond normalization (Bruno & Dessy, 2014). As an alternative, Multivariate Probit (MVP) model has been argued to be advantageous in that it enables a joint estimation of several associated binary outcomes. It employs a simultaneous approach rather than sequential approach in the determination of the influence in a set of independent variables on each of the different agro-food waste management options/practise choices by a household. Unlike MNL and univariate Probit, MVP allows for correlations between unobserved stochastic components and outcome (management choices) relationships. In addition, MVP enables derivation of marginal probabilities directly (Young *et al.*, 2006). Therefore, the study was based on the theory of choice (Launio *et al.*, 2014) using MVP.

4.2.4 Management options

Informed by the above insights, if a household i choose k, it is a representation of a choice set of agro-food waste management options/practises. The choice set could be made up of several management alternatives. Considering each agro-producer household can choose one or more management option/practise, then $k = (Y_1, Y_2, Y_3, \dots Y_n)$ depending on the choice set constitution. From this, the net benefit for the i^{th} household was;

$$\mathrm{Y_{ik}} = \mathrm{U_k} \quad \mathrm{U_0} > 0 \tag{1}$$

Where Y_{ik} is a latent variable and U is utility.

Based on McFadden (1986) notion that choices can be altered by socio-economic and demographic variables, then the latent variable which is a product of management alternatives can be explained by the household characteristics as well as the disturbance that occurs in the estimation of resulting benefit. In essence, the covariance symmetric matrix gives rise to the MVP model (Tarekegn *et al.*, 2017). The system is based on the indicator function in which the unobserved choices are in a binary outcome (adopted = 1 or otherwise = 0) form for each of the management option/practise choices;

$$Y_i = \begin{cases} 1 \; if \; Y_{ik} > 0 \\ 0 \; ot \;\; erwise \end{cases} K = Y_1, Y_2, Y_3, Y_4 \tag{2}$$

Where Y_i the management option and K is options/practises choice set.

Therefore, the anticipated agro-food waste general management options (choice set) were coded as waste reduction (Y_1), utilise (Y_2) give out/sell (Y_3) and or dispose (Y_4). The MVP model for the choice of agro-food waste management options is as portrayed by equations 4-9. Equation 3 is a system of j equations which can be expressed as (Dessie *et al.*, 2018);

$$\mathrm{Y_{ik}} = \mathrm{X_i'}\beta_\mathrm{k} + \ _\mathrm{i} \qquad (3)$$

Where β_k is a range of parameters to be estimated, $\mathrm{X_i'}$ are contextual and Extended Theory of Planned Behaviour construct variables, and $_\mathrm{i}$ is the disturbance term.

Given Equation 3, the choice of individual household agro-food waste management options/practises can be presented as;

Waste reduction	$\mathrm{Y_{1i}} = \mathrm{X_{1i}'}\beta_1 + \ _{1\mathrm{i}}$	(4)
Utilise	$\mathrm{Y_{2i}} = \mathrm{X_{2i}'}\beta_2 + \ _{2\mathrm{i}}$	(5)
Give out/sell	$\mathrm{Y_{3i}} = \mathrm{X_{3i}'}\beta_3 + \ _{3\mathrm{i}}$	(6)
Dispose	$\mathrm{Y_{4i}} = \mathrm{X_{4i}'}\beta_4 + \ _{4\mathrm{i}}$	(7)

Where X_i' is 1 x k vector of independent variable that influences the choice of management options/practises, β_k being k x 1 vector of unknown parameters to be estimated, and $_i$ is the error term with a multivariate normal distribution $[MVN{\sim}(0, \Omega)]$ with a mean of zero and respective variance-covariance matrix V (Equation 8). The values of V are one (1) on the leading diagonal and correlations that is $p_{11}, p_{22}, \dots, p_{66} = 1$ (Dessie *et al.*, 2018; Rodríguez-Entrena & Arriaza, 2013; Tarekegn *et al.*, 2017; Temesgen *et al.*, 2017). The p_{11} to p_{44} represents joint probabilities of choosing a set of agro-food waste management options by considering the adoption and non-adoption aspects as shown in Equation 8.

$$\Omega = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \\ p_{41} & p_{42} & p_{43} & p_{44} \end{bmatrix} \qquad (8)$$

Where p is probability.

4.2.5 Safety risk management practices

In response to the risk perceptions that agro-producer households have towards waste, requisite safety risk management practices are adopted. Therefore, a household i is likely to choose one or more safety risk management measures which are projected to include sorting (Y_1), cleaning (Y_2), heating (Y_3), composting (Y_4), mixing (Y_5) and or specific sourcing (Y_6). The choices are assumed to be simultaneous. Like the choice of agro-food waste management options, MVP was applied to assess the choice of safety risk management practices. As such the theoretical expressions for management options were like those of safety risk practices with a slight difference on the number of equations and the variance-covariance matrix. These are specified as below (Equation 9-15).

Segregation/sorting	$Y_{1i} = X'_{1i}\beta_1 + \;_{1i}$	(9)
Cleaning	$Y_{2i} = X'_{2i}\beta_2 + \;_{2i}$	(10)
Heating	$Y_{3i} = X'_{3i}\beta_3 + \;_{3i}$	(11)
Composting	$Y_{4i} = X'_{4i}\beta_4 + \;_{4i}$	(12)
Mixing	$Y_{5i} = X'_{5i}\beta_5 + \;_{5i}$	(13)
Specific sourcing	$Y_{6i} = X'_{6i}\beta_6 + \;_{6i}$	(14)

The variance-covariance matrix (Equation 15) is a representation of joint probabilities in choosing a combination of safety risk management practices by an agro-producer household. For instance, p_{11} to p_{66} represents joint probabilities of safety risk management practices choice set consisting of segregation, cleaning, heating, composting, mixing and specific sourcing. The adoption and non-adoption are captured in the joint probabilities.

$$\Omega = \begin{matrix} p_{11} & p_{12} & p_{13} & p_{14} & p_{15} & p_{16} \\ p_{21} & p_{22} & p_{23} & p_{24} & p_{25} & p_{26} \\ p_{31} & p_{32} & p_{33} & p_{34} & p_{35} & p_{36} \\ p_{41} & p_{42} & p_{43} & p_{44} & p_{45} & p_{46} \\ p_{51} & p_{52} & p_{53} & p_{54} & p_{55} & p_{56} \\ p_{61} & p_{62} & p_{63} & p_{64} & p_{65} & p_{66} \end{matrix} \qquad (15)$$

4.3 Description of variables used for the study

The variables for modelling choice of agro-food waste management options and safety risk management practices were as described in Table 4-1. Whereas exploratory approach coupled with experience and intuition had a stake in the selection of variables used, most of the variables were adapted from Adu-boahen *et al.* (2014), Brown (2015), Dreschsel *et al.* (2015), Ferronato and Torreta (2019), Haapapuro *et al.* (1997), Hamilton *et al.*, (2014), Jouhara *et al.* (2017), Mamady (2016), McNerney (2019), Menyuka *et al.* (2020), Mu'azu *et al.* (2018), Nigussie *et al.* (2015), Nthambi (2013) and Westendorf *et al.* (1996) among others.

Table 4-1: Description of variables used for the study

Variables	Measurement
Dependent variables	
Management options and safety risk management practices	Adopters=1; Non-adopters=0
Socioeconomic variables	
Sex of household head	Female=1; male=0
Age of household head	Number of years
Education level of the household head	Number of schooling years
Education level of woman of household	Number of schooling years
Household size	Number of persons in a household
Persons aged ≤5 years in a household	Number of persons in a household
Employment status of household head	Employed=1; otherwise=0
Woman of household employment	Employed=1; otherwise=0
Regular servant	Yes=1; no=0
Total garden size	Meter squared
Home ownership status	Own=1; do not =0
Urban agricultural knowledge	Ordinal scale (1-5)
Waste sorting knowledge	Ordinal scale (1-5)
Livestock production	Yes=1; no=0
Crop production	Number of crop enterprises
Monthly per capita agricultural income	Amount (KES)
Monthly per capita disposable income	Amount (KES)
Institutional variables	
Access to agricultural extension services	Access=1; no access=0
Access public waste collection services	Access=1; no access=0
Monthly private waste collectors' charges	Amount (KES)
Waste variables	
Quantity of agro-food waste generated	Quantity (kg)
Experience in using agro-food waste	Number of years
Risk variables	
Safety risk training	Trained=1; not trained=0
Experience in implementing safety risk measures	Number of years
Behavioural Variables	
Behavioural intentions	Ordinal scale (1-5)
Past behaviour	Ordinal scale (1-5)

4.4 Results and discussion

The data analysis of study involved pre-estimation and post-estimation tests that aimed at boosting the reliability and validity of the results. Multicollinearity and cross-correlation tests were conducted as shown in Appendix 2. Likewise, post estimation tests that included Wald chi-square and Likelihood ratio tests were conducted as shown in Table 4-3 and 4-4.

4.4.1 Descriptive analysis

The descriptive results (Table 4-2 and Appendix 2) compared the percentage choice of adoption and non-adoption of waste management practices as well as participation and non-participation in crop, livestock and mixed farming systems as presented in. The chi-square (χ^2) results showed that utilisation of agro-food waste between crop production participants and non-participants were significantly different at $p \leq 0.05$. Participants and non-participants in livestock production had significant differences in the choice of waste reduction, utilisation and disposing at $p \leq 0.01$. The percentage of choice of agro-food waste management options among livestock producers were consistently higher for participants compared to non-participants except for disposing where non-participants' choice for the practice was higher. Similarly, choice of waste management options between participants and non-participants in mixed production showed consistent significant differences except for waste reduction option. Mixed producers had higher level of participation in waste reduction, utilising and giving out than non-mixed producers. Proportion wise, this implies that urban agro-producers were more likely to adopt waste reduction, utilisation and giving/selling agro-food waste upon generation than disposing but preferred waste reduction and utilisation. The findings concurred with Mu'azu *et al.* (2018) that waste reduction at source was the most desirable and effective food waste management practice.

The results displayed in Table 4-2 indicates that segregation and composting of waste were the most preferred safety risk management measures. Comparatively, heat treatment and mixing agro-food waste with salt or dry feeds were the least adopted safety risk practices although cleaning and specific sourcing had low scores as well. This may imply that segregation and composting were the most effective in dealing with safety risk issues arising

Table 4-2: Choice of agro-food waste management options and safety risk management practices among households in Kenya

		Crop farming			Livestock farming			Mixed farming		
Variable	All producers	Participant	Non-participant	χ^2 value	Participant	Non-participant	χ^2 value	Participant	Non-participant	χ^2 value
General management options										
Reduce	86.40	86.37	100	0.16	88.73	79.09	6.60**	88.44	81.62	3.78
Do not reduce	13.60	13.63	0		11.27	20.91		11.56	18.38	
Utilise	85.53	85.71	0	5.92*	93.35	60.91	70.97**	93.44	66.91	54.25**
Do not utilise	14.47	14.29	100		6.65	39.09		6.56	33.09	
Give out/sell	26.75	26.59	100	2.74	28.90	20	3.38	29.69	19.85	4.71*
Do not give out/sell	73.25	73.41	0		71.10	80		70.31	80.15	
Dispose	17.54	17.58	0	0.21	8.09	47.27	88.57**	8.44	38.97	61.51**
Do not dispose	82.46	82.42	100		91.91	52.73		91.56	61.03	
Safety risk management practices										
Segregate	62.72	62.64	100	0.60	67.05	49.09	11.52**	66.88	52.94	7.92**
Do not segregate	37.28	37.36	0		32.95	50.91		33.13	47.06	
Clean	24.12	23.96	100	3.15	27.75	12.73	10.29**	27.19	16.91	5.51*
Do not clean	75.88	76.04	0		72.25	87.27		72.81	83.09	
Heat treat	21.71	21.76	0	0.28	25.72	9.09	13.58**	25.31	13.24	8.19**
Do not heat treat	78.29	78.24	100		74.28	90.91		74.69	86.76	
Compost	57.89	58.02	0	1.38	61.27	47.27	6.71**	63.13	45.59	12.04**
Do not compost	42.11	41.98	100		38.73	52.73		36.88	54.41	
Mix/salt/dry feed	23.90	23.96	0	0.31	30.35	3.64	32.74**	30	9.56	21.92**
Do not mix	76.10	76.04	100		69.65	96.36		70	90.44	
Specific source	32.68	32.75	0	0.49	29.19	43.64	7.92**	27.50	44.85	13.06**
Do not from specific source	67.32	67.25	100		70.81	56.36		72.50	55.15	

***significance at 5% and **significance at 1%**

from agro-food waste utilisation. The results also revealed that the level of adoption of safety risk management measures was consistently higher among participating than non-participating livestock and mixed producers with exception of specific sourcing where non-participating livestock and mixed producers had a higher adoption rate. The difference in adoption of safety risk management strategies between participating and non-participating livestock and mixed producers were all significantly different (Table 4-2).

4.4.2 Choice of agro-food waste management options among urban agro-producer households

The MVP model for agro-food waste management options showed that the Wald test statistics (Wald χ^2 (84) = 261.25, Prob> χ^2=0.00) were significant at $p \leq 0.01$, implying that its subset of coefficients were jointly significant. This also implied that the model's explanatory power of the factors used provided a satisfactory fitting. Equally, the MVP model was significant since the management options lacked independence. The Likelihood ratio test (LR χ^2 (6) = 69.910, Prob> χ^2=0.00) implies that the agro-food waste management options were not mutually exclusive, an indication that the agro-producers chose them simultaneously. As such separate estimation of agro-food waste management options in urban households would have been biased (Dessie *et al.*, 2018; Tarekegn *et al.*, 2017). Therefore, the projection that ρ (rho) values = 0 was rejected. This confirms the appropriateness of the MVP model for the study. The MVP model results (Table 4-3) revealed that there were disparities of contextual factors that determined the choice of agro-food waste management options among urban agro-producer households.

Household women in employment were less likely to implement reduction of agro-food waste efforts at source thus more waste generation in a household. This may imply that employed women had inadequate time to oversee agro-food waste reduction at their households. Although focussing on consumer households, Kim *et al.* (2000) had similar findings regarding younger employed women who were associated with frequently eating out and higher food waste.

Women headed households were more likely to adopt waste reduction practices, implying that women were perceived to have important influence in agro-food waste reduction. This notion could be associated with the role of women as custodians of food related resources in households across many societies of the world. The findings coincided with those of Kim *et al.* (2000) who associated food waste management with women who were said to have critical influence in its reduction. Similarly, Barr (2007) revealed that women were associated with

Table 4-3: Choice of agro-food waste management options among urban agro-producer households

	Waste reduction	Utilise	Giving out/sell	Dispose
Variables	Coefficient	Coefficient	Coefficient	Coefficient
Sex of head	0.4767(0.2322)*	0.1018(0.2260)	-0.0213(0.1673)	-0.1161(0.1939)
Age of head	-0.0148(0.0084)	0.0054(0.0083)	0.0019(0.0063)	-0.0061(0.0070)
Education of head	0.0168(0.0233)	-0.0303(0.0243)	0.0033(0.0184)	0.0040(0.0216)
Employment of head	0.5076(0.2666)	0.3802(0.2481)	0.0375(0.1818)	-0.0922(0.1958)
Household woman employment	-0.6924(0.2573)**	0.0756(0.2782)	0.1066(0.2103)	0.3666(0.2237)
Household size	0.0346(0.0492)	-0.0357(0.0508)	0.0644(0.0382)	0.0322(0.0391)
≤5 years	-0.0433(0.1297)	-0.0895(0.1410)	-0.0221(0.1053)	-0.0443(0.1186)
Agriculture knowledge	0.2625(0.1143)*	0.0995(0.1269)	0.1244(0.0855)	0.0673(0.0927)
Regular servant	-0.2141(0.2402)	0.4795(0.2802)	0.0573(0.1792)	0.0955(0.2150)
Waste separation knowledge	0.2889(0.0894)**	0.4531(0.0949)**	-0.1478(0.0682)*	-0.2254(0.0775)**
Home ownership	0.5152(0.2897)	-0.4431(0.3058)	0.4527(0.2817)	-0.0710(0.2288)
Garden size	0.0315(0.0807)	0.1007(0.0750)	-0.0983(0.0653)	-0.0209(0.0651)
Livestock	0.0356(0.0970)	0.5867(0.1349)**	-0.0463(0.0726)	-0.2470(0.0952)**
Crops	0.0369(0.0339)	0.0041(0.0351)	0.0002(0.0239)	0.0331(0.0269)
Lnurban agriculture income	0.0452(0.0773)	-0.1645(0.0802)*	-0.0130(0.0629)	0.0208(0.0637)
Lndisposable income	0.1362(0.1288)	-0.0340(0.1304)	-0.1312(0.1025)	0.1009(0.1146)
Access to public waste collection	0.4889(0.4420)	-0.0620(0.3353)	0.2168(0.2678)	0.5696(0.2483)*
Lnmonthly private collection fees	0.6131(0.3744)	0.3889(0.3806)	-0.4327(0.3071)	0.1878(0.3139)
Quantity of waste generated	-0.0242(0.0740)	0.1253(0.0700)	0.2209(0.0562)**	-0.3227(0.0688)**
Behavioural intention	-0.4170(0.1455)**	0.0670(0.1305)	-0.2237(0.1030)*	0.0346(0.1110)
Past behaviour	0.2622(0.1938)	-0.3571(0.1729)*	0.7554(0.1435)**	0.0920(0.1613)
_Cons	-4.9228(2.6069)	-0.7489(2.5276)	0.3354(1.9872)	-0.7997(2.1582)
Log likelihood = -543.416; Wald χ^2 (84) = 261.25, Prob> χ^2 = 0.00; LR χ^2 (6) = 69.910, Prob> χ^2 = 0.00				

Standard errors are in the parenthesis, *significance at 5% and **significance at 1%

higher likelihood of reducing waste. Contrary, Secondi *et al.* (2015) established that women were likely to waste more food than men.

Household heads with more knowledge on waste sorting and urban agriculture were more likely to opt for waste reduction as a management option. Higher urban agricultural knowledge may be associated with higher understanding of what it entails to bring food on the table. Additionally, higher knowledge may be associated with a higher understanding of agro-food waste effects as such opting for waste reduction. SIANI (2017) associated increase in knowledge with reduction in food waste across Sweden which was being fostered through raising awareness and collaborations.

The behavioural intention towards utilisation of waste had an inverse effect in adopting waste reduction. This imply that urban agro-producer households' intentions to utilise agro-food waste was likely to increase waste generated thus hampering the waste reduction efforts. Probably this is because of eventual loss of value; waste's value is lesser than the actual product value. These findings concurred with Russell *et al.* (2017) of a negative relationship between intention and food wasting behaviour where respondents who exhibited negative emotions when they thought about food waste ended up wasting comparably more food.

The MVP results further revealed significant influence of waste sorting knowledge on waste reduction, utilisation, giving out/selling, and disposing. More knowledge in waste sorting in households was likely to increase waste reduction and utilisation but reduced the likelihood of giving out/selling and disposing. In other words, agro-producer households that practiced waste sorting were more likely to utilise agro-food waste they generated than giving out, selling or even disposing. Additionally, having high level of waste sorting knowledge enabled households to segregate agro-food waste more effectively. As a result, households were able to map out their agro-food quantities and typologies wasting trend thereby likely to devise ways of managing it better. However, these findings contradicts those of Ali and Siong (2016) where higher knowledge does not translate to concern or the urge to implement waste management practices such as reduction. The contradiction could have been influenced by the attitude of the Shah Alam City residents on waste management, which was generally negative.

Livestock producing households were likely to utilise waste generated in their households. Probably, these materials were used to feed on their animals to manage agro-food waste. This implies that agro-food waste supplement conventional feeds in livestock production enterprises. The findings coincided with those of Wegedie (2018) where cattle feeding was an important avenue in agro-food waste management.

Increased income from urban agriculture among urban agro-producer households was more likely to reduce agro-food waste utilisation. The choice may be in favour of alternative agricultural inputs especially when agro-food waste was associated with filth and likely risks of its utilisation. The results were supported by Ashenmiller (2006) that low income households were likely to recycle waste especially motivated by monetary benefits. The findings were reasonable considering urban agro-producer households participated in urban agriculture and utilised waste for income and minimizing the cost of production associated, respectively. However, Basev (2016) findings revealed that students from high income households were more likely to recycle waste compared to their low income counterparts.

Past behaviour of an urban agro-producer household in utilisation of agro-food waste was a likely a hindrance in its adoption as a waste management option. Past perceived challenges associated to agro-food waste utilisation may have had a stake in forming present behaviour. Therefore, where minimal or no utilisation of agro-food waste had been practiced in the past, would have likely contributed to lesser utilisation of agro-food waste. The results coincided with Knussen *et al.* (2004) findings that positive past behaviour in recycling waste had strong influence on the present waste handling behaviour.

Monthly per capita quantity of agro-food waste generated from a household was associated positively with giving out or selling, implying that the higher the waste generated the higher the likelihood it was to be either given out or sold. This indicates that low amounts of waste did not warrant consideration of others as an avenue for its management, but increased quantities of generated waste encouraged market transactions. Probably, the results may be associated with low value of small quantities of agro-food waste compared to large quantities that have higher value. The findings concur with observations made during the survey that a few households gave out waste generated to their neighbours and in return they received agricultural products especially milk; payment in kind. Afroz *et al.* (2011) and Nigussie *et al.* (2015) associated waste generation (crop residue and animal waste; organic waste) in households with its sale. This enabled household to raise some income.

Commercial utilisation behavioural intention had a negative influence on the choice of the giving out. The relationship implied that intended use of agro-food waste discouraged the adoption of selling/giving out option. These findings seemed reasonable since agro-producer households used generated waste to supplement conventional inputs as such inclination towards utilising it in their gardens compared to giving it out/selling. On the contrary, past behaviour's positive influence on giving/selling meant that households opted to give out/sell waste upon generation based on past behaviour. This implies that the more positive the past behaviour in utilising waste, the higher the likelihood for the agro-producers to give out/sell the waste generated. Probably, this indicates that experience gained in utilising agro-food waste led to increased waste market transactions. Therefore, intentions limited the adoption of the giving out/selling option, but past behaviour enhanced it.

Agro-producer households were more likely to dispose waste generated if they had a higher access to the public waste service. This may also indicate that most agro-producers were forced to self-manage agro-food waste they generated since they had limited or no access to urban authorities' waste collection services. As such enhanced public waste collection was likely to reduce the intensity of agro-food waste use in urban agriculture.

Livestock production had a negative association with disposal of waste as a management option. This implies that a household was less likely to dispose waste if it practiced livestock production. This is an indication that agro-food waste generated in a household is considered an important feed resource in livestock enterprise due to its perceived low cost and availability. These findings were supported by Bakshi *et al.* (2016); Gutiérrez-macías *et al.* (2015) and Truong *et al.* (2019) that agro-food waste can be a key feed component for livestock. However, Westendorf (2000) and Salemdeeb *et al.* (2017) cautioned the use of waste as feeds due to likely pest and disease risks.

The quantity of agro-food waste generated had negative influence in adopting disposal management among households, implying that the higher the quantity of agro-food waste generated from a household, the lesser the likelihood of its disposal. Perhaps this is because large quantities of agro-food waste generated in a household attracts a higher economic benefit resulting to its economic usability.

4.4.3 Choice of safety risk management practices in utilisation of agro-food waste among urban agro-producer households

The MVP model (Table 4-4) for agro-food waste safety risk management practices was significant as indicated by the Wald test statistics (Wald χ^2 (96) = 410.67; Prob > χ^2 = 0.0000). The test statistics implies that the model subset of coefficients were jointly significant and its explanatory power of the adopted factors provided satisfactory fitting. This also implies that the model was significant since the choice decisions of agro-food waste safety risk management practices were interdependent. The likelihood ratio test (LR χ^2 (15) = 63.7853; Prob > χ^2 = 0.0000) indicated strong significance in the choice of management practices and supported presence of the joint correlations thus the ρ (rho) values were greater than zero (Tarekegn *et al.*, 2017; Dessie *et al.*, 2018). This implies that the projection that the ρ (rho) values = 0 was

Table 4-4: Choice of safety risk management practices in utilisation of agro-food waste among urban agro-producer households

	Segregation	Cleaning	Heating	Composting	Mixing	Specific sourcing
Variables	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Sex of head	-0.0025(0.1798)	0.1859(0.1571)	0.0845(0.1645)	-0.1566(0.1396)	-0.0471(0.1756)	0.1716(0.1456)
Age of head	0.0053(0.0068)	0.0061(0.0061)	0.0003(0.0062)	0.0083(0.0053)	-0.0018(0.0067)	0.0009(0.0055)
Household size	0.0014(0.0346)	-0.0120(0.0286)	-0.0173(0.0318)	-0.0024(0.0254)	-0.0432(0.0342)	0.0052(0.0259)
Employment of head	0.3440(0.1881)	-0.2928(0.1841)	-0.0781(0.1870)	0.1141(0.1593)	-0.0730(0.1996)	-0.2312(0.1653)
Household woman employment	0.2900(0.2219)	-0.2604(0.2143)	-0.2010(0.2266)	0.2424(0.1858)	-0.0818(0.2420)	-0.0035(0.1924)
Home ownership	0.0851(0.2426)	0.5423(0.2662)*	-0.0900(0.2247)	0.2697(0.1966)	0.0799(0.2844)	-0.3262(0.1983)
Agriculture knowledge	0.2197(0.0811)**	0.2460(0.0795)**	0.2980(0.0849)**	-0.0087(0.0674)	0.1703(0.0832)*	-0.0801(0.0703)
Extension access	0.7828(0.2034)**	0.2414(0.1606)	-0.0523(0.1743)	-0.1775(0.1499)	-0.2055(0.1788)	-0.5059(0.1607)**
Waste separation knowledge	0.6843(0.0767)**	0.1358(0.0672)*	0.1624(0.0680)*	-0.1812(0.0586)**	0.3374(0.0777)**	-0.1279(0.0593)*
Livestock production	-0.0195(0.2026)	0.3480(0.2022)	0.6757(0.1736)**	0.4445(0.1609)*	1.0328(0.2788)**	-0.2536(0.1647)
Experience using waste	-0.0012(0.0034)	0.0001(0.0033)	0.0016(0.0032)	-0.0010(0.0023)	0.0028(0.0030)	0.0005(0.0024)
Lnurban agriculture income	0.0032(0.0146)	0.0075(0.0131)	0.0346(0.0139)*	0.0048(0.0118)	0.0109(0.0144)	0.0080(0.0122)
Safety risk training	-0.3382(0.2310)	0.3321(0.2010)	-0.2147(0.2171)	0.3632(0.1938)	0.2564(0.2237)	0.4178(0.1910)*
Experience in safety measures	0.0098(0.0060)	0.0148(0.0065)*	0.0174(0.0053)**	-0.0057(0.0050)	0.0227(0.0054)**	0.0033(0.0050)
Behavioural intention	0.4194(0.1154)**	-0.0598(0.1003)	0.0525(0.1086)	0.0984(0.0875)	0.3644(0.1121)**	0.0925(0.0905)
Past behaviour	0.0658(0.1454)	0.0920(0.1249)	0.0226(0.1362)	0.1879(0.1168)	0.2109(0.1411)	0.5149(0.1210)**
_Cons	-1.7247(0.6462)	-2.9937(0.6054)	-3.0343(0.6427)	-0.9837(0.5025)	-2.5921(0.6689)	-0.3418(0.5102)
Log likelihood = -1296.92; Wald χ^2 (96) = 410.67, Prob > χ^2 = 0.0000; LR χ2 (15) = 63.7853 Prob > χ^2 = 0.0000						

Standard errors are in the parenthesis, *significance at 5% and **significance at 1%

rejected. The test statistics supported the suitability of the MVP model in assessing the choice of safety risk management practices. The MVP results for the choice of safety risk management practices among urban agro-producer households are presented in Table 4-4.

Higher urban agriculture knowledge was associated with greater adoption of agro-food waste segregation, cleaning, heating and mixing practices. The association may imply that higher urban agriculture knowledge indicated increased awareness on agricultural perspectives thus contributing to improved understanding in implementing safety risk management practices. Higher knowledge may also imply a greater ability to interpret and utilise agricultural information in choosing and implementing agricultural practices that would enable them to effectively manage agro-food waste. Since the adoption of the management practices was simultaneous, the influence of urban agricultural knowledge on various safety risk management practices may imply that the practices were supplemental to each other. The findings corresponded to those of Hellwig *et al.* (2019) that knowledge contributes to waste sorting management behaviour.

The higher the waste separation knowledge was likely to sway agro-producer households to enhance adoption of segregation, cleaning, heating and mixing but contribute to decline in composting and specific sourcing. Increased knowledge in waste separation may be an indicator of agro-producers' ability to understand the effects of agro-food waste utilisation. As a result, agro-producers with higher knowledge in waste separation were likely to choose relatively more effective safety risk measures. Waste segregation knowledge seemed to be the prerequisite for performing segregation, cleaning, heating and mixing management practices. This improved the ease of implementing and effectiveness of these safety risk management practices. Similarly, Zakianis and Djaja (2017) findings associated low household waste management knowledge with lesser sorting behaviour in Indonesia. On the other hand, higher waste separation knowledge reduced adoption of composting and specific sourcing. This aspect implies that segregated waste was less likely to be composted; an indication that agro-food waste that was set aside for composting was not likely to be sorted. Similarly, increased waste separation knowhow reduced the choosy behaviour in acquisition of agro-food waste. This implies that agro-producers who had higher waste separation knowledge were not worried about the source of agro-food waste acquired since they could easily manage it through efficient waste sorting. Contrary, Loan *et al.* (2019) findings indicated that knowledge and compost training had positive significant influence on composting participation which compares well with the current study's significance of waste separation knowledge.

Increased access to agricultural extension services among agro-producer households enhanced adoption of segregation but reduced adoption of specific sourcing management strategies in utilisation of agro-food waste. Higher access to extension services implies higher diffusion of agricultural knowledge thus empowering agro-producers in managing risks associated with agro-food waste. Guerrero *et al.* (2013) were of the view that when citizens receive information on waste recycling benefits and how to implement sorting it translated to higher likelihood of adopting recycling behaviour.

Livestock production in urban households influenced higher adoption of heating as a safety risk management practice. This implies that use of heat was likely to kill and or minimize the microbes posed by agro-food waste utilisation in livestock production. Agro-producer narrations during the survey indicated that heat treatment practice was specially used by agro-producers who were involved in pig production where agro-food waste was boiled or steamed to soften as well as disinfect it. However, other livestock producers especially those involved in dairy production dried agro-food waste (brewer's residue, vegetable and food waste) on direct sunlight to reduce its odour and moisture content before feeding it to animals. The heat treatment practices were adopted to eliminate likely transmission of pathogens and zoonotic diseases (Anthrax, Brucellosis, Rift Valley Fever, Tuberculosis, Salmonellosis among others) to livestock (especially pigs) and then to humans. According to Haapapuro *et al.* (1997) and Westendorf *et al.* (1996), any agro-food waste that has or had contact with meat or meat products is mostly associated with the likely disease transmissions. Beyihayo *et al.* (2015) advised on the necessity for boiling and drying waste for pigs to kill pathogens and reduce anti-nutritional factors.

Agro-producers were more likely to adopt composting if they were involved in livestock production. The findings coincide with observations made during the field survey where agro-producers heaped animal and crop waste in alternate layers to compost. The indications were that animal waste accelerated the process of composting crop waste. As such agro-producers were able to produce higher quantities of compost manure within shorter periods. Gamroth (2012) and Sánchez-bascones *et al.* (2008) concurred with the findings in that animal waste speeds up the composting process thus improving waste management rapidly.

Livestock production increased the likelihood of adopting the mixing of salt and or dry feeds with agro-food waste practice than non-livestock producers. Some agro-producers indicated that salt was used to minimize pest and microbial effects emanating from waste. For instance, salt was used to kill and eliminate snails and the slimy mucus that they left on waste and fodder. Apart from minimizing agro-food waste risks, farmers' narrations during the survey revealed that they sprinkled salt and dry commercial feeds on waste to entice animals into consuming their feeds portion. The findings were similar to Bakshi *et al.* (2016) and Rivin *et al.* (2014) recommendations in mixing dry feeds and common salt in utilisation of agro-food waste to manage moisture and contaminants respectively.

Adoption of cleaning, heating and mixing practices were likely to rise with increased experience in implementing safety risk measures while utilising agro-food waste. Accumulated experience in utilising agro-food waste may be an indicator of amassed knowledge thus ability to identify the most effective safety risk management measures. As such increased knowhow among the agro-producers contributed to their empowerment in safety related decision making. Similar findings were reported by Kritzinger (2017) whose study candidly explored the role of experience in safety assessment.

Higher commercialisation intentions among agro-producers in using agro-food waste were likely to boost the adoption of waste sorting at the household level. This implies that projected demand for agro-food waste for urban agriculture was a driver for waste separation thus increasing its usability. The segregation approach may be meant to minimize the likely risk on urban agriculture investment. In concurrence, Yu *et al.* (2018) indicated that behavioural intentions were critical in forming the waste sorting behaviour among residents of Hangzhou, China. Higher commercial utilisation intentions were also associated with increased adoption of mixing practice. This implies that mixing would be adopted to suppress pests and pathogens as well as moisture levels thus increasing commercial viability of small-urban farm businesses.

Increased home ownership among urban agro-producer households was likely to boost the choice of cleaning as a safety risk management measure. Home ownership status was an indicator of availability of space for conducting cleaning of agro-food waste. This may imply that since agro-food waste is associated with filth (Crane, 2000), ownership of a private space in terms of a home gave users of waste a platform to clean it which reduced the likelihood of causing nuisance on others. This may also imply that non-homeowners would rarely implement a similar exercise on a landowner's compound.

Amount of monthly per capita agricultural income of a household was associated with enhanced choice of heating of agro-food waste. This implies that the higher the agricultural income, the higher the likelihood of adopting the heating practice. Considering that some aspects of heating such as use of fuel may contribute to increased cost of production in agricultural enterprises, increased agricultural income would enable agro-producer households to meet such costs. This also imply that agro-producers were likely to be more protective of their agricultural investments by adopting safety management practices that they consider effective as agricultural income increases. Since heating was associated to livestock production, this implies that it is an appealing practice in addressing their susceptible nature to pests and pathogens.

Negative past behaviour of agro-producers in utilisation of waste was associated with higher adoption of specific sourcing as a safety risk management practice. This may indicate that agro-producers' past behaviour was not favourable in forming agro-food waste commercial utilisation inclination thus increased vigilance in sourcing of waste. This may imply that aspects of safety risks managed through specific sourcing of agro-food waste were likely to threaten agricultural investments due to past behaviour influence.

4.5 Conclusion

The study aimed at exploring the choice of agro-food waste management options and drivers of the safety risk management practices devised among urban agro-producer households. Reduction and utilisation of agro-food waste are the most preferred management options at 86% adoption while disposal is the least adopted option at 18%. On the other hand, segregation (63%) and composting (58%) are the most adopted safety risk management practises while heating is the least adopted at 22%. These results implied that these management aspects can be enhanced as avenues for promoting sustainable agro-food waste management in urban areas.

The results also reveal that contextual factors for choice of agro-food waste management options differed, but waste sorting knowledge of agro-producer households is largely a cross-cutting factor. Similarly, variations in the determinants of choice of safety risk management practices were recorded but urban agriculture and waste sorting knowhow had a stake across. This implies that knowledge and awareness are critical aspects in agro-food waste management and its safe use. As such awareness education programs may introduce a paradigm shift on how waste is managed and utilised by small-urban farm business practicing households. A further implication is that although waste management is generally a public service, self-management may be an effective avenue in the pursuit of the right to clean and healthy environment for the population.

In absence of a substantive National Feed Policy and the failure to implement the existing waste management laws, agro-producers will continue to take advantage of the lapse thus continued safety threat to the resultant food.

4.6 Limitations and suggestions for further study

Whereas risk management measures employed by agro-producer households were explored, risk perceptions influencing these choices were not concretely identified and assessed. As such risk perceptions aspect of agro-food waste utilisation would avail critical knowledge into the limelight.

CHAPTER FIVE

AN AGRO-FOOD WASTE COMMERCIAL UTILISATION BEHAVIOUR LENS AMONG URBAN AGRO-PRODUCER HOUSEHOLDS IN A DEVELOPING ECONOMY

Abstract

Small-urban farm businesses utilise agro-food waste emanating from own production and other levels of food supply chain activities to supplement conventional inputs. Out of these, the food produce surplus from agro-producer households is offloaded to the urban market. As such, the aim of the study was to assess the determinants of agro-food waste commercial utilisation behaviour among urban agro-producer households. An electronically designed research tool was administered to 456 agro-producer households to collect self-reported estimates of their agro-food waste utilisation behaviour. Results indicated higher budget share towards conventional inputs (0.73) compared to agro-food waste (0.27), but the observed suboptimal production intensification could be rectified with increased use of agro-food waste. Livestock enterprise had the highest production surplus and output sales among households. Structural equation modelling results indicated that attitude, environmental awareness and concern, motivation and perceived moral obligation had positive significant influence on commercial utilisation intention. The adopted constructs for the model could explain 79.1% of the commercial utilisation behaviour variance. Furthermore, commercial utilisation intention, risk perceptions and perceived behavioural control had significant influence on the commercial utilisation behaviour. Findings are an indicator that agro-food waste commercial utilisation intentions among small-urban farm businesses would likely transition to commercial utilisation behaviour. Since behaviour can be learnt and developed, aspects that contribute to commercial utilisation intentions and behaviour would need to be stimulated. As a strategy of reducing the collectible waste, urban authorities may introduce tailor-made programs meant to stimulate commercial utilisation intention and behaviour in small-urban farm businesses. In valuation of agro-food waste, methodologies that could factor in utility would provide more precise insights in its commercial utilisation.

Keywords: Agro-food waste, inputs, commercial utilisation, path, SEM, SmartPLS, Kenya

5.1 Introduction

Whereas there is evidence that urbanization is vital in the developmental process in economies, it is further argued that urbanization is not only a result but also a cause of economic development. However, unstructured population migration to urban areas may result to underemployment and unemployment as such contributing to non-optimal development. Unstructured migration may impact on the living standards of the populace and the sustainability of the existing systems. Furthermore, even if economic growth may have a positive relationship with urbanization, the association is non-linear (Nagashima, 2018; Nguyen & Nguyen, 2018; Turok & Mcgranahan, 2013). Economic growth is majorly realized through increased consumption and production. Increasing population in urban areas may be a growth indicator but also translates into more mouths to feed and generation of waste which necessitates food production and waste management. Moreover, in urban areas, opportunities such as open unused land spaces, demand for agricultural produce, the availability of waste and (absence of) supportive policy may exist. Considering the growing population and low income, the urban populace may adopt urban agriculture as a livelihood support system (Hallett *et al.*, 2016; Opitz *et al.*, 2016; Owuor *et al.*, 2017; van Tuijl *et al.*, 2018).

Compared to conventional rural farms, urban farms are characteristically small and are likely to be disadvantaged in terms of their economies of scale. Due to competing needs of land in urban areas, urban farming may also face rivalry especially from real estate. Notwithstanding this, small urban agribusinesses have a better access to markets owing to shorter supply chains thus reducing transaction costs. As a result, they may scoop higher returns per unit compared to rural farms. Often, urban farms value contribution to the overall economy particularly in developing countries is not precisely known. As such they mostly miss out on government support such as subsidies. Amidst this neglect, recent evidence shows that urban agriculture is critical in realization of United Nations Sustainable Development Goals 1, 2, 3, 8, 11, 12, 13 and 15 (Akinlade *et al.*, 2016; Nicholls *et al.*, 2020).

The scarcity of land compels urban agro-producers to intensify production. The adoption of the intensification angle embraces commercialisation whose aim is to maximize production, minimize costs to maximize benefits. Productivity wise, urban farms are equally productive as conventional rural farms and in many cases they may be more productive due to intensification behaviour (Nicholls *et al.*, 2020). This is particularly achieved through intercropping, continuous production (non-seasonal through irrigation), vertical (and or hanging) gardening and possibly optimal use of farm inputs. This necessitates utilisation of available inputs such as organic household waste as a supplement input. Household waste mostly of the agro-food type is often considered to have a lower cost compared to conventional inputs. As a result, there arises commercial utilisation behaviour of household waste among agro-producers (FAO, 2007; Vandermeulen *et al.*, 2005).

Though utilisation behaviour is traditionally a behavioural neurology and neuropsychology field related to brain damage where the conduct of a patient is observed and analysed (Pandey & Sarma, 2015), it is applicable in other behavioural fields. As such waste utilisation behaviour ought to be an illustration of the manner (series of actions) in which households put to use or sometimes readiness to use waste which they generate or that which they may acquire from external sources (Zhang *et al.*, 2015). Whereas other waste management practises such as burning, burying and dumping are critical in waste management (Adu-boahen *et al.*, 2014; Brown, 2015), perhaps utilisation is comparably more economically beneficial (Kassaye, 2018; Mu'azu *et al.*, 2018; Okonko *et al.*, 2009). Utilisation involves recovery, reuse and recycling of waste through consumption, composting, processing and energy generation. Menyuka *et al.* (2018) explored the role of urban agriculture in the management and commercial utilisation of organic waste in urban areas. The researchers identified animal feeding, soil fertilization and energy production as avenues in which organic waste could be managed. They argued that utilisation of organic waste could contribute to food security, human capital engagement and economic growth, health and sanitation. Furthermore, urban areas are characterized by large population that lives under or barely above the poverty line which makes commercialisation of urban agriculture a critical shock absorber amidst household income fluctuations.

Waste utilisation has been argued to be partially determined by the farmer's degree of intensification and the competing needs of agricultural waste. Especially for smallholder farmers, it has been shown that there is competition between fuel and feed needs from crop residue mainly after harvest. Furthermore, the household and farm socioeconomic characteristics including production goals may influence agro-producers' behaviour (Nigussie *et al.*, 2015). Depending on the type of crop being produced or livestock being reared then waste utilisation behaviour may be influenced. For instance, legumes may not require agro-food waste, but cereal crops may, but again vegetable's high nitrogen requirement may need even higher organic waste. Moreover, livestock such as pigs may influence the behaviour of agro-food waste utilisation compared to other types of livestock enterprises such as poultry. According to Baudron *et al.* (2014) and Valbuena *et al.* (2014), in India, Bangladesh and Kenya over 80 per cent of crop residue are left on the farm after harvest, therefore, being integrated into soil during farm preparation or under conservation agriculture practises.

The existing public waste collection services only cover an estimated 50 percent of the households in Nairobi City, Kenya. In taking the advantage of the ineffective waste management and non-substantive feed policies, small-urban farm businesses tap into agro-food waste as a supplementary input. Upon production, they supply the surplus to the urban market. So, (a) what factors influence the agro-food waste commercial utilisation behaviour among small-urban farm businesses and (b) does commercial utilisation intention translate to commercial utilisation behaviour of agro-food waste?

5.2 Methodology

5.2.1 Study area

The Nairobi City County is the administrative capital of Kenya and has had the highest share of Gross Domestic Product (21.7 per cent) contribution to the overall economy between 2013-2017 compared to the other Kenya's 46 counties (KNBS, 2019b). The study area is the most urbanized (99.8 per cent) County in Kenya whose assessment is an indicator that it was suited to offer an urban reflection. Evidently, it is among the very few Counties that have shown effort towards recognizing and streamlining urban agriculture (RoK, 2015). Whereas trade and industry are the major economic activities in the City, agriculture is practised on road and railway reserves, public spaces, backyards, river banks, under power lines, wetlands (Kamau, 2013), balconies and other open spaces including on steep and non-constructible areas. Land under urban agriculture is estimated to be 13.9 per cent of the Nairobi City County surface area (RoK, 2018).

Approximately, 2400 tonnes of waste per day is generated in Nairobi City where 30-40 per cent of this is not collected. Only about 50 percent of urban population are served with waste collection services. Notably, an estimated 45 per cent of waste in Nairobi City is recovered (NEMA, 2015) but its destination of use is not documented. One of the beneficiaries of waste generated in the County is urban agriculture, which utilise organic waste mostly of agro-food type. Although this is indicative of the urban residents' behaviour towards waste, urban agro-producers survey would provide a more precise picture since they have a greater potential in utilisation of waste compared to other waste supply chain actors. The common urban agriculture activities were projected to include vegetable and fruit, flowers and ornamental plants, cattle, goat, pig, poultry and rabbit rearing among others (Kamau, 2013; MERDA, 2015; RoK, 2018) which are meant for home use and/or market (MERDA, 2015). The diverse agricultural practices among urban agro-producers may provide clues into the current commercial utilisation behaviour and how this could be enhanced to enable exploitation of agro-food waste resource.

5.2.2 Sampling

Although a lower sample size of 356 had been proposed, a total of 456 agro-producer households were sampled using a multistage sampling approach. The increase in sample size was informed by the caution issued by Wolf *et al.* (2013) in boosting the interaction of sample size and parameters. The procedure involved clustering of the City's 85 electoral wards from which ten administrative wards were purposively selected based on their involvement in market-oriented urban agricultural activities. The study was conducted in Kahawa West, Mwiki, Ruai, Githurai, Njiru, Karura, Mugumo-ini, Karen, Uthiru/Ruthimitu and Waithaka wards. A mix of simple random sampling (in cases where there was a respondent list) and snowballing (where there was no respondent list) sampling methods were used to identify the respondents.

5.2.3 Research instrument and data

An electronically structured questionnaire (Appendix 7) was designed on Kobo Toolbox platform to capture self-reported commercial utilisation behaviour of agro-food waste among urban agro-producer households. The questionnaire was then administered by duly trained enumerators using Kobo Collect mobile application using smartphones. The choice of the questionnaire design was informed by the safety of data collected compared to print-out questionnaire (it was projected that there was higher sense of responsibility with own mobile gadget compared to a paper questionnaire). In addition, unlike the paper questionnaire output which involve manual keying-in of data, the electronic-design questionnaire data is automatically stored in a spreadsheet form once filled out. Questionnaires were sent to the Kobo Toolbox server where they could be easily downloaded and exported to other file formats. The latter was also cost-friendly. However, the electronic-design questionnaire was longer (page wise) based on the disaggregated nature of research questions compared to the paper format which could have aggregated questions mainly using tables.

Prior to the survey, potential enumerators were invited to make applications through a network of professionals in agriculture to be enrolled for the survey. The basic application qualifications included possession of a smartphone (at least 6-inch screen size) and power bank gadget. Additionally, the applicants were then screened for suitability based on their educational background (at least a Diploma) and experience in conducting similar surveys. The selected enumerators were involved in a two-day training on the administration of the questionnaire and additional two days for pilot testing. The enumerators were then reassessed based on the training and pre-testing indicators where a team of six enumerators was selected.

Whereas an electronic questionnaire was mainly used, the enumerators were trained on both paper and electronic formats. The paper questionnaire was to be used as an alternative in case of failure of the mobile gadgets. For the few instances paper questionnaire was used, the data was keyed-into the mobile application the same day by the concerned enumerators.

Introductory support to potential respondents was done by local administrators and agricultural extension officers which was aimed at improving the response rate. Once the survey was completed, the data were downloaded in a spreadsheet format and exported to Stata 15 for cleaning and pre-estimation test analysis. Analysis was carried out to obtain the research results which enabled discussion and drawing of implications of the study.

5.2.4 Theoretical framework and research questions development

In assessing behaviour, the Theory of Planned Behaviour (TPB) has been widely accepted as a basis for demonstrating the relationships that arise from behaviour constructs towards a behaviour under consideration (Ajzen, 1985, 1991). According to Ajzen (1991), intention towards performance of a behaviour can be projected using the individual attitude (AT) towards the behaviour, subjective norm (SN) and perceived behavioural control (PBC) contexts. Depending on the approval nature of an individual on their AT, SN and PBC, it is a pointer of strong intention to perform a given behaviour. As the TPB continue to be applied in different fields, new ideas for its predictive power improvement have been suggested. Being a non-static theory, additional variables to the TPB model have been successfully implemented in various studies (Chu & Chiu, 2003; Loan *et al.*, 2019; Nguyen *et al.*, 2018; Taylor & Todd, 1995). Ajzen (1991) on his part felt that where warranted by significant contribution towards the behaviour, additional variables could be considered. This has made the theory more appealing to researchers thus becoming increasingly developed.

One of the major beneficiaries of TPB applications is waste generation and management (Caplescu, 2014; Ioannou *et al.*, 2011; Nguyen *et al.*, 2018; Russell *et al.*, 2017; Tonglet *et al.*, 2004). It is noteworthy that various analytical methodologies are often employed in combination with behavioural theories in explaining waste related behaviours. For instance, in empirical application of logit and ordered logit model to model home composting behaviour in Vietnam, Loan *et al.* (2019) findings indicated that motivational factors in terms of knowledge on composting, attitude and garden ownership were the basis for composting behaviour. Moreover, a general pro-environmental behaviour by a household was indicated to be a likely influence on composting. However, although training in composting was important in explaining participation decision, it did not determine the level of participation.

Unlike Loan *et al.* (2019), Philippsen (2015) employed an extended TPB and multiple regression to assess students' intention to recycle waste. Perceived moral obligation, past behaviour and inconvenience had a significant prediction of behaviour to recycle. Similarly, Nduneseokwu *et al.* (2017) and Nguyen *et al.*, (2018) used the TPB in the assessment of e-waste recycling intention in Nigeria and Vietnam respectively. However, the former study extended the analytical framework with infrastructure and economic incentives and used hierarchical regression for analysis. Infrastructure was a moderating variable for attitude and subjective norm which meant that establishment of appropriate infrastructure would result to weaker influence by attitude and subjective norm on intention to recycle. Conversely, Nguyen *et al.* (2018) applied Structural Equation Modelling (SEM). The findings indicated that environmental awareness, attitude, social-pressure, regulations and laws, recycling cost and inconvenience had significant prediction on e-waste recycling intention.

As a form of utilisation, recycling behaviour of waste is key in environmental quality. Using SEM, Jekria and Daud (2016) research findings on environmental concern and recycling behaviour in Malaysia showed that attitude on recycling was determined by environmental concern whereas attitude enhanced concern thereby resulting to improvement in the recycling behaviour. Earlier, Chu and Chiu (2003) extended and applied the TPB constructs in the assessment of household waste recycling behaviour. Beyond the usual AT, SN and PBC, they factored-in perceived moral obligations (MO). The findings of the study indicated that the extended TPB constructs PBC, AT, SN and MO consecutively had significant influence on the recycling behaviour.

Similar to TPB, SEM has become widely accepted in assessment of human behaviour in waste related issues (Si *et al.*, 2019). Most often, SEM has been employed to assess and predict the structural relationships depicted by TPB thus making the two almost synonymous. Generally, SEM consists of two parts; the structural portion establishing the relationships between latent variables through simultaneous equations and the measurement part that shows associations between latent variables and observed variables (Bentler, 1980). According to Bentler (1980) and Kaplan (2001), the structural portion is basically written as;

$$\eta = B\eta + \Gamma\xi + \zeta \qquad (1)$$

Where η is the vector of endogeneous latent variables (criterion), B is the matrix of coefficients of regressions of η variables on other η variables, Γ is the matrix that contains regression coefficients of $\eta's$ on $\xi's$. In addition, ξ is the vector of exogenous latent variables (predictors), and ζ is the vector of residual terms (specification errors). Notably, the B matrix has zeros on the diagonal, an implication that a variable cannot cause itself, in this case η.

The measurement portion of SEM can be written as;

$$y = \Lambda_y \eta + \varepsilon \tag{2}$$

$$x = \Lambda_x \xi + \delta \tag{3}$$

Where y is explained variable, x are the explanatory variables, Λ_x and Λ_y are matrices for factor loadings, and ε and δ are vectors of uniqueness.

In this respect, variances and covariances for the variables, multipliers and disturbance terms are specified. Since SEM is meant to validate theories regarding constructs, possibilities exist on absence of effect of constructs on others and certain variables failing to load on others. Therefore, through research questions/hypothesis formulation some elements that are used in SEM may be fixed to zero whereas the rest of the parameters are estimated. Also, possibilities of discarding some indicators for inadequate validity and relevance exist. The covariance matrix of the fixed and non-fixed parameters portrays a specific structure defined as;

$$\Sigma = \Sigma(\Omega) \tag{4}$$

Where Σ is the population covariance matrix, and $\Sigma(\Omega)$ is Ω matrix valued function containing all the parameters of the SEM.

Considering that (a) waste is generally filthy and unpleasant if mismanaged, (b) public authorities are responsible for waste generated in urban areas, and (c) the respondent sample were farmers, additional constructs were incorporated into the TPB. Environmental awareness and concern, motivation, moral obligation and risk perceptions were projected to have an additional stake in determining the commercial utilisation behaviour of agro-food waste beyond (Ajzen, 1985, 1991) constructs.

Attitude (AT): Refers to positive or negative evaluation about a behaviour which is formed through behavioural beliefs (Ajzen, 1985). Basically, individuals form behavioural attitudes based on what they know or something they have experienced before. Therefore, the judgement rendered on a behaviour is essentially based on older beliefs. In forming attitudes, individuals may amalgamate five to ten beliefs (Fishbein & Ajzen, 1975). This implies that a given attitude towards a behaviour is a summation of relevant behavioural beliefs. As a result, a positive or negative preference arises towards the behaviour (Ajzen, 1991). Of course, if the individual perceives the behaviour as disruptive, tiring, or does not fit to the established personal arena then they will form a negative attitude and if otherwise positive. Biased and irrational attitudes cannot be ruled out (Ajzen, 2015) which implies objectivity may miss out in forming attitudes. An individual will most likely engage in a behaviour if his/her attitude towards it is positive whereas the opposite is true (Ajzen & Fishbein, 2005). Considering commercial utilisation behaviour intention of agro-food waste, what is the likely attitude towards it? So:

RQ1a: What is the relationship of AT and agro-food waste commercial utilisation intention (CUI)?

RQ1b: What is the relationship of AT and risk perception (RP)?

Subjective Norms (SN): Refers to beliefs of an individual or household about whether people they look up to would approve or disapprove on their specific behaviour. It extends to performing behaviours that the people they hold in high regard or the society approves. The behavioural construct comes with social pressures in performing a behaviour (Aktas *et al.*, 2018; Zhang *et al.*, 2015). Under the current study, it is a belief about other people's (other households, social groups and or community) standard behaviour regarding commercial utilisation intention/behaviour of agro-food waste in urban agriculture. As such subjective norm is likely to influence household agro-food waste commercial utilisation intention positively. So:

RQ2: What is the relationship of SN and agro-food waste CUI?

Perceived Behavioural Control (PBC): Refers to perception of ease or difficulty of performing a behaviour. In instances where they feel certain (strong conviction), intention alone is projected to predict behaviour to be performed. Conversely, when there is uncertainty about the control ability towards the behaviour performance then PBC has a direct link with behaviour. Depending on the situation, individuals or households may feel adequately or inadequately equipped to perform a behaviour. Based on experience (past performance of the same or similar behaviour) or resources (monetary or knowledge) that a household may have, then it may affect (enables or hinders) their ability to perform an intended behaviour (Stancu *et al.*, 2016; Werf *et al.*, 2019a; Werf *et al.*, 2019b) such as commercial utilisation of agro-food waste. So:

RQ3a: What is the relationship of PBC and CUI?

RQ3b: What is the relationship of PBC and commercial utilisation behaviour (CUB)?

Risk perceptions (RP): Refers to beliefs of a potential loss or harm which is subjective of an individual's evaluation of a situation towards performing a behaviour. Whereas it may seem to be based on the level of ignorance, the degree of risk perception (RP) assigned to a behaviour may be entirely or partially influenced by an individual's reference. The level of risk of a behaviour is a representation of its probability and consequences of harm arising from the behaviour; perceived likelihood, sustainability and severity (Brown, 2014; Darker, 2013). So:

RQ4a: What is the relationship of RP and CUB?

RQ4b: What is the relationship of RP and CUI?

Environmental awareness and concern (EAC): Refer to knowledge, positivity and sensitivity towards ecological matters. The construct is an indicator of willingness to protect the environment. Intention of utilising agro-food waste commercially in urban areas may be indirectly taken to mean protective nature of a household towards effects of such waste on the environment. Environmental knowledge was positively associated with the intention to purchase energy efficient appliances (Li *et al.*, 2019). Jekria and Daud (2016) and Nguyen *et al.* (2018) established a positive influence of environmental awareness towards intention to perform a behaviour. So:

RQ5a: What is the relationship of EAC and AT?

RQ5b: What is the relationship of EAC and CUI?

Motivation (MT): Refers to what causes individual households to conduct agro-food waste commercial utilisation. The reasons may emanate internally (environmental beliefs, guilt, intrinsic goals and attitudes) or externally (monetary benefits and social pressure related to laid down rules and laws) (Johansson, 2016; Nguyen & Watanabe, 2020). The motivators may affect intentions of an individual household (Johansson, 2016). Cecere *et al.* (2014) indicated that waste prevention behaviour was dependent on intrinsic motivation. Nguyen and Watanabe (2020) was of the view that motivation could be initiated on an individual/household's confidence on the ability to perform a behaviour. Additionally, high PBC was associated with low motivation and vice versa. The argument was that those who exhibit high PBC are likely to be complacent. As a result they lack the motivation (low if any) to participate in effortful reasoning process towards the intention of performing a behaviour. Ajzen (2012) went further to indicate that intention is influenced by motivation. So:

RQ6a: What is the relationship of MT and PBC?

RQ6b: What is the relationship of MT and CUI?

Perceived moral obligations (MO): Refers to non-legally binding duty that a household may feel it owes and ought to perform which gives rise to moral responsibility. Therefore, the performance of a behaviour is gauged in terms of the perceived correctness or incorrectness (Ajzen, 1991). MO is generally based on self-expectation informed by personal values, which is internal unlike SN that arises from social (external) pressure. However, one's values or personal norms could be easily diffused to the society as such becoming part of subjective norms. Beck and Ajzen (1991) indicated a potentially significant association between MO and SN. Considering a household, its MO is its moral standing towards commercial utilisation intention. Chu and Chiu (2003) findings indicated that MO had positive influence on the intention to recycling waste in Taiwan households. In concurrence, MO was found to positively influence the intention to sort solid waste among the youth in China (Shen *et al.*, 2019). In predicting climate change mitigation behavioural intentions in Taiwan, Chen (2020) findings showed that MO had critical effect. So:

RQ7a: What is the relationship of MO and SN?

RQ7b: What is the relationship of MO and CUI?

Commercial utilisation intention (CUI): Refers to conscious plans that commercial utilisation will be undertaken in an urban agro-producer household. This may also be associated with the probability in performing CUB or the effort thereof (Ajzen, 1991; Fishbein & Ajzen, 1975). Unclear plans, low probability or low efforts would be expected to result to low CUB whereas the vice versa is true (Konerding, 1999). The link between CUI and CUB would be an indicator of transformation of intentions to behaviour. So:

RQ8: What is the relationship of CUI and CUB?

Contextual factors (CF): Refers to factors that characterize the settings in which urban households operate in, other than the TPB constructs. In numerous TPB studies, contextual (background) characteristics are often not considered (Miao, 2015; Shen *et al.*, 2019). They may include socio-economic and institutional factors, personality, intelligence, emotions, general attitudes, and life values among other factors. They are generally assumed to have a stake in developing intention (Ajzen, 1991; Ajzen, 2015; Ioannou *et al.*, 2011). Although Ajzen (2015) was of the view that CF are only expected to indirectly influence behavioural intentions, this argument does not stand since Zhang (2014) established a direct association between CF and behavioural intentions to policy changes. So:

RQ9: What is the relationship of CF and CUI?

The indicators that were used to build the study constructs are as presented on Table 5-1 and Appendix 3. However, the picked indicators are only a synthesised form of the original after undergoing a rigorous validity and reliability assessment; collinearity, composite reliability, average variances extracted, cross loadings and cross-validated redundancy tests were executed as shown in the results and discussion section. The indicators that did not meet the established criteria (0.70 indicator loading) were dropped as shown in Table 5-1 and Figure 5-1. In implementing the selection of indicators used, SmartPLS which is popularly known as PLS-SEM or PLS path (Ringle *et al.*, 2015) was employed. The software choice was based on

Table 5-1: Indicators used to estimate the model constructs

Construct	Measurement item/indicator	Status
	I am interested in agricultural and food waste commercial utilisation	Dropped
	I think agricultural and food waste utilisation is cost friendly	Dropped
AT	Agro-food waste utilisation ought to be promoted	Picked
	Agro-food waste utilisation is an appropriate way to manage solid waste in urban areas	Picked
	When utilised properly agricultural and food waste is beneficial	Dropped
	Agricultural and food waste is unsafe for utilisation	Dropped
	The County government and landlords should be solely responsible for the management of agricultural and food waste	Dropped
SN	Most of the people I look to in terms of values utilise agro-food waste	Picked
	It is a common practise for people to utilise agro-food waste in urban agriculture	Picked
PBC	I have made it a routine to utilise agro-food waste upon generation	Picked
	It is quite effortless for me to utilise agro-food waste	Picked
	Inadequate knowledge makes agricultural and food waste utilisation very difficult for me	Dropped
EAC	Agro-food waste has economic value	Picked
	The little agricultural and food waste generated by every household if left unmanaged could potentially ruin the environmental quality	Dropped
	Failure to properly manage agricultural and food waste could contribute to negative health effects	Dropped
	I feel disgusted when I see or pass near agricultural and food waste that has been improperly disposed	Dropped
	I feel freshened and satisfied when my surroundings are clean	Picked
	I feel guilty if I dispose off the agricultural and food waste without utilising it	Dropped
PMO	I take it as my duty to utilise agro-food waste emanating from my household	Picked
	I feel if every household was to utilise its agricultural and food waste we would have a better environment	Dropped
	Everybody within a household has a role to play in managing agro-food waste especially through utilisation	Picked
	My religion encourages prudent utilisation of resources	Dropped
	I usually feel at peace when I utilise waste beneficially	Picked

MT	In my household, agro-food waste utilisation is a waste management strategy	Picked
	By utilising agricultural and food waste we set a good example to others	Dropped
	Having had faced food inadequacy in the past I ensure that whenever agricultural and food waste is generated, I put it to good use	Dropped
	My household has some land space where we utilise agricultural and food waste	Dropped
	My household utilises agro-food waste as a cost-saving mechanism	Picked
RP	I would associate agro-food waste utilisation with pests and pathogen risk	Dropped
	I would associate agro-food waste utilisation with injurious elements risk	Picked
	I would associate agro-food waste utilisation with health and poisoning risk	Dropped
	I would associate agro-food waste utilisation with death and or investment loss risk	Dropped
	I would associate agro-food waste utilisation with pollution risk	Dropped
	I would associate agro-food waste utilisation with costly treatment of the affected risk	Picked
CUI	I plan to utilise agro-food waste on a regular basis to manage waste emanating from my household	Picked
	I plan to participate in waste management drives in my neighbourhood	Picked
	I plan to encourage others to utilise agro-food waste to improve waste management	Picked
	I intend to properly dispose off agricultural and food waste emanating from my household if am not able to use it	Dropped
	I always segregate agricultural and food waste before using it	Dropped
CUB	I regularly utilise agro-food waste from my household	Picked
	I regularly outsource agro-food waste for use in my household	Picked
	I always ensure I disinfect agricultural and food waste before utilising it	Dropped
	I sometimes sell agricultural and food waste to others who can use it	Dropped
	I sometimes give away agricultural and food waste to others who can use it	Dropped

Indicator's scale: 1=strongly disagree (very low), 2= disagree (low), 3=moderately agree (moderate), 4=agree (high), 5=strongly agree (very high)

AT=Attitude; SN=Subjective norm; PBC=Perceived behavioural control; EAC=Environmental awareness and concern; PMO=Perceived moral obligation; MT=Motivation; RP=Risk perceptions; CUI=Commercial utilisation intention; CUB=Commercial utilisation behaviour its ability to estimate complex models without a pre-imposed distributional requirement. It is also appealing due to its causal-predictive ability and user-friendliness. As such it enables relational estimation with much ease without advance technical knowledge compared to other SEM software such as CB-SEM (Hair *et al.*, 2019) and Stata-SEM. The CF construct included employment status of the woman of the household (employed=1; housewife=0) and urban agriculture knowledge (1=very low, 2=low, 3=moderate, 4=high, 5=very high).

5.3 Results and discussion

5.3.1 Agro-food waste utilisation and produce sales

Kales enterprise was the most popular enterprise (86%) among urban agro-producer households for the three months period under consideration. Cereals as well as spinach indicated high production participation at 64% and 60% respectively. Notably, legumes, indigenous vegetables, poultry and banana enterprises had over 50% production participation rate. Value of agro-food waste used was highest in the vegetable group of enterprises followed by livestock, and tree and flower propagation. However, the highest mean produce sales were from the livestock enterprise followed by poultry, vegetables, and tree and flower propagation consecutively. The mean total value of waste utilised in urban agro-producer households was Kes9,724.15[7]. This implied that the budget share value of waste utilised was 27% in relation to conventional inputs (see the section that follows). This proportion presents a tangible contribution of agro-food waste in urban agriculture thus having a role in the urban food supply chain.

Average garden size used was 311m^2 although the range was 10m^2 (especially for roadside tree and flower propagators) to 6,000m^2. The agro-producers indicated that garden size under use fluctuated seasonally. Some agro-producers had up to 12,000m^2 garden size during some production periods (especially during dry weather) to maximize on the value of produce during the time. However, Ogendi *et al.* (2019) findings had indicated that city producer had garden sizes of 0.5 to 1.0 acres; approximately 2,000-4,000m^2. The disparity could be explained by seasonal fluctuations but use of wetlands also increased farm sizes in urban areas.

Majority of the agro-producers sourced animal feeds (especially fodder) outside their homes. Whereas crop enterprises were practiced beyond the home boundaries, livestock and poultry enterprises were carried out within the home compound. This was associated with the

[7] The exchange rate at the time of the survey was KES107.707 = 1$USD

high insecurity in livestock and poultry compared to crops although regular management required on animals could be a reason. During the study, it was observed that producers dried, sieved and fed poultry manure to cattle and pigs. Some producers indicated that they harvested rabbit waste (especially urine) and was a high value product, but the claims could not be substantiated since some refuted them. Agro-food waste was also commonly boiled before feeding it to pigs. However, some producers indicated that they could not feed waste to their pigs since they had been contracted to supply pork to sausage processors who were against the practice. This notion could be associated with Choe *et al.* (2017) findings that pig fed on food waste had inferior meat quality although Márquez and Ramos (2007) had indicated that food waste has only minor effects on the carcass quality thus could be fed to pigs.

5.3.2 Conventional inputs utilisation

In utilisation of other inputs (other than labour), the results indicated that livestock commercial feeds had the highest share of conventional inputs budget. During the three months period under consideration, urban agro-producers spent an average of Kes21,842.35 followed by fertilizer at Kes658.40. Expenditure on livestock veterinary services was estimated at Kes632.13 while fodder and pesticides were Kes576.14 and 574.60 respectively. Whereas a chunk of agro-producers did not spend on either one or more of these conventional inputs, livestock feeds recorded the highest upper expenditure at Kes480,000 while expenditure on other inputs had highs of under Kes50,000. The overall mean value of conventional inputs used in urban agro-producer households was estimated at Kes25,978.84. This translated to 73% of the total budget share for inputs used in urban agro-producer households. This is an indicator that agro-producers are largely inclined towards conventional inputs but with noteworthy contribution of agro-food waste in urban agriculture commercialisation. During the survey, it was observed that there was a likely suboptimal level of production intensification. Therefore, enhanced support towards production intensification would be expected to propel agro-producers to transition to a higher level of agro-food waste commercialisation.

Table 5-2: Agricultural production, waste utilisation and sale of surplus produce among urban agro-producer households

	Production participation	Value of waste utilised				Value of produce sold			
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Vegetables	-	3,121.40	4,117.24	0	45,000.00	26,219.18	50,731.08	0	450,000.00
Kales	86%								
Amaranth	22%								
Spinach	60%								
Cabbage	23%								
Tomato	20%								
Pumpkin	33%								
Indigenous vegetables	55%								
Fruits	-	1,310.75	1,675.72	0	30,000.00	6,257.79	18,891.09	0	150,000.00
Banana	52%								
Other fruits	42%								
Legumes: Beans	55%	177.32	968.36	0	20,000.00	482.68	3,863.35	0	58,000.00
Cereals: Maize	64%	174.98	1,204.40	0	20,000.00	2,070.07	10,197.25	0	115,000.00
Tubers	-	24.52	163.47	0	2,700.00	1,640.57	16,077.68	0	270,000.00
Irish potatoes	25%								
Arrow root	19%								
Sweet potato	21%								
Fodder	38%	1,092.00	728.37	0	12,500.00	768.2	6,143.86	0	90,000.00

Livestock	-	2,438.16	12,524.24	0	200,000.00	40,012.57	99,038.94	0	1,000,000.00
Cattle	41%								
Goat/sheep	13%								
Pig	20%								
Rabbit	6%								
Poultry	54%					31,335.79	108,213.30	0	1,200,000.00
Tree and flower propagation	11%	1,385.02	16,682.67	0	350,000.00	18,782.89	78,471.77	0	600,000.00

5.3.3 Assessment of measurement model

Based on Hair *et al.* (2019) evaluation of the measurement model procedure, the results of the study revealed that indicator loadings of 0.691 to 0.927 were registered, as shown in Table 5-3. The assessment criterion advocates a minimum of 0.70 for indicator loadings which would imply acceptable level of reliability of the item under consideration. However, as a rule of thumb, Hair *et al.* (2019) indicated that a minimum of 0.60 indicator loading was a sufficient basis for gauging the reliability of the indicators and data generated thereof if it is not for confirmatory purposes. According to Chin (1998) and Hair *et al.* (2019), any indicator that does not meet the set criterion is considered unreliable, as such should be deleted. Therefore, discarding of indicators that did not meet the set criterion was implemented during the modelling process. As a result, some of the indicators of AT, EAC, RP, MT, PMO, CUI, CUB and CF constructs were dropped. Consequently, the overall explanatory power of model improved. The aforementioned loadings of the improved model were a pointer that more than 50 percent of the variance of the indicators could be explained. Hair *et al.* (2019) argued that indicator loadings of 0.70 to 0.90 were evidence of 'satisfactoriness to goodness' of the indicators, as long as they were less than 0.95. Therefore, all the indicators used for the measurement model in agro-food waste commercial utilisation were reliable.

Although Cronbach's alpha and rho-A could have been used to check for internal consistency, composite reliability has been argued to be a better method given that it largely retains the standardized loadings of constructs (Fornell & Larcker, 1981). Composite approach has low sensitivity to variations and is compensatory unlike other methods of measuring internal consistency. The internal consistency of the measurement model using composite reliability (CR) indicated scores ranging from 0.698 to 0.890 (Table 5-3). The convergent validity of the constructs based on average variance extracted (AVE) indicated a range of 0.536 to 0.801. These indications revealed that the constructs used in modelling agro-food waste commercial utilisation model were acceptable since they had more than 0.50 scores. This implied that at least 50 percent of variance of the indicator items used could be explained by the constructs selected for the model (Hair *et al.*, 2019). Therefore, convergent validity was attained for the study model.

Table 5-3: Construct reliability and validity

	Indicator	Mean	Std. Dev.	Indicator Loadings	CR	AVE
AT	at_1	4.353	0.833	0.751	0.792	0.656
	at_2	4.268	0.959	0.865		
CUI	bi_1	4.362	0.826	0.823	0.784	0.549
	bi_2	3.732	1.4	0.691		
	bi_3	3.967	1.2	0.703		
CF	cf_1	0.17	0.375	0.702	0.698	0.536
	cf_2	3.314	0.994	0.762		
EAC	eac_1	4.529	0.71	0.762	0.739	0.586
	eac_2	4.649	0.642	0.768		
MO	mo_1	4.279	0.982	0.808	0.825	0.611
	mo_2	4.215	0.949	0.768		
	mo_3	4.445	0.857	0.768		
MT	mt_1	3.996	1.16	0.889	0.890	0.801
	mt_2	3.939	1.232	0.901		
PBC	pbc_1	3.831	1.177	0.902	0.798	0.666
	pbc_2	3.351	1.467	0.721		
RP	rp_1	3.342	1.448	0.916	0.807	0.679
	rp_2	3.352	1.273	0.720		
SN	sn_1	3.642	1.273	0.874	0.838	0.722
	sn_2	3.307	1.071	0.824		
CUB	ub_1	3.342	1.448	0.927	0.882	0.790
	ub_2	3.908	1.185	0.849		

AT = Attitude; SN = Subjective norm; PBC = Perceived behavioural control; EAC = Environmental awareness and concern; PMO = Perceived moral obligation; MT = Motivation; RP = Risk perceptions; CUI = Commercial utilisation intention; CUB = Commercial utilisation behaviour

To establish the distinctiveness of the constructs adopted for the agro-food waste commercial utilisation model, the assessment of discriminant validity was implemented (Table 5-4). Based on Fornell-Larcker criterion that shared variance for all model constructs should not exceed their AVEs, the study results indicated that all the shared variances were smaller than their respective AVEs (diagonal). However, Henseler and Sarstedt (2013) argued that Fornell-Larcker criterion was not a good measure for assessing discriminant validity since it is sensitive to slight indicator loading disparities. Therefore, to confirm the reliability of the current study findings the cross-loadings were assessed (Table 5-4). The cross loadings were comparably higher than the inter-correlations of the construct of all the other observed variables (Hussain *et al.*, 2018) in the agro-food waste commercial utilisation model. This confirmed that the constructs adopted for the study model were discriminately valid.

Table 5-4: Fornell-Larcker criterion and cross-loadings

C/I*	AT	CF	CUB	CUI	EAC	MO	MT	PBC	RP	SN
AT	**0.810**									
CF	0.060	**0.732**								
CUB	0.289	0.178	**0.889**							
CUI	0.382	0.168	0.315	**0.741**						
EAC	0.343	0.197	0.320	0.403	**0.765**					
MO	0.270	0.148	0.523	0.370	0.359	**0.782**				
MT	0.431	0.186	0.600	0.446	0.359	0.594	**0.895**			
PBC	0.383	0.101	0.561	0.299	0.349	0.599	0.646	**0.816**		
RP	0.353	0.189	0.883	0.268	0.302	0.449	0.547	0.559	**0.824**	
SN	0.385	0.131	0.436	0.237	0.320	0.384	0.463	0.544	0.676	**0.850**
at_1	**0.751**	0.025	0.215	0.253	0.240	0.221	0.325	0.306	0.253	0.294
at_2	**0.865**	0.068	0.251	0.357	0.310	0.219	0.372	0.317	0.315	0.329
cf_1	-0.025	**0.702**	0.002	0.117	0.044	0.033	0.055	0.016	-0.010	-0.040
cf_2	0.107	**0.762**	0.247	0.129	0.236	0.177	0.211	0.127	0.275	0.220
ub_1	0.263	0.167	**0.927**	0.242	0.267	0.390	0.463	0.445	0.916	0.396
ub_2	0.252	0.148	**0.849**	0.337	0.315	0.577	0.641	0.582	0.612	0.382
bi_1	0.322	0.164	0.408	**0.823**	0.327	0.394	0.443	0.300	0.327	0.209
bi_2	0.282	0.057	0.037	**0.691**	0.280	0.139	0.266	0.145	0.045	0.135
bi_3	0.237	0.126	0.113	**0.703**	0.291	0.201	0.209	0.167	0.120	0.167

eac_1	0.270	0.175	0.342	0.299	**0.762**	0.320	0.337	0.284	0.314	0.283
eac_2	0.255	0.128	0.150	0.318	**0.768**	0.230	0.213	0.250	0.149	0.208
mo_1	0.222	0.088	0.520	0.292	0.271	**0.808**	0.582	0.561	0.455	0.350
mo_2	0.209	0.127	0.307	0.287	0.246	**0.768**	0.355	0.396	0.283	0.297
mo_3	0.201	0.135	0.386	0.290	0.332	**0.768**	0.443	0.436	0.300	0.245
mt_1	0.320	0.144	0.562	0.355	0.277	0.534	**0.889**	0.586	0.502	0.409
mt_2	0.449	0.189	0.514	0.441	0.364	0.529	**0.901**	0.570	0.478	0.421
pbc_1	0.306	0.108	0.594	0.220	0.266	0.549	0.619	**0.902**	0.585	0.504
pbc_2	0.340	0.047	0.263	0.295	0.330	0.417	0.406	**0.721**	0.274	0.369
rp_1	0.263	0.167	0.927	0.242	0.267	0.390	0.463	0.445	**0.916**	0.396
rp_2	0.361	0.149	0.433	0.199	0.235	0.361	0.461	0.521	**0.720**	0.714
sn_1	0.307	0.138	0.411	0.175	0.201	0.317	0.321	0.501	0.712	**0.874**
sn_2	0.289	0.069	0.300	0.204	0.317	0.288	0.317	0.395	0.407	**0.824**

*C/I refer to construct or indicators

5.3.4 Evaluation of the structural model

Whereas the measurement model had been established to be reliable and valid, these aspects are not considered adequate in determining the suitability of a structural model (Hair *et al.*, 2019; Hussain *et al.*, 2018). Therefore, structural assessments are requisite. According to Hussain *et al.* (2018), the assessment involve establishing the predictive relevancy and constructs relationship of the model. Often coefficient of determination (R^2), goodness of fit index, path coefficients (β), p-values/T statistics, effect size (f^2) and the predictive relevance of the model indicators (Q^2) are considered. In comparison, Hair *et al.* (2019) considered the coefficient of determination (R^2), the blindfolding-based cross-validated redundancy measure (Q^2), and the statistical significance and relevance of the path coefficients portrayed by the constructs as the basis for assessing the structural conduct of a model.

Whereas the standard assessment criteria outlined by Hair *et al.* (2019) and Hussain *et al.* (2018) are critical, assessment of collinearity is important as well (Hair *et al.*, 2019) before commencing the structural evaluation of the model. The results of the collinearity test indicated variance inflation factors range of 1.005 to 1.570 which meant that the model did not have collinearity problems (Becker *et al.*, 2015). The R^2 for the agro-food waste commercial utilisation behaviour was established to be 0.791 as shown in Table 5-5 and Figure 5-1. This implied that 79.1% of the commercial utilisation behaviour variance could be explained by the model's constructs. This would be considered substantial in-sample explanatory power for the behaviour depicted among urban agro-producer households. The R^2 for PBC and CUI were second and third largest at 0.417 and 0.309 which indicated their strength in explaining the commercial utilisation behaviour variance was higher than the other constructs.

Bootstrapping procedure revealed the path coefficients as presented in Table 5-5 and Figure 5-1. Considering the RQ1a, it was established that AT had significant and positive influence on CUI. As such, the AT and CUI have a positive relationship. The findings implied that household attitudes were critical in forming intentions towards agro-food waste commercial utilisation considerations. As such positive attitudes were expected to contribute to increased agro-food waste commercialisation intentions. The findings coincided with those of Ayob (2017) towards waste separation intention among students in Malaysia. Heidari *et al.* (2018) showed similar findings towards waste separation at source in Iran. Similarly, RQ1b indicated that AT had significant positive relationship with RP. The findings implied that the overall attitude of agro-producer households towards agro-food waste commercialisation had a stake in the level of risk perception towards waste utilisation. Williams and Noyes (2007) also noted that attitudes had effect on trust, risk perception and the likelihood of information acceptance. As such increased positivity in attitude towards agro-food waste utilisation would alter their level of risk perception.

Research question RQ2 and RQ3a showed insignificant negative relationship of both SN and PBC on CUI. The findings contradicted with Ayob *et al.* (2017) on the PBC aspect but coincided with the insignificant effect of SN on CUI. This study findings went against Ajzen (1985, 1991) projections that PBC and SN were likely to influence behavioural intentions.

Table 5-5: Path coefficients

Research question	Path	Coefficient	Standard Deviation	T Statistics
RQ1a	AT -> CUI	0.204**	0.051	4.023
RQ1b	AT -> RP	0.353**	0.043	8.276
RQ2	SN -> CUI	-0.041	0.058	0.700
RQ3a	PBC -> CUI	-0.091	0.064	1.431
RQ3b	PBC -> CUB	0.083*	0.035	2.340
RQ4a	RP -> CUB	0.818**	0.020	40.027
RQ4b	RP -> CUI	-0.015	0.072	0.203
RQ5a	EAC -> AT	0.343**	0.045	7.558
RQ5b	EAC -> CUI	0.223**	0.051	4.346
RQ6a	MT -> PBC	0.646**	0.033	19.832
RQ6b	MT -> CUI	0.267**	0.077	3.457
RQ7a	MO -> SN	0.384**	0.038	10.057
RQ7b	MO -> CUI	0.144*	0.073	1.979
RQ8	CUI -> CUB	0.071*	0.028	2.534
RQ9	CF -> CUI	0.058	0.042	1.399

*5% significance and **1% significance

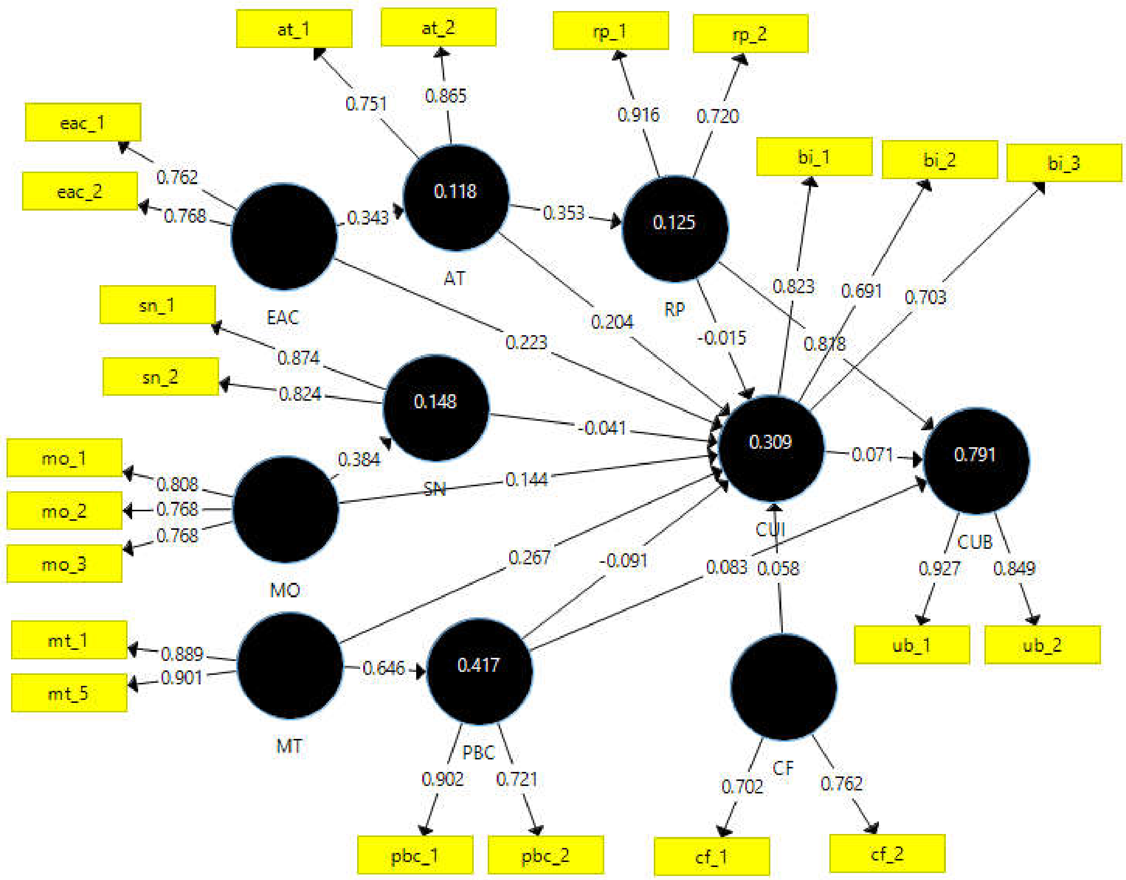

Figure 5-1: Indicators loadings, coefficients of determination and path coefficients

Nystrand and Olsen (2020) also established insignificant association between PBC and intention towards consuming functional foods. The RQ3b was confirmed by the positive significant effect portrayed by PBC on CUB. This implied that PBC of the agro-producer household influenced the agro-food waste commercial utilisation behaviour but not its intentions. Similar PBC and CUB association was also established in Heidari *et al.* (2018) in source separation of waste intention and behaviour.

RQ4a showed significant influence of RP on CUB although it was negative as had been hypothesized. However, this may imply that farmers who had higher level of risk perceptions were likely to form commercial utilisation behaviour. This may also be interpreted as increased interest in agro-food waste as a supplementary input in urban agriculture would likely establish higher inherent risk issues, but agro-producers would address them and utilise it due to expected benefits. This path also had the highest effect towards the commercial utilisation behaviour of agro-food waste. This meant that RP had the topmost influence on the ultimate decision to commercialise using agro-food waste. Kummeneje and Rundmo (2020) findings indicated that risk perceptions among cyclists in Norway had influence on their traffic behaviour. However, RP had negative but insignificant influence on CUI.

EAC relationships with AT and CUI indicated strong positive significant association. Therefore, for RQ5a and RQ5b, the EAC relationship to AT and CUI was positive. The association indicated that the agro-producer awareness and concern towards the environment had a stake in determining the household's attitude on agro-food waste commercialisation. The findings were similar to those of Li *et al.* (2019) that both environmental concern and environmental knowledge had significant influence on attitude towards purchase of energy efficient appliances. The EAC as well affected the intentions of commercial utilisation of waste. This may have implied that agro-producer households considered commercial utilisation of agro-food waste as a strategy of managing likely negative environmental effects while tapping the benefits. Li *et al.* (2019) also established a positive influence of environmental knowledge on intention to purchase. Further, the t-statistic of the path coefficients showed significant positive influence of agro-producer households' MT on their perceived ability to control the commercial aspect of agro-food waste as well as the intentions to commercialise. This meant that motivation among household members in utilising agro-food waste beneficially from a commercialisation aspect was important in developing the overall behaviour. Similarly, Ajzen (2012) and Johansson (2016) associated motivation to development of behavioural intentions.

MO of the urban agro-producer households had positive significant effect on SN and CUI. This implied that MO influenced the social pressures as such MO of an individual household was likely to be diffused to other households who would embrace it as a norm thus becoming part of the SN in a community/society. MO also initiated the inner push of agro-producer households in developing the commercial utilisation intentions for agro-food waste. This was a confirmation for the hypotheses RQ7a and RQ7b. Similarly, software piracy intentions were shown to have positive relationship with perceived moral obligation (Hashim *et al.*, 2018).

CUI had positive significant influence on CUB. This indicated that once an agro-producer household developed intentions to commercialise agricultural production using agro-food waste then they were likely to end up commercializing. This implies once urban agro-producer households developed agro-food waste commercialisation intentions, they were likely to transition to actual commercialisation. The association was supported by Foltz *et al.* (2016)

findings that the intention towards amending social networking security credentials influenced the ultimate behaviour.

The specific indirect effects of the commercial utilisation model were as shown in Table 5-7. The coefficients are indication of the mediation role played out by various constructs in the model.

Table 5-6: Specific indirect effects

Path	Coefficient	Std. Dev.	T Statistics
AT -> CUI -> CUB	0.014*	0.006	2.478
EAC -> AT -> CUI -> CUB	0.005*	0.002	2.485
CF -> CUI -> CUB	0.004	0.003	1.186
EAC -> CUI -> CUB	0.016*	0.006	2.464
MO -> CUI -> CUB	0.010	0.008	1.354
MT -> CUI -> CUB	0.019	0.010	1.821
PBC -> CUI -> CUB	-0.006	0.005	1.259
MT -> PBC -> CUI -> CUB	-0.004	0.003	1.265
RP -> CUI -> CUB	-0.001	0.005	0.201
AT -> RP -> CUI -> CUB	0.000	0.002	0.200
EAC -> AT -> RP -> CUI -> CUB	0.000	0.001	0.196
SN -> CUI -> CUB	-0.003	0.005	0.582
MO -> SN -> CUI -> CUB	-0.001	0.002	0.572
MT -> PBC -> CUB	0.053*	0.024	2.239
AT -> RP -> CUB	0.289**	0.034	8.565
EAC -> AT -> RP -> CUB	0.099**	0.020	4.928
EAC -> AT -> CUI	0.070**	0.019	3.759
MT -> PBC -> CUI	-0.059	0.041	1.436
AT -> RP -> CUI	-0.005	0.026	0.200
EAC -> AT -> RP -> CUI	-0.002	0.009	0.195
MO -> SN -> CUI	-0.016	0.023	0.686
EAC -> AT -> RP	0.121**	0.025	4.825

**significant at 1% and *significant at 5%

The blindfolding-based cross-validated redundancy measure (Q^2) results were as presented in Table 5-6. Application of the rule of thumb as suggested by Hair *et al.* (2019)

showed that the adopted constructs were relevant in their predictive accuracy of the structural model. The relevance ranged from small to large as shown in Table 5-6.

Table 5-7: Construct cross-validated redundancy

Construct	Q^2	Predictive relevance
AT	0.074	Small
CUB	0.601	Large
CUI	0.146	Small to moderate
PBC	0.268	Moderate
RP	0.088	Small
SN	0.103	Small to moderate

5.4 Conclusion

The study sought to understand what drives agro-food waste commercial utilisation intention and its transition to behaviour. Kale enterprise production participation is the highest among agro-producer households at 86 percent. The highest use of agro-food waste is in vegetables (Kes3121.40) while the highest produce sales (surplus) are in livestock enterprise (Kes40,012.57). Higher expenditure share is linked to conventional inputs (73%) compared to agro-food waste (27%). The agro-food waste portion present an avenue for growth in intensification of urban agriculture. The path coefficients for the structural equation indicate that commercial utilisation intentions, risk perceptions and perceived behavioural control have significant influence on the commercial utilisation behaviour. This implies that the commercialisation intentions formed in an urban agro-producer household are likely to transition to agro-food waste commercial utilisation behaviour. A further implication is that if small-urban farm businesses can be empowered through agro-food waste management and utilisation programs, they will likely develop interest in commercial utilisation of waste and may result to actionable commercialisation.

5.5 Limitations and suggestions for further research

There was a considerable challenge in attaching value to agro-food waste. In some cases, the value attached to waste was the price associated. Considering this was not the real value for waste, better methodological basis could be employed, the utility of waste could be factored in.

CHAPTER SIX

WASTE MARKET IN DEVELOPING ECONOMIES: WHAT DETERMINES SOURCE-BASED DEMAND FOR AGRO-FOOD WASTE AMONG URBAN AGRO-PRODUCER HOUSEHOLDS?

Abstract

As a supplement to conventional inputs, agro-food waste and its sourcing have largely remained empirically unexplored. The study sought to assess expenditure allocation in acquisition of agro-food waste input from various source markets among urban agro-producer households. An electronically structured questionnaire and printout key informant interview schedule were administered to 456 agro-producer households and 48 other food supply chain actors respectively, in urban Kenya. Results indicated that other households' sourced waste had the largest quantitative share of 30.85% whereas processors had the highest budget allocation of 26.60% in agro-producer households. Zellner's seemingly unrelated regression model indicated that agro-food waste and conventional inputs prices as well as socio-demographic factors had significant effect in determining source-based agro-food waste expenditure shares. Expenditure elasticities indicated that own household (0.8640), other households (0.8970), restaurants (0.6998), agro-markets (1.1988) and processors (1.7481) sourced waste were normal goods whereas dumpsite waste (-0.0769) was an inferior commodity. With exception of restaurants-sourced waste (0.3702), all own-price elasticities were negative implying compliance with law of demand in acquisition of waste from other sources. Compensated source-based cross-price elasticities indicated that source-based agro-food wastes were more of substitutes than compliments. Although there were slight disparities, the Linear and Quadratic Almost Ideal Demand Systems' results largely portrayed consistent results, implying either could be applicable in waste demand analysis. On overall, the findings implies that source-based demand is a representation of institutional interactions that exist among an urban agro-producer household vis-à-vis other waste supply chain actors which portrays a basis for waste market development. Being the first of its kind, the study is likely to contribute to the shaping and strengthening of source-based waste demand economic theory.

Key words: source-based, demand, elasticities, substitute, compliment, thematic analysis, Kenya

6.1 Introduction

Food waste and food security are opposing forces (Truong *et al.*, 2019) but still food waste could potentially be used to contribute to food security (Opitz *et al.*, 2016; Sabiiti, 2011). Considering food waste is highest at retail and consumer levels, the problem is compounded by the growing urban population. The urban population is projected to be approximately 70 per cent of global population by 2050. In absolute numbers, the population will increase to 9.7 billion people by 2050 from 7.7 billion in 2019 (Truong *et al.*, 2019; UN, 2018; UN, 2019). In effort to meet the food needs of the growing population in the future, more food will be produced and distributed to urban areas which translates to increasing agricultural and food waste (agro-food waste), *ceteris paribus* (Tefft *et al.*, 2017). As noted by He *et al.* (2019), agricultural waste related research has been advancing especially in regard to low-carbon and energy generation, emissions, the material and energy flow and the prevention and control of pollution emanating from agricultural waste. These aspects are demand indicators for agricultural waste.

The persistent growth of population has contributed to increasing demand for material resources globally. This is a threat to sustainable development (Moraes *et al.*, 2019). Therefore, whenever waste occurs it presents loss of scarce productive resources (Ghosh *et al.*, 2016). Agricultural production in effort to produce food involve exploitation of resources. Whereas some level of waste is considered inevitable (UN, 2000), improved resource use efficiency and recycling of waste in supply chains would proportionally reduce pressure on productive resources (Akenji *et al.*, 2015; UNEP, 2018). As such, acquisition and utilisation of agro-food waste by food supply chain actors would contribute to economic benefits as well as the development of the waste market (European Commision, 2016; NCA, 2016). On overall, the circular economy will be promoted and sustainability enhanced (Akenji *et al.*, 2015; Ghosh *et al.*, 2016; Moraes *et al.*, 2019).

Generally, households, offices, restaurants, shopping outlets, institutions, industries among others are considered as sources of waste (UN, 2000). However, households especially farming ones are both generators and users of waste (Mohee, 2007). In an attempt to minimize cost of production they may opt for types of inputs associated with lower costs such as agro-food waste (Case *et al.*, 2017). Since such households are not self-sufficient in production of agricultural inputs to support their agricultural activities, the other avenues that generate organic waste such as industry and other households become their sources of waste. Therefore, agro-producers would be expected to acquire waste especially agro-food waste as valuable sources of nutrients (Lin *et al.*, 2013; Drechsel *et al.*, 2015; Wielemaker *et al.*, 2018) meant to supplement the conventional inputs.

There has been few attempts in exploring waste related demand across the globe (Bel & Gradus, 2014; Callan & Thomas, 2006; Nigussie *et al.*, 2015; Scott & Watson, 2009; Strathman *et al.*, 1995). However, the focus has mainly been on demand for waste collection services. To the best of our knowledge, no study has attempted to explore source-based demand for waste. In Kenya, whereas there are indications of use of agro-food waste in urban agriculture, there is limited literature on its demand. Empirical evidence on agro-food waste market participation and intensity of use has not been forthcoming. The sources of agro-food waste that is used in urban agriculture has remained elusive and yet to be concretely identified. Moreover, source-based demand for agro-food waste by urban agro-producer households is absent in literature. Therefore, the study sought to (a) assess urban agro-producer source-based expenditure allocation in acquisition of agro-food waste, (b) estimate price and expenditure elasticities of demand in acquisition of agro-food waste and (c) assess the role of other agro-food waste cycle actors in waste market development in urban Kenya.

6.1.1 Demand for agro-food waste

Growing awareness of ecological and health jeopardies related to the utilisation of agro-chemical fertilisers in Sri-Lanka made the demand for organic fertilisers to rise. Compost making facilities enabled waste re-use in agricultural activities especially in farms located near such facilities. Composting plants are seen as a basis for improvement of efficiency in waste collection, segregation and re-use efforts (Dubbeling *et al.*, 2016). Likewise, Opitz *et al.* (2016) held that waste utilisation and management through recycling of plant residue and kitchen waste are key in the organic nutrient supply in the urban agriculture systems which are critical in resource use efficiency. Moreover, Bakshi *et al.* (2016) also observed that vegetable waste is valuable and can be used as animal feeds due to its nutritional content, acceptability and palatability. These studies are indicators of basis for demand for waste in urban agriculture, based on valuable appeal.

While assessing the organic waste demand-supply balance in China, Zhou *et al.* (2018) formulated latent demand of agricultural waste and supply of compost through agricultural waste conversion. The findings indicated a demand surplus ratio of 1.21 which meant a complete assimilation of compost emanating from agricultural waste within the farms was possible. However, the actual demand-supply ratio of 0.61 indicated supply surplus of organic compost. Livestock waste was completely absorbed within the farms but straw compost had a large surplus. Parrot *et al.* (2009) findings on use of kitchen and livestock waste in lowlands of Cameroon indicated that vegetable production, use of livestock waste, and distance from garden to home were the main predictors for kitchen waste demand. On the other hand, farmer's age, education level, garden-home distance and garden size were significant in explaining demand for livestock waste. The use of recovered and recycled domestic waste was higher for shorter garden-home distances, younger farmers, and higher education level. However, these studies are deficient in quantifying and valuation of waste demand which are critical in understanding the intensity of demand.

As a solution for managing solid waste mostly in urban areas, Rashmika and Edirisinghe (2016) argued that composting can only be an effective practise if there would be demand for compost by the farming community. They were of the view that a well thought marketing campaign aimed at devising the right marketing mix (product, place, promotion and price) would offer some paradigm shift from the use of chemical fertiliser to compost utilisation. Based on this notion, the researchers employed an OLS model to understand the demand for compost in Sri Lanka. Results indicated that farmer's income, land size, sand quality (content), price of compost as well as paddy cultivation determined the demand for compost. Similar findings on the negative influence of price on demand for compost were established by Folefack (2008). The study indicated supply surplus for compost due to unfavourable price, infrastructure and inadequate awareness (requisite campaigns). These studies' findings concurred with Rouse *et al.* (2008) who explored marketing of compost and issues of willingness to pay and demand mismatch due to pricing. Folefack (2008) and Rouse *et al.* (2008) only used descriptive statistics which limited them in establishing cause-effect relationships. In Rashmika and Edirisinghe (2016), OLS estimates were biased and inconsistent since the sample for the study constituted only farmers who used compost.

In assessing the simultaneity nature of disposal and recycling of solid waste, Callan and Thomas (2006) used household characteristics, urban area attribute and policy factors to model the demand functions. Although price for disposal had an insignificant influence on disposal, it had a negative significant influence on the recycling demand thereby influencing disposal indirectly. However, average household size, average household size squared, age, frequency of recycling and quantity recycled had significant determination of demand. According to Nigussie *et al.* (2015), urban agricultural waste can be used for competing needs such as fuel, feed, and soil amendment which is critical in the determination of demand for waste. The findings indicated that education of the household head, experience in using urban waste and land tenure were the key determinants of urban waste demand.

6.2 Methodology

6.2.1 Study area

Nairobi City County (see Appendix 4) is not only a major agricultural trade centre for Kenya but also an important market in the East African region. In addition to the waste produced by urban agro-producers, the City markets are conglomeration of agro-food produce emanating from urban and rural areas as well as cross-border regions thereby critical contributors of waste. The choice of the study area was partly informed by diversity of waste sources including other households, agro-producers, processors, restaurants, agro-markets and dumpsites. The nearness to diverse sources of waste was also considered vital in the selection of the study area. Nairobi City County has over 20 per cent of its resident households involved in urban agriculture (Lee-smith, 2010). An estimated 13.9 per cent of the County total surface area is used for agricultural activities (RoK, 2018). Moreover, an estimated 45 percent of waste in Nairobi City is recovered (NEMA, 2015) but its destination of use is not documented although there are indicators that some of it is used in urban agriculture (FAO, 2012; Karanja *et al.*, 2010). As such the study area could offer critical insights in source-based demand for agro-food waste.

6.2.2 Sampling procedure

A sample of 456 urban agro-producers was involved in the survey whereas 48 key informants were used to compliment the information gathered from agro-producers. Although a lower sample size of 356 had been proposed, the use of structural equation modelling in one aspect of the project necessitated increase of sample size to 456 as cautioned by Wolf *et al.* (2013) in order to strengthen the association of sample size and parameters. Through multi-stage sampling procedure, the study area was at first clustered into existing administrative wards from which ten wards (Kahawa West, Mwiki, Ruai, Githurai, Njiru, Karura, Mugumo-ini, Karen, Uthiru/Ruthimitu and Waithaka) were purposively selected for the survey. The cluster selection was informed by the existing urban agricultural activities and agro-food waste production. Secondly, the sample size was distributed equally among the ten clusters, but adjustments were made based on the agricultural activities' situation across wards. Thirdly, a mix of systematic random (where respondents were pre-identified) and referral sampling (where not pre-identified) were used to select the specific agro-producer households for the survey. The key informant interviews were conducted to establish the agro-food waste links between the agro-producers and the other food supply chain actors. The key informants were either purposively selected based on their contribution in agro-food waste generation and or referral sampling in cases where facilitation in accessing such informants was required.

An electronically designed questionnaire (Appendix 7) was administered by duly trained enumerators on the agro-producer households' sample to collect self-reported cross-sectional data on agro-food waste sources. The questionnaire design was done in Kobo Toolbox and implemented in Kobo Collect mobile application. In preparing the enumerators to administer the questionnaire, two days training was conducted to familiarize with the questionnaire using smartphones and questionnaire printouts. An additional two days of pretesting the questionnaire was done. The post training and pretesting involved improving the questionnaire by revising information that was needed or otherwise. This was meant to improve the flow and adequacy of the questionnaire. Data collection was done in an offline-online mode. This meant that data was collected offline, but internet connectivity was sought only when sending the completed questionnaires to the Kobo Toolbox server. Upon completion of the survey, data was downloaded in Microsoft Excel and exported to Stata for analysis.

The key informants consisted of garbage collectors, processors, restaurants and agro-markets which comprised of 12 actors per category. The selection was based on recommendations by Guest *et al.* (2006) and Latham (2013) regarding point of saturation in qualitative studies. A printout interview guide (Appendix 8) was used to collect the required data from the key informants. The key informants involved in the study were sampled across the Nairobi City County notwithstanding the selected clusters for the agro-producer's survey (Table 6-1).

Table 6-1: Key informant sample distribution

Agro-food waste source	Description	Sample size
Restaurants	Hotel	4
	Educational institution	4
	Health facility	4
Agro-markets	Fresh produce traders	5
	Grain traders	5
	Market management	2
Processors	Agro-processors	8
	Slaughterhouses	4
Garbage collectors	Hand (waste) pickers	6
	Truck (waste) collectors	6

However, the key informants within or surrounding the selected clusters were considered first before heading to other areas. The sample distribution was as shown in Table 6-1.

6.2.3 Data analysis

6.2.3.1 Analytical framework

In order to capture agro-producer choice for the avenue to source for agro-food waste appropriately, a Price Independent Generalised Logarithmic functional form was adopted (Blundell, 1988). The choice was based on the study's use of disaggregated source based individual household expenditure functional forms which were aggregated to obtain agro-food waste expenditure. Since the demand for agro-food waste inputs in agro-production was anticipated to be two related (weak separability) stage decisions (to acquire or not to and intensity of use) then a simultaneous equation model was applied. Whereas other demand system models such as Rotterdam model, transcendental logarithmic system, indirect addilog model and generalized addilog model have been used in demand analysis (Babu *et al.*, 2017), linear approximation of an Almost Ideal Demand System (LA-AIDS) form was considered. AIDS as proposed by Deaton and Muellbauer (1980) utilises an arbitrary first-order approximation for demand systems. AIDS is touted for satisfying the axioms of choice, perfect aggregation over individuals or households, and its functional form shows consistency with household budget data. Moreover, it employs simplicity in estimation and testing of true restrictions of demand theory and it ensures combination of the theoretical structures of Rotterdam and translog models (Babu *et al.*, 2017). The AIDS expenditure function can be written as;

$$In\, C(U,P) = a_o + \sum_i a_i InP_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij} In\, P_j In\, P_i + \overline{U}\, b_o \sum_i P_i^{bi} \quad (1)$$

Where a_i, bi and γ_{ij} = parameters to be estimated, $\overline{U}$ = utility level, P = prices, j = index for the various avenues that urban agro-producer households can source agro-food waste, and i=index for household under consideration

The waste sources projected were own household, other households, restaurants, agro-markets, processors and dumpsites. The waste sources were assumed to generate distinguishable agro-food waste. This implies that the waste generated from each of the identified sources was named as per the source, for instance restaurant waste. This makes it easier to relate the expenditure allocations to the common way of budgeting for commodities within a household. The expenditure function is linearly homogeneous in P and is consistent with aggregation over individuals. By differentiating the expenditure function using Shephard's lemma, substituting for $\overline{U}$ and replacement of the overall price with Stone's (1954) index while ensuring parameter restrictions (additivity, homogeneity and symmetry) then the AIDS model become linearized; LA-AIDS (Babu *et al.*, 2017; Ngui *et al.*, 2011). Without reinventing the wheel, literature has abundant of detailed resources on modelling of the LA-AIDS model, see Babu *et al.* (2017).

In implementing two-stage LA-AIDS, as specified by Heien and Wessells (1990) and Ngui *et al.* (2011), a probit model was employed for the first decision on all the avenues that agro-producer households can acquire agro-food waste from, thereby taking the form;

$$Z_{ji} = f(p_{1i}, \dots, p_{ji}, y_i, d_{1i}, \dots, d_{ki}) \tag{2}$$

Where Z_{ji} for it household acquisition of agro-food waste from the jt source is;

$$Z_{ji} = \begin{cases} 1 \; if \; w_{jk} > 0 \\ 0 \; ot \;\; erwise \end{cases} \; K = 1,2, \tag{3}$$

The Maximum Likelihood Estimates generated in the Probit model are employed to compute the Inverse Mill's Ratio (IMR) for each agro-producer household and each agro-food waste source. Thus, the IMR for it household that acquires agro-food waste from the jt source can be derived as;

$$X_{ji} = \frac{\theta(p_{1i},\dots,p_{ji},y_i,d_{1i},\dots,d_{ki})}{\Phi(p_{1i},\dots,p_{ji},y_i,d_{1i},\dots,d_{ki})} \tag{4}$$

The IMR for the it household that does not acquire agro-food waste from the jt source can be derived as;

$$X_{ji} = \frac{\theta(p_{1i},\dots,p_{ji},y_i,d_{1i},\dots,d_{ki})}{1-\Phi(p_{1i},\dots,p_{ji},y_i,d_{1i},\dots,d_{ki})} \tag{5}$$

Where θ = standard normal density function and Φ = cumulative distribution function

In stage two, the IMR for each agro-producer household in each of the agro-food waste sources is used as an instrumental variable in the differentiated AIDS equation. Thus the model can be expressed as (Ngui *et al.*, 2011);

$$w_j = w_{jo} + \sum_k w_{jk}\, d_k + \sum a_{ij} InP_i + b_j In\frac{y}{P} + \xi_j x_{ji} + \varepsilon_j \tag{6}$$

Where x_{ji} = IMR, w_j = expenditure share of agro-food waste acquired from source j, d_k = contextual factors associated with household i, InP_i = natural logarithm of price, and ε_j = disturbance term

The applicability of the above equation may not stand because it violates the adding up property that is assumed for AIDS models. To solve this problem, the condition $\xi_j x_{ji} = 0$ must be satisfied. However, it may not be possible since x_{ji} can take any value. Alternatively, to satisfy the additivity property, the equation can be written as;

$$w_j = w_{jo} + \sum_k w_{jk}\, d_k + \sum a_{ij} InP_i + b_j In\frac{y}{P} + \xi_i x_{li} \quad \sum_{j=1}^{n-1} \xi_j\, x_{ji} + \varepsilon_j \quad (7)$$

The parameter restrictions (Equation 8-10) for the AIDS model were imposed on Equation 7 as specified by Babu *et al.* (2017);

$$\sum_{i=1}^{n} a_i = 1; \sum_{i=1ij}^{n} b_i = 0; \sum_{j}^{n} \gamma_{ij} = 0 \quad \text{(Additivity)} \quad (8)$$

$$\sum_{j}^{n} \gamma_{ij} = 0 \quad \text{(Homogeneity)} \quad (9)$$

$$\gamma_{ij} = \gamma_{ji}, \quad j(i \neq j) \quad \text{(Symmetry)} \quad (10)$$

Effect of changes in prices on expenditure shares were captured by the vector of parameters γij and changes in total expenditure (y) are captured by the parameter vector βi.

Heien and Wessells (1990) and Ngui *et al.* (2011) argued that in order to maintain the homogeneity and symmetry properties of the complete demand system in allocation of household budget, Iterated Seemingly Unrelated Regression may be used for estimation. Shibia *et al.* (2017) also used a similar approach. As such Zellner's seemingly unrelated regression (ZSUR) was adopted in estimating the LA-AIDS model. Additionally, QUAIDS was adopted as a comparative model for LA-AIDS results to assess consistency.

Elasticities of agro-food source-based waste input were then computed as proposed by Green and Alston (1990, 1991) and Babu *et al.* (2017) as shown in Equation 11-15.

$$e_{ij} = \frac{y_{ij}}{w_i} \quad \beta_i \frac{w_j}{w_i} \quad (11)$$

$$e_{ii} = \quad 1 + \frac{y_{ii}}{w_i} \quad b_i \quad (12)$$

$$\eta_{ij} = \frac{y_{ij}}{w_i + w_j} + w_j \quad (13)$$

$$\eta_{ij} = \quad 1 + \frac{y_{ii}}{w_i} \quad w_i \quad (14)$$

Where e is Marshallian elasticities and η is Hicksian (income compensated) elasticities measure while ii represents own, ij represents cross, w_j is expenditure share for the jth source and w_i is expenditure for the ith source.

On the other hand, expenditure elasticities were computed as;

$$e_{ix} = 1 + \frac{b_i}{w_i} \tag{15}$$

Table 6-2: Description of agro-food waste demand variables

Variable	Description/units
Dependent variables:	
Expenditure share of waste acquired	Fraction: waste expenditure from source j/total expenditure
Waste variables	
Ln own waste price	See footnote[8]
Ln other households' price	Other households' total expenditure (Kes)[9]/quantity of agro-food waste from other households (Kg)
Ln restaurants price	Restaurants total expenditure (Kes)/quantity of agro-food waste from restaurants (Kg)
Ln agro-market price	Agro-markets total expenditure (Kes)/quantity of agro-food waste from agro-markets (Kg)
Ln processors waste price	Processors total expenditure (Kes)/quantity of agro-food waste from processors (Kg)
Ln dumpsite waste price	Dumpsites total expenditure (Kes)/quantity of agro-food waste from dumpsites (Kg)
Ln total expenditure on waste	Total expenditure from all sources (Kes)
Ln Monthly pc own waste	Amount (kg) of waste generated from own household monthly per person
Conventional input variables	
Ln inorganic fertilizer[10] price	Expenditure on fertilizer (Kes)/quantity acquired (Kg)
Ln feeds price	Expenditure on commercial feeds (Kes)/quantity acquired (Kg)
Ln fodder price	Expenditure on fodder (Kes)/quantity acquired (Kg)

[8] Sum of agro-food waste total expenditure (Kes) from other households, restaurants, agro-markets, processors and dumpsites divided by the total quantity of agro-food waste (kg) acquired from these sources by a given household

[9] The exchange rate at the time of the survey was KES107.707 = 1$USD

[10] Inorganic fertilizers included granules and foliar

Socio-demographics	
Age of household head	Number of years
Education level of household head	Number of schooling years
Livestock production	Dummy (participate=1; otherwise=0)
Vegetable production	Dummy (participate=1; otherwise=0)
Ln monthly pc urban agricultural income	Amount of agricultural income (Kes) per person per month
Ln transactions cost	Amount of transaction costs per kg of waste (Kes/Kg)
Other variables	
Inverse Mills ratio	Generated from stage one of ZSUR

The variables for examining agro-food waste demand (Table 6-2) were selected based on intuition, experience in utilising waste as well as Bakshi *et al.* (2016), Parrot (2009) and Zhou (2018) findings. Requisite statistical tests (chi-square, Breusch-Pagan test of independence and cross-correlations) were conducted to boost the validity, reliability and interpretation of data as shown in Table 6-4 and Appendix 4.

6.2.3.2 Thematic analysis

Thematic analysis is an attempt to improve the understanding of an issue or idea by organizing its critical aspects. Based on this, issues identified by various agro-food waste cycle actors were subjected to thematic analysis to enrich the data that was gathered from urban agro-producer households. Therefore, the qualitative data that was generated from key informant interviews; waste collectors, agro-markets, restaurants and processors as described in Table 6-1 was analysed for agro-food waste themes. This involved categorizing the identified themes into lowest-order (basic themes), middle-order (organizing themes) and highest-order (global theme). The basic themes identified were used to illustrate contribution of signification towards organizing themes and the global theme.

Extraction of data from key informant interviews involved modifying Attride-Stirling (2001) and Thomas and Harden (2008) thematic analysis methodologies. The study applied three steps: (i) selection and pooling text, (ii) reconsideration of pooled text and developing descriptive themes and (iii) generating analytical themes. However, these steps were not static as such overlaps (back-and-forth processes) were experienced during the exploratory analysis. Further, progressive refining and arrangement of text and themes were also implemented during the thematic analysis process. The overlaps were critical in boosting the validity, reliability and relevance of the study text that was used and the findings arrived at.

6.3 Results and discussion

6.3.1 Descriptive statistics

Urban agro-producer households acquired the largest proportion of agro-food waste from other households followed by processors and own household as shown in Table 6-3. This meant that other agro-producer household were critical in provision of agro-food waste to urban households. Restaurants and dumpsites contributed the lowest quantity shares to the overall agro-food waste that was used in urban agro-producer households. This is an indicator that dumpsites and restaurants were the least preferred source of agro-food waste.

Source-based agro-food waste prices per kilogram showed that the highest mean was for agro-market waste followed by own household and other households' waste. The lowest mean price was for dumpsite-sourced waste. This implies that for every shilling set aside for agro-food waste, agro-producer households could acquire higher quantities of agro-food waste from dumpsites compared to agro-markets. This also implies that the per unit price of agro-market waste could have been hiked by the small quantities that were sold to agro-producers since most of those involved were micro traders. Since agro-producers only required to pay for labour to pick and bulk dumpsite waste, this could likely have influenced its low-cost price per unit.

Expenditure shares for the various agro-food waste sources indicated that processors attracted the largest share followed by own household and other households. On the other hand, restaurants and dumpsites had the lowest budg*et al*locations. This implied that most of the budget set aside for agro-food waste was spent on processors whereas the least was on dumpsites. The findings were consistent with the narrations by agro-producers during the survey that acquisition of dumpsite waste was the cheapest since only hired or family labour was required.

Average distance from the source of waste was longest from processors followed by agro-markets and shortest from dumpsites. This may imply that processing plants are situated much further from urban agro-producer households while dumpsites (waste deposition points) were nearest to the households. As such dumpsites may have been the most accessible sources of waste. The results are reasonable since common waste bins and or concrete pits are established near residential areas where waste emanating from households is deposited.

Agro-markets waste sourcing was associated with the highest transaction costs (loading, transport and offloading) per kilogram acquired. Probably, the individual trader basis of sourcing agro-market waste by urban agro-producer households contributed to higher average transaction costs. The longer distance associated with agro-markets waste may as well have contributed to high transaction costs. Other households and processors had the lowest associated transaction costs. The results may have implied that the larger quantities of agro-food waste that were acquired from other households contributed to on average lower transaction costs. However, despite the longer distance associated with processors, larger quantities and fewer trips of waste acquired from the source may have contributed to lower average costs. The low quantities of agro-food waste sourced from dumpsites and use of labour by agro-producer households may have contributed to higher average transaction costs for dumpsite sourcing. Similarly, the low quantities of waste and shorter distances from restaurants may also have contributed to relatively lower transaction costs.

Table 6-3: Descriptive statistics for household waste sourcing

Source	Quantity share (%)	Budget share (%)	Price/kg (Kes)	Distance (Km)	Transaction cost/kg (Kes)
Own household	24.53	26.06	7.43	-	-
Other households	30.85	24.88	6.16	1.90	0.53
Restaurants	1.87	3.00	5.73	1.88	0.62
Agro-markets	14.71	19.21	8.11	3.12	0.81
Processors	27.58	26.60	3.59	3.24	0.46
Dumpsites	0.46	0.25	2.77	0.90	0.65

6.3.2 Determinants of agro-food waste demand

The ZSUR results revealed that all the expenditure share models were significant at $p \leq 0.01$. The R^2 and χ^2 statistics indicated that the explanatory variables used for the study were able to explain the expenditure shares of agro-food waste in urban agro-producer households as presented in Table 6-4. The Breusch-Pagan test of independence for the models indicated that the χ^2 was highly significant at $p \leq 0.01$. Therefore, the projection that correlations of residuals were equal to zero was rejected. This association indicates a joint source-based demand determination for agro-food waste.

Price of own household agro-food waste was associated with likely rise in demand for waste generated by a household. Based on the law of demand, this relationship seems unusual although it may imply that increased quality (as associated with its increased price) was likely to enhance own household waste utilisation share. Similarly, own waste price had positive influence on agro-market waste demand, implying that increase in own waste price led to

Table 6-4: ZSUR: source-based determinants of expenditure allocations in acquisition of agro-food waste

Variables	Own household	Other households	Restaurants	Agro-markets	Processors	Dumpsites
Ln own waste price	0.0965(0.0301)**	-0.0416(0.0496)	0.0391(0.0702)	0.1016(0.0298)**	-0.1139(0.0732)	-0.0231(0.0205)
Ln other households' price	0.0265(0.0307)	-0.0014(0.0487)	-0.0443(0.0191)*	-0.1205(0.0303)**	0.0496(0.0424)	0.0094(0.0103)
Ln restaurants price	-0.0459(0.0373)	-0.0703(0.0525)	0.0748(0.0438)	-0.0661(0.0382)	0.0286(0.0447)	0.0491(0.0301)
Ln agro-market price	-0.0378(0.0247)	-0.0707(0.0343)*	-0.0071(0.0230)	-0.0982(0.0309)**	-0.0385(0.0285)	-0.0171(0.0135)
Ln processors waste price	0.0083(0.0536)	0.0925(0.0701)	0.0342(0.0304)	-0.0552(0.0407)	-0.1375(0.0424)**	-0.0163(0.0195)
Ln dumpsite waste price	0.0318(0.0759)	0.1082(0.1124)	-0.0487(0.0971)	0.1552(0.0765)*	0.0897(0.1043)	-0.1295(0.0405)**
Ln total expenditure on waste	0.0843(0.0115)**	0.0105(0.0173)	-0.0162(0.0131)	0.0160(0.0131)	0.0816(0.0399)*	0.0181(0.0288)
Ln fertilizer price	0.0152(0.0061)*	0.0187(0.0086)*	0.0014(0.0042)	0.0021(0.0060)	-0.0087(0.0064)	0.0012(0.0028)
Ln feeds price	-0.0079(0.0096)	0.0046(0.0121)	-0.0030(0.0088)	-0.0060(0.0089)	-0.0010(0.0096)	-0.0047(0.0062)
Ln fodder price	0.0078(0.0038)*	0.0108(0.0054)*	0.0024(0.0033)	0.0088(0.0039)*	-0.0040(0.0039)	-0.0003(0.0015)
Monthly pc own waste	0.0020(0.0003)**	-0.0009(0.0004)*	0.0004(0.0003)	-0.0001(0.0003)	-0.0005(0.0008)	0.0002(0.0001)
Age of household head	0.0027(0.0010)**	-0.0014(0.0013)	0.0004(0.0010)	0.0001(0.0010)	-0.0001(0.0010)	-0.0006(0.0008)
Education level of household head	0.0028(0.0029)	-0.0005(0.0041)	0.0039(0.0040)	-0.0029(0.0030)	-0.0015(0.0030)	-0.0013(0.0017)
Livestock production	0.1217(0.0605)*	-0.1056(0.0549)	-0.0054(0.0311)	0.0016(0.0396)	0.0296(0.0441)	-0.0341(0.0309)
Vegetable production	-0.0283(0.0322)	0.0606(0.0484)	-0.0004(0.0234)	0.0193(0.0335)	-0.0855(0.0355)*	-0.0140(0.0110)
Ln monthly pc urban agricultural income	0.0273(0.0084)**	-0.0275(0.0130)*	0.0055(0.0060)	0.0084(0.0084)	-0.0007(0.0085)	-0.0132(0.0128)
Ln transactions cost	-	0.0005(0.0112)	-0.0033(0.0194)	-0.0104(0.0079)	-0.0447(0.0146)**	-0.0190(0.0115)
Inverse Mills ratio	-0.0511(0.1058)	-0.0824(0.0678)	-0.1531(0.1195)	-0.0215(0.0396)	0.0465(0.1045)	-0.0747(0.0517)
_Cons	0.3681(0.2019)	0.7582(0.2347)	0.1801(0.2338)	0.1034(0.2171)	-0.4499(0.5489)	0.4016(0.1003)
Model statistics	χ^2=171.73, p=0.0000	χ^2=94.77, p=0.0000	χ^2=65.67, p=0.0000	χ^2=157.27, p=0.0000	χ^2=154.05, p=0.0000	χ^2=114.4, p=0.0000
Breusch-Pagan test of independence: χ^2 (15) = 242.197, Pr = 0.0000						

ZSUR = Zellner's seemingly unrelated regression; Pc=per capita, Standard errors are in the parenthesis, *significance at 5% and **significance at 1%

increased agro-market waste acquisition. This also implies that when own household waste cost per unit increased, agro-market waste was used as a substitute which concurs with the cross-price elasticities results presented in Table 6-6 and 6-7.

There would be a likely significant reduction in demand for restaurants and agro-market waste due to rise in price of other households' sourced agro-food waste. This implies that the complementary nature of other households' waste to restaurant and agro-market-sourced waste contributed to decline in demand. Rashmika and Edirisinghe (2016) highlighted price of compost as an important determinant of demand in Kurunegala, Sri Lanka.

Increase in agro-market sourced waste price was associated with reduced acquisition of agro-food waste from other households and agro-markets. The later supports the law of demand in that an increase in own price is expected to decrease in quantity demanded of a good. The former implies that other households and agro-markets sourced waste were compliments. As such increased agro-market waste price would also result to reduced quantity demanded from other households.

The quantity of agro-food waste demanded from processors was likely to decline because of rise in its price. This implies that the association coincides with the law of demand, inverse relationship of price and quantity. Similarly, increase in own-price for dumpsite-sourced waste was associated with decline in its quantity demanded. Furthermore, the dumpsite-sourced waste price was likely to contribute to a rise in the agro-markets-sourced waste demanded by urban agro-producer households. This implies that dumpsite and agro-market-sourced waste are substitutes in urban agriculture.

Upward review of agro-food waste budget among urban agro-producer households was likely to significantly increase the budget share for own household and processor-sourced waste. The results concurred with the expenditure elasticities as illustrated on Table 6-4. This implies that the own household and processor-sourced waste were normal goods.

Inorganic fertilizer price increment was likely to trigger a rise in own household and other households sourced waste budget share. This implies that increase in fertilizer prices contributed to decline in purchasing power as such rising the preference for agro-food waste. The relationship also implies that own household and other household agro-food waste are fertilizer substitutes.

Livestock fodder price was also a determinant of own household, other household and agro-markets waste expenditure share. Fodder price hike was likely to contribute to rise in quantity demanded of own household, other household and agro-market sourced waste. This implies that increased fodder prices reduced urban agro-producers fodder purchasing power as a result opting for less expensive alternatives form of feeds for urban agriculture. As such own household, other household and agro-market waste acted as fodder substitutes.

A hike in monthly per capita own household generated waste was associated with likely increase in own household agro-food waste expenditure, as would be expected under the law of demand. Conversely, the higher the quantities of agro-food waste generated from own household was likely to reduce the other households sourced waste expenditure share. This implies that increased generation of waste within a household enhanced self-reliance thus suppressing external acquisition.

Older household heads were associated with higher likelihood of adopting use of own household generated waste than externally sourced waste. Probably, this may imply that older agro-producers may have been sceptical about the quality and safety of externally sourced agro-food waste. This also implies that older agro-producers could be more efficient in managing waste through utilisation of waste generated in their household as reducing the need for external acquisition. The findings concurred with those of Parrot *et al.* (2009) that age of farmers is critical in determining domestic waste utilisation as input.

The ZSUR results indicated that increase in livestock production was associated with likely increment of utilising own household waste. The inclination may be explained by the nature of safety issues largely associated with agro-food waste sourced outside the household. Due to livestock susceptibility, agro-producers may have been hesitant in sourcing agro-food waste externally. On the other hand, increased vegetable production was likely to contribute to reduced processor-sourced waste demand. The results imply that processing facilities were not the preferred sources of agro-food waste for vegetable producers. As such higher vegetable production meant increased use of waste from other sources thereby reducing the processor-sourced waste share. Similarly, Parrot *et al.* (2009) findings indicated that vegetable production influenced organic waste utilisation in farming households. However, Nigussie *et al.* (2015) findings indicated there exist competing needs for agricultural waste as livestock feed and fertilizer (soil amendment) and sometimes for fuel. Notwithstanding the competition, Nigussie *et al.* (2015) noted that livestock and crop farmers could benefit from improved linkages and as a result intensified use of agro-food waste.

Increased urban agriculture income was likely to contribute to rise in own household waste expenditure share. This indicates that urban agro-producer households prefer waste generated from their households. Since increased agricultural income may be an indicator of increased production and or intensification, this would imply that urban agro-producers are able to generate more waste from their backyards which would be expected to reduce the external demand. Conversely, increased urban agriculture income was likely to contribute to decline in other households sourced waste expenditure share. The results reinforce the findings of declined external acquisition of agro-food waste due to increased agricultural income.

Finally, the increase in transaction costs were associated with likely reduction in processor-sourced waste. The results coincide with the descriptive results whereby processors were associated with longest distances from urban agro-producer households. Although not absolute, longer distances are indicators of higher transaction costs and lesser accessibility. Therefore, transaction cost hinders waste market development.

6.3.3 Expenditure elasticities

The expenditure elasticities of demand for agro-food waste were as presented in Table 6-5. All the elasticities were positive except for dumpsite-sourced waste which was negative. Expenditure elasticity (1.7481) showed that agro-food waste from processors was elastic and significant at $p \leq 0.01$. This implied that a one percent increment in overall budget for agro-food waste among urban agro-producer households would likely contribute to increase in processor-sourced waste expenditure share by 1.7481 percent, *ceteris paribus*. This also implied that agro-food waste sourced from processors was a luxury good among agro-producer households.

The agro-market sourced waste expenditure was elastic (1.1988) at $p \leq 0.01$. As such the former implied a likely increase in expenditure share for agro-market sourced waste by 1.1988 percent in case of rise in budget towards agro-food waste by one percent in the short run. As such agro-market sourced waste was a luxury input in agro-producer households.

Expenditure elasticity results for own household waste showed inelastic inclination; 0.8640 at $p \leq 0.01$. Despite there not being direct expenditure for own household agro-food waste, the urban agro-producer households incurred cost of production and or purchasing food products that contributed to waste. Additionally, a one percent increase in agro-food waste budget would likely lead to 0.8640 percent increase in own household waste expenditure, holding other factors constant. The results implied that the expenditure associated with waste generated from own household was a normal good. However, QUAIDS indicated that own household agro-food waste had largely unit elastic expenditure; 1.0101 (Appendix 4).

Dumpsite-sourced waste portrayed inelastic expenditure where its LA-AIDS estimate was insignificant (Table 6-5), only its QUAIDS estimates were significant at $p \leq 0.05$ (Appendix 4). The results indicated that an increase in the overall agro-food waste budget by one percent in an urban agro-producer household would likely contribute to a decrease in its demand by 0.0769 percent, in the short term. This implied that as agro-food waste increases, the expenditure share for the dumpsite-sourced waste would decline. As such, dumpsite-sourced waste is an inferior good.

Table 6-5: LA-AIDS expenditure elasticities

Waste type/source	Elasticity	Standard error
Own household	0.8640**	0.0427
Other households	0.8970**	0.0412
Restaurants	0.6998**	0.1469
Agro-markets	1.1988**	0.0738
Processors	1.7481**	0.1036
Dumpsites	-0.0769	0.2194

***significance at 5% and **significance at 1%**

Other households and restaurants sourced waste expenditure were inelastic. A one percent increase in overall expenditure for agro-food waste was attributed to a rise in other households sourced waste expenditure share by 0.8970 percent at $p \leq 0.01$. Restaurants-sourced waste expenditure share would increase by 0.6998 percent due to rise in the overall budget for agro-food waste one percent at $p \leq 0.01$. This implies that other households and restaurants-sourced waste are normal goods. The QUAIDS estimates were consistent with LA-AIDS for other households and restaurants sourced waste.

6.3.4 Price elasticities

Uncompensated own-price elasticities results (Table 6-6) indicated that agro-food waste sourced from other households (-1.0213), processors (-1.5574) and dumpsites (-6.3308) were elastic, implying that the urban agro-producers were highly responsive to their price changes. Therefore, relatively larger changes in quantities of agro-food waste acquired from other households, processors and dumpsites were likely to be implemented in case of a one percent change in respective prices. In comparison, the uncompensated own-price elasticities showed agro-food waste sourced from own households (-0.9437), restaurants (0.3702) and agro-markets (-0.1789) were price inelastic. The price inelastic results implies that agro-producers quantity of agro-food waste demanded from own household, restaurants and agro-markets were lowly responsive to their price changes. In addition, all own-price elasticities of demand were

Table 6-6: Uncompensated elasticities

	LA-AIDS model					
Waste type/ source	Own household	Other households	Restaurants	Agro-markets	Processors	Dumpsites
Own household	**-0.9437**(0.0845)**	0.1916(0.0800)*	0.0156(0.0441)	0.1738(0.0569)**	-0.1397(0.0598)*	-0.1616(0.0285)**
Other households	0.1335(0.0590)*	**-1.0213**(0.0800)**	-0.0578(0.0353)	-0.2643(0.0464)**	0.2253(0.0495)**	0.0876(0.0225)**
Restaurants	0.1473(0.2797)	-0.4168(0.2997)	**0.3702**(0.4133)	-1.0083(0.2593)**	-0.3323(0.3482)	0.5400(0.2460)*
Agro-markets	0.2428(0.1102)*	-0.8067(0.1212)**	-0.3304(0.0797)**	**-0.1789**(0.1293)	-0.2466(0.1087)**	0.1210(0.0518)*
Processors	-0.6257(0.1554)**	0.4639(0.1743)**	-0.1851(0.1445)	-0.4140(0.1460)**	**-1.5574**(0.2297)**	0.5702(0.1080)**
Dumpsites	-2.4406(0.4794)**	2.3455(0.5010)**	1.4532(0.6465)*	1.2279(0.4420)**	3.8216(0.6830)**	**-6.3308**(0.9181)**

Elasticity (standard error in parenthesis); *significance at 5% and **significance at 1%

negative except for restaurants. As per the law of demand, an increase in price of a product is expected to result to decrease in its quantity demanded thus the own-price elasticity is expected to be negative. The positive own price elasticities for waste sourced from restaurants implies that a likely increase in price of agro-food waste by one percent would contribute to 0.3702 percent rise in demand thus violating the law of demand. This also implies that agro-food waste from restaurants is a giffen good. The LA-AIDS results for uncompensated price elasticities were consistent with QUAIDS demand system (Appendix 4).

Uncompensated cross-price elasticities indicated that the highest responsiveness for quantity demanded was likely for dumpsite-sourced waste due to changes of other waste prices. For instance, a one percent increase in own household sourced waste price would have contributed to a decline in quantity of dumpsite-based waste by 2.44 percent. This implies that dumpsite and own household waste were compliments. On the other hand, a one percent increase in the prices of other household, restaurants, agro-markets and processors sourced waste would likely contribute to increase in the quantity demanded of dumpsite-sourced waste by 2.35, 1.45, 1.22 and 3.82 percent respectively. The positive relationship implies that other households, restaurants, agro-markets, processors waste are substitutes to dumpsite-sourced waste.

Compensated own-price elasticities showed that own household (-0.7253), other household (-0.7181), restaurants (0.3979) and agro-markets (-0.0236) source-waste were price inelastic as presented in Table 6-6. Conversely, processors (-1.3902) and dumpsite (-6.3319) sourced waste were price elastic. This implies that the later were more price responsive to price changes compared to the former. Additionally, the results implies that the respective demands for waste would change by -0.0236, 0.3979, -0.7181, -0.7253, -1.3902 and -6.3319 percent due to increase in price by one percent.

Compensated cross-price elasticities (Table 6-7) indicated that processors-sourced waste had the strongest substitution response of 3.8143 implying one percent rise in the price of processors waste would increase the quantity demanded for dumpsites waste by 3.8143 percent. Adopting Shibia *et al.* (2017) interpretation, other households sourced waste showed the second strongest substitution response (2.3196) as such there is likely rise in demand for dumpsite-sourced waste by 2.3196 percent due to increase in price for other households waste by one percent. On overall, dumpsite-sourced waste showed the highest sensitivity in changes of other waste prices. The compensated cross-price elasticities results indicated that source-based agro-food wastes were more of substitutes than complements. Although with minimal

Table 6-7: Compensated elasticities

Waste type/ source	Own household	Other households	Restaurants	Agro-markets	Processors	Dumpsites
Own household	**-0.7253**(0.0854)**	0.4836(0.0781)**	0.0498(0.0439)	0.2857(0.0564)**	-0.0570(0.0592)	-0.1486(0.0285)**
Other households	0.3603(0.0584)**	**-0.7181**(0.0795)**	-0.0223(0.0351)	-0.1481(0.0459)**	0.3111(0.0489)**	0.1011(0.0225)**
Restaurants	0.3243(0.2800)	-0.1803(0.2989)	**0.3979**(0.4123)	-0.9176(0.2596)**	-0.2654(0.3482)	0.5506(0.2459)*
Agro-markets	0.5460(0.1098)**	-0.4016(0.1194)**	-0.2830(0.0794)**	**-0.0236**(0.1288)	-0.1320(0.1079)	0.1391(0.0517)**
Processors	-0.1836(0.1559)	1.0546(0.1723)**	-0.1160(0.1441)	-0.1876(0.1458)	**-1.3902**(0.2285)**	0.5966(0.1079)**
Dumpsites	-2.4601(0.4775)**	2.3196(0.5028)**	1.4501(0.6458)*	1.2180(0.4437)**	3.8143(0.6843)**	**-6.3319**(0.9176)**

Elasticity (standard error in parenthesis); *significance at 5% and **significance at 1%

differences, the results were consistent for both LA-AIDS and QUAIDS demand systems (see Appendix 4).

Uncompensated and compensated cross-price elasticities signs were consistent for all types of waste implying that the income and substitution effect due to price changes were equally critical. However, the magnitude for uncompensated and compensated elasticities indicated inconsistencies where the former was either larger or smaller than the later. In cases where the compensated elasticities' magnitude were smaller than uncompensated elasticities implied that the pure substitution effect was only compensated partially by income effect (Ngui *et al.*, 2011). Conversely, in cases where the magnitude of uncompensated elasticities was smaller than compensated elasticities, this implies that the income effect only compensated substitution effect partially.

6.3.5 Thematic analysis for agro-food waste cycle actors

Given the importance of understanding waste processes in urban areas, quality of life through improved environmental considerations may be enhanced. Considering the data from waste collectors, restaurants, agro-markets and processors, the organizing themes were established to be generation, management and demand of waste whereas waste market was the global theme as shown in Table 6-8.

Under the generation of waste theme, processors indicated that low quality agricultural raw materials and parts that were considered non usable were not processed. These included wastewater, blood, horns, hooves, ears and intestinal undigested materials from slaughterhouses whereas peels, hard stocks, fibre and seeds waste were generated from crop related processors. Agro-markets were majorly linked to raw food that had gone bad, low quality food emanating from pest infestation (especially dry grains), unsold produce availed in the market and wrappers for agro-produce (such as banana leaves) that was availed to the mark*et al*ongside produce for sale. Hard stocks, covers, peels and seeds were also generated by traders in course of adding value to food they sold through shredding, cooking and repackaging. Although unavoidable waste was indicated as the most common agro-food waste generated, transport, storage and market forces related waste were also common. Whereas restaurants, agro-markets and processors indicated responsibility in generation of agro-food waste, they bestowed its management obligation with urban authorities. This view was despite the inefficiency and ineffective nature of public waste collection services the actors experienced. As a result, it necessitated making their own arrangements to amend the situation. More so, waste disposal behaviour by agro-market actors contributed to filth in the markets.

Table 6-8: Thematic analysis for key informants

Actors examined	Basic themes	Organizing themes	Global theme
Processors Agro-markets Restaurant	▪ Waste typologies ▪ Generation frequency ▪ Causes of generation ▪ Who is responsible?	• Generation of waste	
Waste collectors Processors Agro-markets Restaurants	▪ Responsibility and satisfaction ▪ Self and private contract management ▪ Public management ▪ Efficiency ▪ Cost ▪ Risks associated ▪ Reuse and recycling ▪ Actors' cooperation ▪ Capacity ▪ Behaviour ▪ Coordination	• Waste management	❖ Waste market
Waste collectors Processors Agro-markets Restaurants	▪ Users of waste ▪ Risks associated ▪ Utility and economics associated ▪ Willingness to acquire and utilise waste ▪ Price of waste ▪ Intensification of use ▪ Coordination ▪ Bulking and formalization	• Demand and utilisation	

As highlighted, self-management of waste was common beyond bulking at the generation site. Higher satisfaction in management of waste was associated with self-management (self-management and private contracting) compared to urban authority's services. This implies that higher accountability enhanced higher satisfaction unlike the case of public waste services. Notably, self-management capacity was limited but passion was evident. However, higher accountability and efficiency of waste management services attracted greater associated cost. As indicated by agro-market waste actors, users of agro-food waste preferred collecting waste from individual traders rather than heaped waste within the market. This inclination may be associated with filth of heaped waste whereas individual traders offered fresher waste. Furthermore, the heaped waste was not segregated whereas arrangements with individual traders enabled sorting of waste to the users' requirements. This implies that the risk

associated may have put off users of waste from market dumps. The non-segregation of waste was indicated to be a major source of risk for waste collectors who often did not use protective gear and or equipment.

Despite being very low, instances of waste recovery, reuse and recycling were highlighted by waste actors. They associated waste utilisation with urban agriculture practitioners. However, the key informants noted that agro-food waste cycle actors' cooperation through sorting, bulking and information sharing would likely enhance waste utilisation especially among urban agro-producer households and ecological products (for instance charcoal briquettes) manufacturers. The study area had organic production and market groups that would likely enhance agro-food waste utilisation. Whereas agro-food waste has been associated with low-cost appeal, slaughterhouses operators indicated persistent low demand for waste even in instances where it was composted. The operators indicated minimal contact with urban farmers which may imply there was low diffusion of compost information. A considerably low price of waste was quoted by slaughterhouses operators, Kes 1.00 to Kes 1.50 per kg. Folefack (2008) findings in Cameroon indicated a lower demand than supply for compost prepared from household waste. Informed by the key informants' data, in Kenya the waste market is existent but uncoordinated. Coordination of waste utilisation through collaboration of agro-food waste actors may in turn contribute to waste market development.

Based on the agro-producer survey and key informant interviews, the network of urban agro-food waste supply chain actors was established to be as shown in Figure 6-1. Whereas urban agriculture involves waste generation, rural agro-producer households were identified as critical contributors of waste in the urban agro-food waste supply chain.

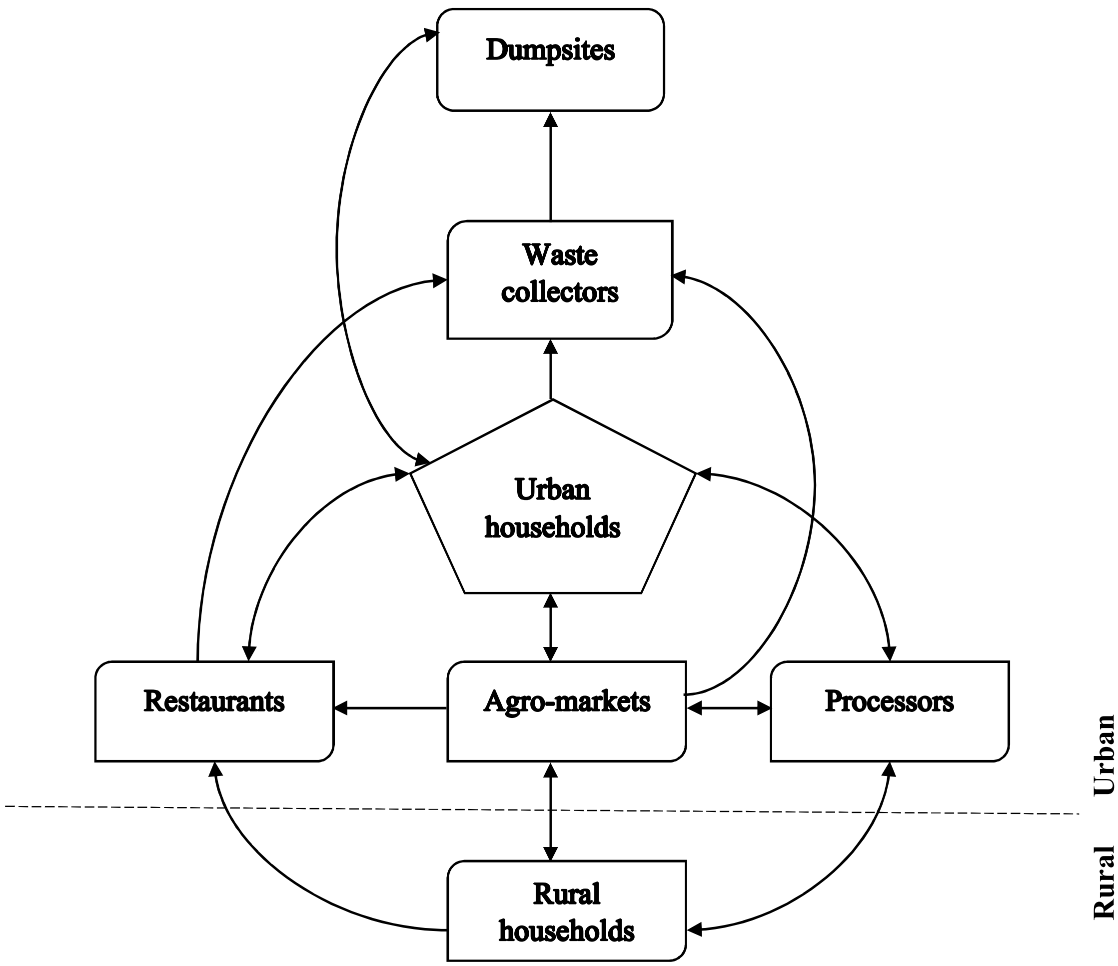

Figure 6-1: Agro-food produce and waste supply framework

6.4 Conclusion

The study sought to assess source-based demand of agro-food waste, estimated price and expenditure elasticities of demand as well as assess the role of agro-food waste actors in waste market development in urban Kenya. Wastes and conventional input prices are key determinants of demand. Results indicate that other households, agro-markets and restaurants sourced waste are complementary goods whereas own household, other households and agro-markets are substitutes to fodder. The elasticity estimates are largely consistent with economic theory of own-price negativity. There are clear indications that source-based agro-food wastes are more of substitutes than complements. Own household, other household and restaurants are normal goods (expenditure elasticities <1) whereas agro-markets and processors sourced waste are luxury commodities within urban households. Other agro-food waste cycle actors are important in the improvement of supply chain coordinators among agro-food waste cycle actors. As such involvement and commitment of agro-food waste stakeholders would be a basis for a sustainable investment in utilising waste.

To enrich the waste demand theory, future studies could consider adopting across-seasons longitudinal approach to minimize the seasonal effects on agro-food waste demand. A more in-depth agro-food waste supply chain assessment may avail informative insights in waste market strengths, weaknesses, opportunities and threats which will be a good basis for its development.

CHAPTER SEVEN

GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

7.1 Critical review

The study adopted fractional response models to assess the drivers of generation of agro-food waste in urban agro-producer households. Using the fractional model approach, the identified shortcomings of OLS, Logit and Tobit as emphasized by (Currit, 2002; Halli, 1992; Smith & Brame, 2003) were addressed. Particularly, fractional response simplified the requirement of knowing the distribution of the response variables in advance (Gallani *et al.*, 2015). In this case, only the correct specification of the conditional mean was required. In addition, the methodology enhanced the characterization of agro-food waste generated in urban settings and the role of behaviour. The methodology confirmed that behavioural aspects were critical in strengthening waste generation framework thereby improving prediction.

Traditionally, the Multinomial Logit model has been accepted as a basis for assessing choice of existing alternatives independently (Kohansal & Firoozzare, 2013). However, its prevalent weakness of assuming mutual exclusivity (independence) of choices has rendered it misleading (Tarekegn *et al.*, 2017; Dessie *et al.*, 2018). The use of MVP instead strengthened the simultaneity nature of agro-food management choices in real-life situation thus enabling joint estimation. The joint probabilities indicated its appropriateness in assessing choice of waste management options and safety risk management practices. Therefore, the study was critical in boosting the theory of choice at the household.

The flexibility of the Theory of Planned Behaviour promotes its development. Using structural equation modelling, the behavioural aspects of commercial utilisation of agro-food waste in urban households were highlighted. As a result, environmental awareness and concern, risk perceptions, moral obligation, motivation and contextual factors constructs were included in the original Theory of Planned Behaviour constructs. Using this methodology, likely transition of agro-food waste commercial utilisation intentions to behaviour were projected and confirmed. Hasbullah *et al.* (2014) and Miller (2017) candidly showed how the theory of planned behaviour has endured borderless application. The theory once again proves its versatility in assessing and understanding behaviour.

Generally, agro-food waste market has largely not been an area of interest in research. However, with the changing narrative of considering waste as a problem to waste as a resource (Wilson *et al.*, 2015) the research highlights the interrelationships of the agro-food waste supply chain actors. Using the linear approximation of almost ideal demand systems, agro-food waste sourcing activities and expenditure allocations in urban farming households were enhanced (Ngui *et al.*, 2011). Mixed methodologies regarding qualitative and quantitative aspects were used boosts the validity and reliability of data generated. Thematic analysis of key supply chain actors offered tips on areas that need to be addressed in the coordination of the agro-food waste chain. The study is critical in influencing the economic theory of demand.

7.2 Consolidated discussion

Crop production farming system was the most common form of urban agriculture. Although dominated by male headed households, approximately one-third of the households were women headed. Household heads had an average age of 50.25 years whose main occupation was agribusiness, self-employed. This implies that urban agriculture is a livelihood strategy among urban agro-producer households as argued by Opitz *et al.* (2016).Similarly, Mkwambisi (2011) highlighted the income role of urban agriculture in female headed households which was a form of empowerment.

Utilisation of waste as a supplement to conventional input in urban agriculture may be a driver of generation of agro-food waste typologies. The study established a link between livestock and crop production where increased generation of animal waste was a likely contributor to rise in crop produce and waste. Positive influence of crop waste on livestock production was also likely. This implies that production aspects in urban agriculture are likely to contribute to generation of increased waste. Findings also implies that agriculture could be adopted as a strategy for agro-food waste management in urban areas as such positively contributing to the food supply chain. Similarly, Karanja *et al.* (2010) cited how the flow of nutrient supported waste management and in turn urban agriculture. Tadesse *et al.* (2021) reiterated how urban agriculture contributed to nutrient accumulation and food production.

Behavioural aspects in livestock feeding regimes offered insights into the unconscious nature of waste generation within urban households. Older folks were associated with unplanned livestock feeding habits which was associated with likely hike in waste generated. The unawareness nature of the respondents in waste typologies generated from their households may be an indicator of likely upsurge in waste. The quantity of agro-food waste generated in a household mostly dawned on the respondents upon estimation; an average daily per capita of 11.42 kg.

There is a general agreement that waste reduction is the most preferred and effective approach in managing waste. However, the unavoidable nature of some wastes makes it critical in adopting other waste management strategies. Findings indicated utilisation, giving out and or selling were common methods of managing agro-food waste. This implies that where waste reduction was not achievable, utilisation within households could be adopted as an alternative. The findings were similar to Mu'azu *et al.* (2018) that waste reduction was the most promising avenue for waste management. Furthermore, urban agro-producer households adopted a combination of waste reduction, utilisation, giving out/selling and disposal of waste to improve waste management effectiveness. The multiple aspects of waste management were also highlighted by Erich (2018).

Urban agricultural and waste segregation knowledge were established to be critical in management of waste. These aspects enabled agro-producer households to manage risks associated with utilisation of agro-food waste. Waste segregation and composting were the most preferred safety risk management strategies. Similarly, Jara-samaniego *et al.* (2015) put forward a case for sustainable waste management in South America where compost was the most cost-efficient approach in urban areas. This argument was also supported by Njenga *et al.* (2007) that composting availed vital soil nutrients to urban agriculture thus enhancing agro-food waste management. The susceptibility of livestock to risks associated with agro-food waste influenced safety risk management practices in urban households. The knowledge aspects may be associated to increased comprehension of the effectiveness of waste management approaches as emphasised by SIANI (2017).

Risk perceptions may curtail the utilisation of agro-food waste. However, they may also increase agro-producers' consciousness towards utilising agro-food waste thereby addressing them. This enables safe use of agro-food waste as such averting the likely damages. Compared to rural farms, urban farms are generally small although the later tend to be more intensified. Intensification may propel commercialisation intention and behaviour as such promoting intention-behaviour transition. Therefore, promoting development of agro-food waste commercialisation intention may be a rider towards intensifying use of agro-food waste in urban agriculture. This may form a basis for implementation of the proposed National Sustainable Waste Management Act (RoK, 2019). Mohareb *et al.* (2017) argued that urban agriculture could adopt a commercial perspective. Hovorka (2004) approached urban agriculture commercialisation from entrepreneurship where urban poverty was addressed. Mkwambisi *et al.* (2011) explicitly showcase the role of urban agriculture in income generation and employment creation among low- and high-income participants.

The evaluation of agro-food waste demand in urban agro-producer households indicated inclination towards other households in waste sourcing. This implied that agro-producer households were largely dependent on other (neighbouring) households in meeting their agro-food waste needs. Although not robust, the agro-food waste actors' interrelationships were indicated to have potential in the development of the waste market. Abdulredha (2018) used thematic analysis in assessing waste management in Iraq. The study noted that there was weak coordination due to non-inclusive nature of waste management practices. This approach rendered waste management ineffective and largely unsustainable. In essence, agro-food waste demand and coordination present a platform for sustainable waste management through timely utilisation. Opitz *et al.* (2016), Menyuka *et al.* (2018) and Nicholls *et al.* (2020) candidly expounded on the role of urban agriculture demand for organic waste as a basis for sustainable development. Mohareb *et al.* (2017) indicated rise in global interest in uptake and scaling up of urban gardening towards commercial inclination. This was argued as a basis for promoting urban agriculture integration into the urban system thus enhancing resource use efficiency. Martellozzo *et al.* (2014) reinforced the importance of urban agriculture in meeting urban population vegetable demand for which urban resources (including agro-food waste) could play a role in closing the existing deficit.

7.3 Conclusions

Objective 1: To assess the drivers of agro-food waste typologies generation among urban agro-producer households in Kenya.

The livestock farming system is the highest generator of agro-food waste at the rate of 9.20kg (daily per capita). This contributes to higher overall daily per capita agricultural waste of 10.75kg compared 0.67kg food waste. The livestock-crop farming system integration through utilisation of agro-food waste may be promoted. The number of agri-enterprises a household practice is on overall the major contributor of marginal changes in generation of agricultural (0.32) and food waste (0.72) portions. This implies that higher diversity of agri-enterprises at the household level contributed to higher generation of agro-food waste.

Objective 2: To assess the role of contextual factors in the choice of agro-food waste management practises among urban agro-producer households in Kenya.

Waste reduction and utilisation are the most preferred agro-food waste management options at the household, each at 86%. On the other hand, agro-food waste segregation and composting are the most preferred safety risk management practices at 63% and 58% respectively. This indicates the options and practices were the likely entry points in improving management of agro-food waste. Urban agriculture and waste segregation knowledge aspects are the key indicators in management of agro-food waste generation and the resultant safety risks. Therefore, higher knowledge offered better self-management guarantees for proper management of waste in households.

Objective 3: To determine factors influencing agro-food waste commercial utilisation behaviour among urban agro-producer households in Kenya.

The budget allocation for agro-food waste (27%) is higher compared to that of conventional inputs (73%) at the household. However, quantitatively agro-food waste use is higher compared to conventional inputs. Commercial utilisation intention formation at the household is a critical influence in determination of commercial utilisation behaviour. This implied that commercial utilisation intention transitioned to commercial utilisation behaviour.

Objective 4: To evaluate the determinants of demand for agro-food waste among urban agro-producer households in Kenya.

Other households form the most important support system in sourcing of agro-food waste in urban agriculture. Currently, 31% of the agro-food waste sourcing by urban households is from other households although the highest agro-food waste budget allocation is on processors at 27%. Agro-food waste types from various sources are largely normal goods and substitutes to each other as well as to conventional inputs. There is a general weak coordination in the waste market which implies curtailing of diffusion of information and access to waste among agro-food waste supply chain actors.

7.4 Recommendations

1) Urban agro-producers should implement enterprise specialization by limiting the number of agri-enterprises practiced. This would enable them into channelling of more resources and managerial skills to fewer enterprises as such increasing efficiency and minimizing the resultant agro-food waste.
2) Urban authorities should formulate and implement education programs in conjunction with other stakeholders who are involved in urban agriculture and waste management. This is expected to enhance adoption of requisite agro-food waste management and safety risk management practices. As such minimizing the likely damages from mismanagement and safety risk issues associated with agro-food waste.
3) Urban authorities need to stimulate commercial utilisation intentions and behaviour through participatory tailor-made programs. This would enhance sustainable use of waste resources in urban areas thereby tapping into economic benefits and managing the environmental risk. As a result of commercialization of agro-food waste, urban authorities may experience reduced quantities of waste to deal with and the cost associated in urban areas.

4) Urban authorities should formulate requisite guidelines for promotion of waste market coordination. This is expected to contribute to its development through increased diffusion of information and access to agro-food waste by the agro-food waste supply chain actors.

7.5 Areas for further study

1) To minimize the seasonal effect arising from cross-sectional research design, a longitudinal study would be critical. This approach would enhance data accuracy in waste generation and utilisation in urban agro-producer households across seasons.
2) The current study estimated the value of agro-food waste based on the market price. It would be insightful if researchers would introduce methodologies that would capture the utility aspect. This is likely to avail more accurate value for agro-food waste.

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Appendices

Appendix 1: Chapter Three

Multicollinearity test

Variable	VIF	1/VIF
Education level of household head	2.30	0.434009
Education level of wife or household woman	2.00	0.500271
Per capita urban agriculture income	1.94	0.515516
Per capita disposable income	1.87	0.533775
Buy large food quantities	1.80	0.55463
Mature agri-enterprises	1.74	0.557655
Mature crop enterprises	1.68	0.559956
Subjective norm	1.59	0.628252
Perceived behavioural control	1.54	0.648255
Plan food purchase	1.54	0.649841
Refrigerator use	1.51	0.663675
Age household head	1.48	0.674341
Urban agriculture knowledge	1.41	0.708256
Home ownership status	1.37	0.727742
Regular servant	1.37	0.729405
Employment status of woman of household	1.36	0.733414
≤5 years	1.36	0.734128
Household size	1.34	0.745462
Employment status of household head	1.33	0.752917
Plans produce harvest	1.30	0.766353
Prepare excess food	1.28	0.780903
Attitude	1.28	0.781625
Guaranteed market	1.27	0.788687
Access to extension	1.27	0.789822
Unable to sell	1.23	0.815757
Eat away from home	1.21	0.826666
Group membership	1.21	0.827068
Sex of head	1.17	0.857433
≥70 years	1.10	0.907092
Religion	1.06	0.943367
Mean VIF	1.48	

Cross-correlations test

	Sex of head	Age of head	Education of head	Education of wife	Household size
Sex of household head	1				
Age of household head	0.0918	1			
Education level of household head	-0.1926	-0.1898	1		
Education level of wife or household woman	-0.0564	-0.1976	0.6579	1	
Household size	-0.1135	0.0862	0.0832	0.0663	1
≤5 years	-0.1056	-0.2001	0.0214	0.0379	0.3841
≥70 years	0.077	0.1318	-0.1109	-0.1	0.0061
Employment status of household head	-0.1624	-0.1565	0.3027	0.2037	0.0163
Employment status of woman of household	-0.0662	-0.1969	0.2768	0.289	-0.0198
Per capita disposable income	-0.0276	0.0288	0.2203	0.2278	-0.0006
Per capita urban agriculture income	0.0621	0.0208	0.1965	0.1514	0.0617
Home ownership status	0.0137	0.3186	0.0894	0.0651	0.0736
Urban agriculture knowledge	-0.1073	-0.0127	0.2217	0.1064	0.0113
Guaranteed market	-0.0485	0.0233	0.0314	-0.0093	0.016
Unable sell frequency	0.0969	-0.0637	-0.0159	0.0116	0.044
Access to extension service	0.0214	0.0921	0.1325	0.0828	0.0283
Group membership	-0.0017	0.0772	0.0987	0.0405	0.0099
Regular servant	0.0364	0.0629	0.2188	0.1561	0.0262
Religion	-0.0045	0.0181	0.0057	-0.0035	-0.0631
Mature crop enterprises	-0.0223	0.1707	0.0158	-0.0871	-0.0171
Mature agri-enterprises	-0.0225	0.209	-0.0159	-0.1098	0.0003
Prepare excess food during meals	0.0354	-0.0662	0.2333	0.174	0.0026
Refrigerator use	0.0163	0.0979	0.3167	0.2738	0.0302
Plan food purchase	-0.0441	-0.043	0.2383	0.2743	-0.0117
Plans produce harvest	-0.0288	0.0381	0.1452	0.1288	0.009
Buy large food quantities	-0.0006	-0.1218	0.3677	0.3144	0.0723
Monthly per capita frequency eats out-of-home	0.0221	0.0171	0.01	0.0356	0.064
Attitude	-0.073	0.0508	0.0007	-0.0104	-0.0393
Subjective norm	0.0209	-0.0007	-0.1328	-0.0965	0.0532
Perceived behavioural control	0.0328	-0.0221	-0.1114	-0.0867	0.0825

	≤5 years	≥70 years	Employment status of household head	Employment status of woman of household	Per capita disposable income
≤5 years	1				
≥70 years	-0.0379	1			
Employment status of household head	0.0799	-0.0448	1		
Employment status of woman of household	0.0159	-0.0336	0.3484	1	
Per capita disposable income	-0.0552	-0.0158	0.0472	0.1395	1
Per capita urban agriculture income	-0.1331	-0.0299	-0.0383	0.0192	0.5933
Home ownership status	-0.0673	0.0377	-0.0324	-0.0676	-0.0107
Urban agriculture knowledge	-0.0581	-0.129	0.0971	0.0639	0.1404
Guaranteed market	-0.0277	0.0135	0.0443	0.0037	0.0797
Unable sell frequency	-0.0123	-0.0203	0.0224	-0.0723	-0.0137
Access to extension service	-0.0363	0.084	0.1048	0.1905	0.0793
Group membership	-0.0062	-0.0235	0.1177	0.0102	0.0175
Regular servant	-0.0329	-0.0392	0.1681	0.1795	0.2034
Religion	0.0878	-0.0024	0.0548	0.0206	0.0033
Mature crop enterprises	-0.1078	-0.0431	0.0321	-0.0036	-0.1128
Mature agri-enterprises	-0.1093	-0.04	0.002	-0.026	-0.115
Prepare excess food during meals	0.024	-0.0537	0.0482	0.1435	0.1322
Refrigerator use	-0.021	-0.0441	0.2013	0.2242	0.148
Plan food purchase	-0.045	-0.0549	0.1302	0.0771	0.0417
produce harvest	-0.0082	-0.0694	0.0209	-0.0254	0.017
Buy large food quantities	0.0611	-0.0626	0.2184	0.1873	0.1
Monthly per capita frequency eats out-of-home	0.0171	-0.0299	0.0527	-0.0229	0.0092
Attitude	-0.0298	-0.1569	0.0876	-0.0259	-0.1529
Subjective norm	-0.0392	-0.1199	0.0383	-0.0493	-0.0786
Perceived behavioural control	0.015	-0.0275	0.061	0.0183	-0.176

	Per capita urban agriculture income	Home ownership status	Urban agriculture knowledge	Guaranteed market	Unable sell frequency
Per capita urban agriculture income	1				
Home ownership status	0.0016	1			
Urban agriculture knowledge	0.2532	0.0224	1		
Guaranteed market	-0.0114	0.0303	-0.1345	1	
Unable sell frequency	0.0083	-0.1987	0.0912	-0.1512	1
Access to extension service	0.0663	0.0507	0.1675	-0.0496	0.0146
Group membership	0.0949	0.0497	0.1886	0.0356	-0.0645
Regular servant	0.2729	-0.1385	0.2065	0.0044	0.0508
Religion	0.0041	0.0372	0.0184	-0.0445	-0.003
Mature crop enterprises	-0.0678	0.2445	0.1246	0.1571	-0.1107
Mature agri-enterprises	-0.0298	0.2816	0.1298	0.1536	-0.1321
Prepare excess food during meals	0.0453	0.077	-0.0221	0.1616	0.0225
Refrigerator use	0.2098	0.0682	0.1865	0.0157	0.0932
Plan food purchase	0.1093	0.0327	0.1688	0.0565	0.0647
produce harvest	0.0185	0.0056	0.2006	0.1973	0.0216
Buy large food quantities	0.1482	0.0286	0.1512	0.1281	-0.0184
Monthly per capita frequency eats out-of-home	-0.0717	0.0096	-0.0186	0.1553	0.219
Attitude	0.0325	-0.0325	0.1886	-0.0049	0.0014
Subjective norm	0.0503	0.0482	0.2266	-0.076	0.0626
Perceived behavioural control	-0.069	-0.0069	-0.0656	0.1007	-0.0302

	Access to extension service	Group membership	Regular servant	Religion	crops
Access to extension service	1				
Group membership	0.2641	1			
Regular servant	0.213	0.1808	1		
Religion	0.0482	0.0251	0.0489	1	
Mature crop enterprises	0.0639	0.1388	-0.0372	-0.0195	1
Mature agri-enterprises	0.0693	0.1534	-0.0267	-0.0228	0.3653
Prepare excess food during meals	0.1888	0.0151	0.0784	-0.0381	0.0221
Refrigerator use	0.2216	0.1639	0.3423	0.1068	-0.0014
Plan food purchase	0.0856	0.0866	0.1133	-0.0172	0.0349
produce harvest	0.0483	0.1863	0.1208	0.0216	0.2329
Buy large food quantities	0.1819	0.1419	0.198	0.0016	0.0162
Monthly per capita frequency eats out-of-home	0.051	0.0531	-0.0186	-0.0459	0.0413
Attitude	0.0379	0.1593	0.14	-0.034	0.0344
Subjective norm	0.0605	0.0451	0.0623	-0.0544	0.0262
Perceived behavioural control	0.0554	-0.052	0.0166	-0.0218	0.0199

	Mature agri-enterprises	Prepare excess food during meals	Refrigerator use	Plan food purchase	Plans produce harvest
Mature agri-enterprises	1				
Prepare excess food during meals	-0.0048	1			
Refrigerator use	0.0166	0.1284	1		
Plan food purchase	0.0212	0.1696	0.2668	1	
produce harvest	0.2366	0.0697	0.0801	0.1965	1
Buy large food quantities	0.0186	0.2914	0.3708	0.5309	0.1387
Monthly per capita frequency eats out-of-home	0.0344	0.1715	0.1533	0.0374	0.1428
Attitude	0.0584	-0.1635	0.0532	0.0481	0.0661
Subjective norm	0.0536	-0.0924	0.0167	0.0537	-0.079
Perceived behavioural control	0.0506	-0.0823	-0.0405	-0.0332	-0.1792

	Buy large food	Monthly per capita	Attitude	Subjective norm	Perceived behaviour al control
Buy large food quantities	1				
Monthly per capita frequency eats out-of-home	0.1139	1			
Attitude	-0.0091	0.0071	1		
Subjective norm	-0.0314	-0.0583	0.2844	1	
Perceived behavioural control	-0.0677	-0.1066	0.1813	0.4796	1

Descriptive statistics of variables used in the study

Variable	Mean	Standard deviation	Minimum	Maximum
Sex of household head	0.29	0.45	0.00	1.00
Age of household head	50.25	13.82	20.00	91.00
Education level of household head	12.63	4.34	0.00	26.00
Education level of wife or household woman	11.44	4.79	0.00	24.00
Household size	4.82	2.46	1.00	20.00
≤5 years	0.54	0.82	0.00	6.00
≥70 years	0.33	3.32	0.00	3.00
Employment status of household head	0.25	0.43	0.00	1.00
Employment status of woman of household	0.17	0.38	0.00	1.00
Per capita disposable income	149.97	336.25	0.00	5,162.96
Per capita urban agriculture income	372.65	821.50	7.78	10,200.00
Home ownership status	0.86	0.35	0.00	1.00
Urban agriculture knowledge	3.31	0.99	1.00	5.00
Guaranteed market	0.70	0.46	0.00	1.00
Unable sell frequency	2.41	6.56	0.00	60.00
Access to extension service	0.28	0.45	0.00	1.00
Group membership	0.16	0.36	0.00	1.00
Regular servant	0.28	0.45	0.00	1.00
Religion	0.01	0.10	0.00	1.00
Mature crop enterprises	6.65	3.65	0.00	16.00
Mature agri-enterprises	8.10	4.26	1.00	20.00
Prepare excess food during meals	0.44	0.50	0.00	1.00
Refrigerator use	0.44	0.50	0.00	1.00
Plan food purchase	0.59	0.49	0.00	1.00
Plans produce harvest	0.64	0.48	0.00	1.00
Buy large food quantities	0.49	0.50	0.00	1.00
Monthly frequency eats out-of-home	19.51	12.87	0.00	78.00
Attitude	3.68	0.43	1.71	4.86
Subjective norm	3.32	1.00	1.00	5.00
Perceived behavioural control	3.38	0.89	1.67	5.00

Appendix 2: Chapter Four

Multicollinearity test for variables used is assessing agro-food waste management options

Variable	VIF	1/VIF
Monthly per capita urban agriculture income	2.1900	0.4570
Monthly per capita disposable income	2.0100	0.4976
Waste separation knowledge	1.9200	0.5214
Past behaviour	1.7700	0.5662
Monthly per capita agro-food waste generated	1.7300	0.5781
Livestock	1.5800	0.6320
Crops	1.5000	0.6665
Household size	1.4900	0.6704
Garden size	1.4600	0.6847
Home ownership	1.4200	0.7038
Age of head	1.3900	0.7202
Agriculture knowledge	1.3700	0.7277
Education of household woman	1.3600	0.7327
≤5 years	1.3300	0.7538
Regular servant	1.3200	0.7570
Employment of head	1.2800	0.7785
Household woman employment	1.2700	0.7854
Access to public waste collection	1.2700	0.7882
Behavioural intentions	1.1800	0.8452
Sex of head	1.1000	0.9054
Monthly private collection fees	1.0800	0.9285
Mean VIF	1.48	

Multicollinearity test for variables used to assess the choice of safety risk management strategies

Variable	VIF	1/VIF
Waste separation knowledge	1.8400	0.5433
Past behaviour	1.8400	0.5439
Age of head	1.4400	0.6942
Experience in safety measures	1.3200	0.7573
Livestock	1.2900	0.7753
Home ownership	1.2800	0.7784
Employment of head	1.2600	0.7956
Household woman employment	1.2500	0.7982
Safety risk training	1.2000	0.8302
Extension access	1.2000	0.8322
Agriculture knowledge	1.2000	0.8353
Experience using waste	1.1400	0.8800
Behavioural intentions	1.1300	0.8817
Sex of head	1.1000	0.9064
Monthly per capita urban agriculture income	1.0700	0.9374
Household size	1.0600	0.9397
Mean VIF	1.2900	

Correlation of variables used in the study

	Sex of head	Age of head	Education of head	Education of household woman	Employment of head	Household woman employment	Household size	≤5 years	Agriculture knowledge
Sex of head	1								
Age of head	0.09	1							
Education of head	-0.2008	-0.1933	1						
Education of household woman	-0.0544	-0.1967	0.654	1					
Employment of head	-0.1597	-0.1544	0.3028	0.207	1				
Household woman employment	-0.0648	-0.1973	0.275	0.2844	0.3599	1			
Household size	-0.1114	0.0879	0.0847	0.065	0.012	-0.0208	1		
≤5 years	-0.1004	-0.1983	0.0255	0.0317	0.0738	0.0091	0.3818	1	
Agriculture knowledge	-0.111	-0.0129	0.2256	0.1088	0.1048	0.0647	0.0156	-0.0483	1
Regular servant	0.0371	0.0634	0.2173	0.152	0.1772	0.1716	0.0266	-0.0369	0.2076
Waste separation knowledge	-0.0288	0.0758	-0.0185	-0.0441	0.0606	0.0066	0.0624	-0.0313	0.2236
Home ownership	0.0154	0.3203	0.0894	0.0639	-0.0353	-0.0692	0.0722	-0.0718	0.0243
Garden size	-0.0807	0.1069	0.1665	0.1028	-0.0169	0.1202	0.1136	-0.033	0.0503
Access to public waste collection	0.0252	-0.1746	0.0943	0.0587	0.0977	0.0306	0.0344	0.0051	0.1374
Monthly private collection fees	-0.0261	-0.0475	-0.0056	0.0492	-0.0326	0.0012	0.0783	0.0517	0.0859
Livestock	-0.0064	0.208	-0.097	-0.0378	-0.0848	-0.0735	0.0372	-0.078	0.0264
Crops	-0.0289	0.1674	0.0176	-0.0831	0.0437	-0.0002	-0.0114	-0.0946	0.1193
Extension access	0.0253	0.0939	0.1309	0.078	0.1044	0.1856	0.0244	-0.0502	0.1809
Experience using waste	-0.0222	0.199	-0.0295	-0.1506	-0.0894	-0.1293	-0.0263	-0.0593	-0.0186
Safety risk training	-0.088	-0.0084	0.1882	0.0966	0.1293	0.0981	-0.0523	0.0625	0.2589
Experience in safety measures	0.0478	0.3969	-0.1158	-0.1136	-0.1308	-0.1318	-0.0517	-0.0783	0.106
Monthly per capita urban agriculture income	0.0612	0.0203	0.1947	0.1519	-0.0358	0.0185	0.063	-0.1318	0.2525
Monthly per capita disposable income	-0.0272	0.029	0.2185	0.2257	0.051	0.1352	-0.0007	-0.0582	0.1415
Monthly per capita agro-food waste generated	-0.0185	0.0218	0.0975	0.0812	0.0678	-0.0252	-0.0183	-0.0757	0.0773
Behavioural intentions	-0.0321	-0.0772	0.1029	0.0826	0.0916	0.1309	0.0245	0.0441	0.1306
Past behaviour	0.0218	0.0123	0.0073	-0.0128	0.0477	0.0204	0.0975	-0.0036	0.2172

	Regular servant	Waste separation knowledge	Home ownership	Garden size	Access to public waste collection	Monthly private collection fees	Livestock	Crops	Extension access
Regular servant	1								
Waste separation knowledge	0.0286	1							
Home ownership	-0.1395	0.0923	1						
Garden size	0.2076	-0.0223	0.067	1					
Access to public waste collection	0.0964	-0.0268	-0.339	-0.116	1				
Monthly private collection fees	0.0051	-0.0696	-0.0154	-0.0745	0.0644	1			
Livestock	-0.0809	0.2536	0.3495	0.0435	-0.2544	-0.061	1		
Crops	-0.0373	0.2309	0.2507	0.1762	-0.2209	-0.1554	0.263	1	
Extension access	0.2105	0.0799	0.0487	0.0162	0.1512	0.0118	0.0608	0.0736	1
Experience using waste	-0.0366	-0.0443	0.1589	0.03	-0.079	-0.0461	0.0671	0.1093	0.0123
Safety risk training	0.104	0.0314	0.0001	0.139	0.0536	0.0223	-0.1125	-0.0193	0.2233
Experience in safety measures	0.0289	0.0978	0.0773	0.1054	-0.0414	-0.009	0.0545	0.1983	0.0128
Monthly per capita urban agriculture income	0.273	-0.0244	0.0022	0.3534	0.0266	0.0338	-0.013	-0.0708	0.0684
Monthly per capita disposable income	0.2002	-0.082	-0.0111	0.5041	0.0368	0.0097	-0.0938	-0.1131	0.0769
Monthly per capita agro-food waste generated	0.092	-0.0678	0.052	0.0454	-0.042	0.0713	0.0774	-0.034	0.0749
Behavioural intentions	0.0773	0.2064	0.0277	-0.0088	-0.0626	-0.0123	0.0753	0.0752	0.0051
Past behaviour	0.0614	0.6271	0.0539	-0.0596	0.0196	-0.0478	0.1341	0.14	0.1922

	Experience using waste	Safety risk training	Experience in safety measures	Monthly per capita urban agriculture income	Monthly per capita disposable income	Monthly per capita agro-food waste generated	Behavioural intentions	Past behaviour
Experience using waste	1							
Safety risk training	-0.0239	1						
Experience in safety measures	0.2252	0.1524	1					
Monthly per capita urban agriculture income	0.0149	0.1613	-0.0031	1				
Monthly per capita disposable income	-0.0184	0.2496	0.0574	0.5937	1			
Monthly per capita agro-food waste generated	-0.0244	-0.0172	-0.0261	0.1568	0.1627	1		
Behavioural intentions	-0.1736	0.0259	-0.1079	-0.012	-0.0877	0.0197	1	
Past behaviour	-0.0451	0.0994	-0.0138	0.0565	-0.0748	0.0232	0.233	1

Summary of descriptive statistics for variables used in the study

Variable	Mean	Std. Dev.	Min	Max
Sex of head	0.29	0.45	0.00	1.00
Age of head	50.25	13.82	20.00	91.00
Education of head	12.63	4.34	0.00	26.00
Education of household woman	11.44	4.79	0.00	24.00
Employment of head	0.25	0.43	0.00	1.00
Household woman employment	0.17	0.38	0.00	1.00
Household size	4.82	2.46	1.00	20.00
≤5 years	0.54	0.82	0.00	6.00
Agriculture knowledge	3.31	0.99	1.00	5.00
Regular servant	0.28	0.45	0.00	1.00
Waste separation knowledge	3.34	1.45	1.00	5.00
Home ownership	0.86	0.35	0.00	1.00
Garden size	311.02	427.18	10.00	6,000.00
Access to public waste collection	0.09	0.29	0.00	1.00
Monthly private collection fees	222.76	61.53	55.00	850.00
Livestock	0.76	0.43	0.00	1.00
Crops	6.65	3.65	0.00	16.00
Extension access	0.28	0.45	0.00	1.00
Experience using waste	17.89	26.56	0.00	30.00
Safety risk training	0.14	0.35	0.00	1.00
Experience in safety measures	10.67	14.17	0.00	16.00
Monthly per capita agro-food waste generated	342.51	1,747.82	0.00	34,287.43
Monthly per capita urban agriculture income	9,483.90	24,644.95	233.33	306,000.00
Monthly per capita disposable income	4,499.22	10,087.45	2,150.28	154,888.90
Behavioural intentions	4.12	0.74	1.00	5.00
Past behaviour	2.59	0.71	1.00	5.00

The exchange rate at the time of the survey was KES107.70 = 1$USD

Appendix 3: Chapter Five

Constructs used in the SEM model

Variable	Mean	Standard deviation	Minimum	Maximum
Attitude	3.6826	0.4260	1.7143	4.8571
Subjective norm	3.3246	0.9989	1.0000	5.0000
Perceived behavioural control	3.3757	0.8901	1.6667	5.0000
Environmental awareness and concern	4.4531	0.5041	2.4000	5.0000
Moral obligation	4.1488	0.6203	1.1667	5.0000
Motivation	4.0031	0.7548	1.2000	5.0000
Commercial intentions	4.1201	0.7360	1.7500	5.0000
Commercial utilisation behaviour	2.5892	0.7145	1.0000	5.0000
Risk perceptions	2.3118	0.5612	1.1667	4.1667

Appendix 4: Chapter six

QUAIDS expenditure elasticities

Waste type/source	Elasticity	Standard error
Own household	1.0101**	0.0259
Other households	0.9697**	0.0394
Restaurants	0.4567**	0.1591
Agro-markets	0.9133**	0.0738
Processors	1.6565**	0.1031
Dumpsites	-0.4859*	0.2201

***significance at 5% and **significance at 1%**

Uncompensated elasticities: QUAIDS

Waste type/source	Own household	Other households	Restaurants	Agro-markets	Processors	Dumpsites
Own household	**-0.7116**(0.0557)**	0.0558(0.0567)	-0.0142(0.0434)	0.0277(0.0444)	-0.2213(0.0501)**	-0.1464(0.0287)**
Other households	0.0537(0.0422)	**-1.0602**(0.0750)**	-0.0657(0.0372)	-0.2249(0.0450)**	0.2568(0.0491)**	0.0705(0.0226)**
Restaurants	0.0736(0.2749)	-0.3565(0.3174)	**0.2208**(0.4631)*	-1.0276(0.2792)**	0.0869(0.3797)	0.5462(0.2644)*
Agro-markets	0.0826(0.0879)	-0.5630(0.1192)**	-0.3325(0.0866)**	**-0.1328**(0.1301)	-0.0396(0.1113)	0.0719(0.0524)
Processors	-0.7772(0.1307)**	0.6327(0.1738)**	-0.0203(0.1570)	-0.1568(0.1479)	**-1.9181**(0.2377)**	0.5832(0.1097)**
Dumpsites	-2.0158(0.4810)**	2.1729(0.5061)**	1.4955(0.6943)*	0.8177(0.4448)	3.8956(0.6960)**	**-5.8801**(0.9478)**

Elasticity (standard error); ***significance at 5% and **significance at 1%**

Compensated elasticities: QUAIDS

Waste type/source	Own household	Other households	Restaurants	Agro-markets	Processors	Dumpsites
Own household	**-0.4562**(0.0562)**	0.3971(0.0557)**	0.0257(0.0433)	0.1586(0.0445)**	-0.1247(0.0497)*	-0.1312(0.0287)**
Other households	0.2990(0.0415)**	**-0.7325**(0.0739)**	-0.0274(0.0370)	-0.0993(0.0448)*	0.3496(0.0486)**	0.0851(0.0226)**
Restaurants	0.1891(0.2758)	-0.2021(0.3152)	**0.2389**(0.4621)	-0.9685(0.2814)**	0.1305(0.3784)	0.5531(0.2643)*
Agro-markets	0.3136(0.0868)**	-0.2543(0.1169)*	-0.2964(0.0862)**	**-0.0146**(0.1308)	0.0478(0.1100)	0.0857(0.0524)
Processors	-0.3583(0.1310)**	1.1925(0.1711)**	0.0452(0.1567)	0.0578(0.1489)	**-1.7597**(0.2358)**	0.6082(0.1096)**
Dumpsites	-2.1386(0.4806)**	2.0087(0.5051)**	1.4763(0.6937)*	0.7547(0.4490)	3.8492(0.6956)**	**-5.8874**(0.9474)**

Elasticity (standard error); ***significance at 5% and **significance at 1%**

Descriptive statistics

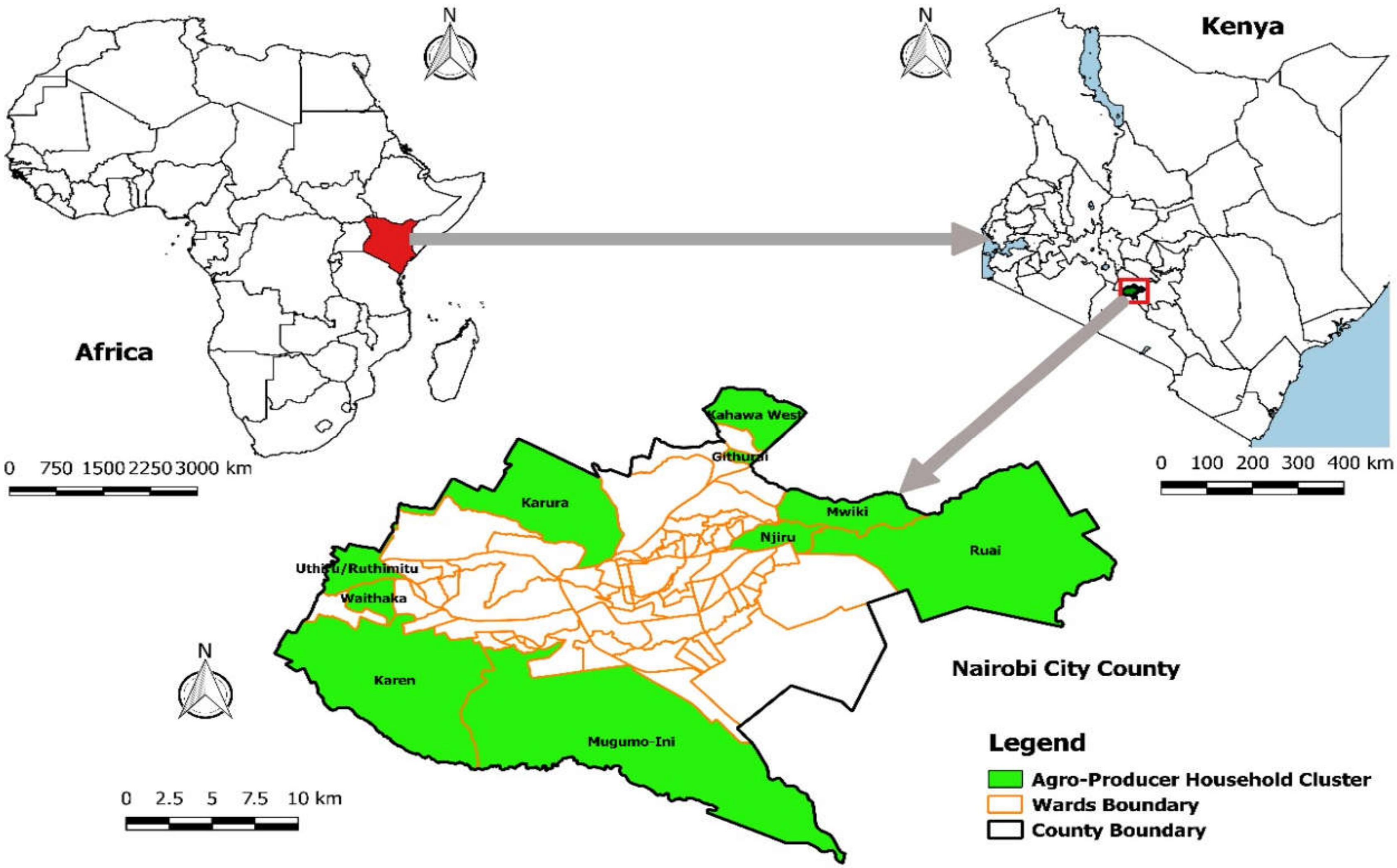
Variable	Mean	Std. Dev.	Min	Max
Own household price	7.43	11.76	0.20	135
Other household's price	6.16	11.47	0.13	100.00
Restaurant's price	5.73	11.78	0.44	60.00
Agro-markets price	8.11	8.71	0.20	60.87
Processor's price	3.59	4.90	0.42	33.00
Dumpsite price	2.77	2.61	0.63	11.54
Fertilizer price	79.37	22.82	50.00	120.00
Livestock feeds price	35.52	19.62	3.65	100.00
Fodder price	1.70	4,549.53	0.22	200.00
Monthly per capita own waste	342.51	1,747.82	0.00	34,287.43
Age of the household head	50.25	13.82	20.00	91.00
Education of the household head	12.63	4.34	0.00	26.00
Livestock production	0.76	0.43	0.00	1.00
Vegetable production	0.80	0.40	0.00	1.00
Monthly pc urban agricultural income	9,483.90	24,644.95	233.33	306,000.00
Transaction's cost	1,301.14	2,431.54	0.00	24,000.00

Sample cross-correlations

	Own waste price	Other household price	Restaurant price	Agro-market price	Processor price	Dumpsite price	Waste expenditure	Fertilizer price	Feed's price
Own waste price	1								
Other household price	0.3401	1							
Restaurant price	0.2506	0.1196	1						
Agro-market price	0.4837	0.0799	0.0759	1					
Processor price	0.3524	0.0714	0.0321	0.0497	1				
Dumpsite price	0.1494	0.009	-0.0005	-0.0451	-0.0063	1			
Waste expenditure	0.2611	0.2221	0.1576	0.1313	0.0223	0.0923	1		
Fertilizer price	0.0562	0.074	0.0733	-0.0336	-0.0227	0.1075	-0.0945	1	
Feed's price	-0.1632	-0.073	-0.0083	-0.0626	-0.1413	-0.0216	0.109	-0.0531	1
Fodder price	-0.0463	-0.0134	-0.0284	-0.0017	-0.0912	0.0356	0.2673	-0.0838	0.4348
Monthly per capita own waste	-0.0449	-0.0281	-0.0205	-0.0425	0.0031	-0.0055	0.282	0.0571	0.1871
Age of the household head	-0.0719	0.0001	-0.0502	-0.0109	-0.074	0.0068	0.0646	-0.0605	0.1305
Education of the household head	0.0378	0.0408	-0.0286	0.0468	-0.0002	-0.0034	0.1432	-0.0289	-0.0674
Livestock production	-0.1867	-0.1086	-0.0074	-0.0982	-0.1576	0.0009	0.0712	-0.1342	0.58
Vegetable production	-0.0176	0.0535	-0.0369	-0.0234	-0.1065	0.0625	-0.069	0.1094	0.0633
Monthly pc urban agricultural income	-0.0472	-0.0791	0.0003	-0.007	-0.0365	0.024	0.3458	-0.0757	0.0485
Transaction's cost	0.2071	0.0981	0.1323	0.2117	-0.0046	0.0659	0.1656	0.049	-0.256
Mills	0.0863	-0.2294	0.0746	0.4305	-0.3245	-0.1243	0.2517	-0.2307	0.1566

	Fodder price	Monthly per capita own waste	Age of the household head	Education of the household head	Livestock production	Vegetable production	Monthly pc urban agricultural income	Transaction's cost	Mills
Fodder price	1								
Monthly per capita own waste	0.1537	1							
Age of the household head	0.0846	0.0155	1						
Education of the household head	0.0644	0.1241	-0.1637	1					
Livestock production	0.4109	0.0733	0.2173	-0.0446	1				
Vegetable production	0.0657	0.0093	0.0665	-0.0189	0.1552	1			
Monthly pc urban agricultural income	0.2355	0.1383	-0.0727	0.1567	0.0434	-0.1085	1		
Transaction's cost	-0.2447	-0.3322	-0.1721	0.0449	-0.3358	-0.0534	-0.1226	1	
Mills	0.2303	-0.0016	0.0174	0.0244	0.1766	-0.3044	0.4439	0.2312	1

Appendix 5: Map of the study area



Appendix 6: Respondent's Informed Consent

My name is Charles Karani, a PhD student at Egerton University. I am inviting you to take part in the study titled "**Behavioural analysis in management and commercialisation of agro-food waste among urban agro-producer households in Kenya"**. The study aims at contributing to management and commercial utilisation of agro-food waste in urban (Nairobi) Kenya. Your participation will only be through your consent which may be immediately or later. You are also invited to make clarifications on anything that is not clear regarding this study.

The information provided will only be used for the purpose of this study and as such will be confidential. Your name will not be required in the study process and instead a number will be used to identify you. In case you are unsure or cannot be able to answer or interpret some questions, you will be allowed to seek assistance from a person of your choice or the enumerator who will be conducting the exercise. Your participation in the study will be for free and thereof you will not be paid.

You are guaranteed that all ethical considerations and approvals have been undertaken. For any questions regarding the authenticity of the research please contact the office below:

Board of Postgraduate Studies,
Egerton University, Njoro Campus,
P.O. BOX 536, Egerton, Kenya.
+254-051-2217891/2 or +254-051-2217781.

I……………………………………………………………………………… under my free will give consent to participate in the research being conducted by Mr. Charles Karani whose nature has been explained by him/his research assistant. After explanation regarding the aim of the study, I understand that my participation is on my free will.

……………………………………………………………………………….

Respondent's signature/thumb print

Date …………………………………… dd/mm/yy

Appendix 7: Questionnaire

Instructions: Using your smartphone, slide to the left in the Kobo Collect app to load the next page. Tick or fill appropriately.

1.0 General information

1.1 Research assistant identification number ______________________________

1.2 Date and time of the interview_______________________________________

1.3 Respondent's (urban agro-producer) serial number______________________

2.0 Household information

2.1 Name of the ward in which the household is located_____________________

2.2 Name of the neighbourhood____

2.3 General income status of the neighbourhood in which the household is located

- o Low income
- o Middle income
- o High income

2.4 What is the age of the household head? (Years)___________________________________

2.5 What is the sex of the household head?

- o Male
- o Female

2.6 What is the education level of the household head? (Schooling years) ________________

2.7 What is the education level of the wife of the household? (Schooling years)

____

2.8 Where was the household head brought up?

- o Rural area
- o Urban area

2.9 What is your household size? (Number of people) ________________________________

2.10 Number of children aged 0-5 years in the household? _____________________________

2.11 Number of people aged 70 years and above in the household? ____________________

2.12 What is your home ownership status?

- o Own
- o Rental

2.13 What is the religion of the household head?

- o Islam
- o Christianity

- Hinduism
- Africa Traditionalist
- Atheist
- Other

3.0 Urban agriculture information

3.1 What is the current total household garden(s) size? (Meter squares) __________________

3.2 During the last three (3) months, in which agri-enterprises has your household been involved in?

- Vegetables
- Fruits
- Legumes
- Cereals
- Tubers
- Fodder
- Livestock (cattle, sheep, goats, and donkeys) EXCEPT poultry
- Poultry
- Agro-forestry
- Tree and flower propagation
- Aquaculture

3.3 Garden size of vegetables (meter squares) ____

3.4 Garden size of fruits (meter squares) ____

3.5 Garden size of legumes (meter squares) ____

3.6 Garden size of cereals (meter squares) ____

3.7 Garden size of tubers (meter squares) ____

3.8 Garden size of fodder (meter squares) ____

3.9 Garden size of livestock (meter squares) ____

3.10 Garden size of agro-forestry (meter squares) ____________________________________

3.11 Garden size of tree and flower propagation (meter squares) ________________________

3.12 Garden size of aquaculture (meter squares) _____________________________________

3.13 What is the ownership status of the garden(s)?

- With legal documents
- Rental
- Public space
- Gifted to use

3.14 On a scale of 1-5 (1=very low & 5=very high), how would you rate your urban agriculture knowledge?

- Very low
- Low
- Moderate
- High
- Very high

3.15 Which type of agriculture do you practice?

- Organic or certified organic agriculture
- Conventional or non-organic agriculture
- Both conventional and certified organic agriculture

3.16 Does your household have access to agricultural extension services?

- Yes
- No

3.17 Is the household head a member of an agricultural group?

- Yes
- No

3.18 Does your household purchase urban produced agricultural products?

- Yes
- No

3.19 How often do you purchase urban produced agricultural products?

- Often
- Less often

3.20 How many hours (total) have servant(s) worked in your household for the last one (1) week? ____________________________

3.21 Do you have regular servant(s) in your household?

- Yes
- No

4.0 Production and marketing in urban agriculture

4.1 Do you normally plan when to harvest your produce?

- Yes
- No

4.2 Do you have guaranteed market for your produce?

- Yes
- No

4.3 How many times have you not been able to sell all produce harvested and availed to the market in the last three (3) months?

____

4.4 Among the agro-enterprises you have been involved in the last three months, from which ones have you sold some produce?

- Vegetables
- Fruits
- Legumes
- Cereals
- Tubers
- Fodder
- Livestock (cattle, sheep, goats, and donkeys) EXCEPT poultry
- Poultry
- Agro-forestry
- Tree and flower propagation
- Aquaculture

4.5 What is the estimated value of vegetable sales during the last 3 months? Ksh

____

4.6 What is the estimated value of fruit sales during the last 3 months? Ksh

____

4.7 What is the estimated value of legume sales during the last 3 months? Ksh

____

4.8 What is the estimated value of cereal sales during the last 3 months? Ksh

____

4.9 What is the estimated value of tuber sales during the last 3 months? Ksh

____

4.10 What is the estimated value of fodder sales during the last 3 months? Ksh

____

4.11 What is the estimated value of livestock sales during the last 3 months? Ksh

____

4.12 What is the estimated value of poultry sales during the last 3 months? Ksh

____

4.13 What is the estimated value of agro-forestry sales during the last 3 months? Ksh

____

4.14 What is the estimated value of tree and flower propagation sales during the last 3 months? Ksh ___________________

4.15 What is the estimated value of aquaculture sales during the last 3 months? Ksh

____

5.0 Agricultural waste

5.1 Have your household's crops been destroyed by weather, pest and or disease in the last three (3) months?

- o Yes
- o No

5.2 What was the resultant quantity (kg) of crop residue (waste) due to weather destruction?

____

5.3 What was the resultant quantity (kg) of crop residue (waste) due to pest destruction?

____

5.4 What was the resultant quantity (kg) of crop residue (waste) due to disease destruction?

____

5.5 What did you do with the crop residue (waste) arising from weather, pest and disease destruction?

- o Ploughed back/left in the garden
- o Fed to animals
- o Prepared compost
- o Given away and or sold
- o Disposed from the garden

5.6 Estimated quantity (kg) of crop waste that was ploughed back or left in the garden to rot

____

5.7 Estimated quantity (kg) of crop waste that was fed to animals _________________

5.8 Estimated quantity (kg) of crop waste that was used to prepare compost _______________

5.9 Estimated quantity (kg) of crop waste that was given away and or sold ______________

5.10 Estimated quantity (kg) of crop waste that was disposed from the garden ___________

6.0 Agricultural and food waste generation and management

6.1 How often do you plan when purchasing food?

- Regularly
- Rarely

6.2 Does your household buy food in large quantities?

- Yes
- No

6.3 How often does your household prepare more food than they need for one meal?

- Often
- Less often

6.4 Do you use a refrigerator for food storage in your household?

- Yes
- No

6.5 How many times does your household members eat away from home in a month?

____

6.6 Over the last two weeks (14 days), which agricultural and food waste typologies has your household generated?

- Inedible food waste
- Edible food waste
- Crop waste
- Animal waste

6.7 Total quantity (kg) of INEDIBLE food waste generated over the last 14 days ___________

6.8 Total quantity (kg) of EDIBLE food waste generated over the last 14 days ___________

6.9 Total quantity (kg) of crop residue waste generated over the last 14 days ___________

7.0 Total quantity (kg) of animal waste generated over the last 14 days ________________

7.1 Once you generate agricultural and food waste in your household, how do you get rid of it?

- Utilise
- Give away or sell
- Dispose

7.2 What is the value (Ksh) of agricultural and food waste that you have generated and utilised in the last 14 days? _______________

7.3 What is the value (Ksh) of agricultural and food waste that you have generated and given away and or sold in the last 14 days? _______________

7.4 What is your household's frequency of waste disposal per month? _______________

7.5 Do you use Nairobi City County (NCC) waste disposal services?

- o Yes
- o No

7.6 Generally, what is the frequency of waste collection per month by NCC? ___________

7.7 What is the distance from household's main door to the designated NCC waste pick-up point (km)? ________________

7.8 Do you use private waste collectors' services?

- o Yes
- o No

7.9 Generally, what is the frequency of private waste collection per month? _____________

7.10 Generally, how much do private collectors charge a household per month (Ksh)?

____

7.11 Distance from household's main door to the private waste collection site (km)?

____

7.12 Does your household do self-disposal of waste?

- o Yes
- o No

7.13 If your household do self-disposal of waste, how do you implement it?

- o To a pit/place within the compound
- o Take it to designated public disposal outside the compound
- o Throw it to non-designated dumpsites; roadside/riverbanks

7.14 Do you practise waste separation (sorting) in your household?

- o Yes
- o No

7.15 Have you attempted to reduce the amount of agricultural and food waste that you generate in your household?

- o Yes
- o No

7.16 If yes (above), how has your household attempted to reduce agricultural and food waste?

- o Planning when buying food

- Proper storage of food
- Eating all the food prepared
- Eating leftovers
- Preparing a common meal for children and adults
- Buying only what is needed at a time
- Mostly buying food with longer shelf life
- Proper crop management
- Training on urban agriculture

8.0 Household agricultural and food waste utilisation behaviour

On a scale of 1-5 {1= strongly disagree (very low or rare) and 5=strongly agree (very frequent)}; how would you rate your agreement to the following aspects?

8.1 I am interested in agricultural and food waste commercial utilisation

- Very low interest
- Low interest
- Somewhat interested
- Interest
- Very high interest

8.2 I think agricultural and food waste utilisation is cost friendly

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.3 Agricultural and food waste utilisation ought to be promoted

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.4 Agricultural and food waste utilisation is an appropriate way to manage solid waste in urban areas

- Strongly disagree

- Disagree
- Moderately agree
- Agree
- Strongly agree

8.5 When utilised properly agricultural and food waste is beneficial

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.6 Agricultural and food waste is unsafe for utilisation

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.7 The County government and landlords should be solely responsible for the management of agricultural and food waste

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.8 Most of the people I look up to in terms of values utilise agricultural and food waste

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.9 It is a common practise for people to utilise agricultural and food waste in urban agriculture

- Strongly disagree
- Disagree

- Moderately agree
- Agree
- Strongly agree

8.10 I have made it a routine to utilise agricultural and food waste upon generation

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.11 It is quite effortless for me to utilise agricultural and food waste

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.12 Inadequate knowledge makes agricultural and food waste utilisation very difficult for me

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.13 Agricultural and food waste has economic value

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.14 The little agricultural and food waste generated by every household if left unmanaged could potentially ruin the environmental quality

- Strongly disagree
- Disagree
- Moderately agree
- Agree

- Strongly agree

8.15 Failure to properly manage agricultural and food waste could contribute to negative health effects

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.16 I feel disgusted when I see or pass near agricultural and food waste that has been improperly disposed

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.17 I feel freshened and satisfied when my surroundings are clean

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.18 I feel guilty if I dispose off the agricultural and food waste without utilising it

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.19 I take it as my duty to utilise agricultural and food waste emanating from my household

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.20 I feel if every household was to utilise its agricultural and food waste, we would have a better environment

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.21 Everybody within a household has a role to play in managing agricultural and food waste especially through utilisation

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.22 My religion encourages prudent utilisation of resources

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.23 I usually feel at peace when I utilise waste beneficially

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.24 In my household, agricultural and food waste utilisation is a waste management strategy

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.25 By utilising agricultural and food waste we set a good example to others

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.26 Having had faced food inadequacy in the past I ensure that whenever agricultural and food waste is generated, I put it to good use

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.27 My household has some land space where we utilise agricultural and food waste

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.28 My household utilises agricultural and food waste as a cost-saving mechanism

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.29 I plan to utilise agricultural and food waste on a regular basis to manage waste emanating from my household

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.30 I plan to participate in waste management drives in my neighbourhood

- Strongly disagree

- Disagree
- Moderately agree
- Agree
- Strongly agree

8.31 I plan to encourage others to utilise agricultural and food waste to improve waste management

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.32 I intend to properly dispose off agricultural and food waste emanating from my household if am not able to use it

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.33 I always segregate agricultural and food waste before using it

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.34 I regularly utilise agricultural and food waste from my household

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.35 I regularly acquire agricultural and food waste from other sources for use in my household

- Strongly disagree

- Disagree
- Moderately agree
- Agree
- Strongly agree

8.36 I always ensure I disinfect agricultural and food waste before utilising it

- Strongly disagree
- Disagree
- Moderately agree
- Agree
- Strongly agree

8.37 I sometimes sell agricultural and food waste to others who can use it

- Very rarely
- Rarely
- Occasionally
- Frequently
- Very frequently

8.38 I sometimes give away agricultural and food waste to others who can use it

- Very rarely
- Rarely
- Occasionally
- Frequently
- Very frequently

9.0 External agricultural and food waste sourcing

9.1 From which sources did you acquire agricultural and food waste during the last 3 months?

- Other households
- Restaurants
- Agro-markets
- Processors/slaughterhouses
- Dumpsites
- None of the above

9.2 What is the quantity (kg) of agricultural and food waste acquired from other households during the last 3 months? ______________________

9.3 What is the average expenditure (ksh) incurred in acquisition of agricultural and food waste from other households during the last 3 months? ____________________________

9.4 What is the average distance (km) to the other households from where you have acquired agricultural and food waste in the last 3 months? ___________________________

9.5 What is the total transport cost for agricultural and food waste acquired from other households during the last 3 months? _________________________________

9.6 What is the quantity (kg) of agricultural and food waste acquired from restaurants during the last 3 months? ____

9.7 What is the average expenditure (ksh) incurred in acquisition of agricultural and food waste from restaurants during the last 3 months? _________________________________

9.8 What is the average distance (km) to the restaurants from where you have acquired agricultural and food waste in the last 3 months? ________________________________

9.9 What is the total transport cost for agricultural and food waste acquired from restaurants during the last 3 months? ____

9.10 What is the quantity (kg) of agricultural and food waste acquired from agro-markets during the last 3 months? ____

9.11 What is the average expenditure (ksh) incurred in acquisition of agricultural and food waste from agro-markets during the last 3 months? ______________________________

9.12 What is the average distance (km) to the agro-markets from where you have acquired agricultural and food waste in the last 3 months? ________________________________

9.13 What is the total transport cost for agricultural and food waste acquired from agro-markets during the last 3 months? ____

9.14 What is the quantity (kg) of agricultural and food waste acquired from industrial/processors during the last 3 months? ________________________________

9.15 What is the average expenditure (ksh) incurred in acquisition of agricultural and food waste from industrial/processors during the last 3 months? _________________________

9.16 What is the average distance (km) to the industrial/processors from where you have acquired agricultural and food waste in the last 3 months? _________________________

9.17 What is the total transport cost for agricultural and food waste acquired from industrial/processors during the last 3 months? ___________________________________

9.18 What is the quantity (kg) of agricultural and food waste acquired from dumpsite(s) during the last 3 months? ____

9.19 What is the average expenditure (ksh) incurred in acquisition of agricultural and food waste from dumpsites during the last 3 months? ___________________________________

9.20 What is the average distance (km) to the dumpsites from where you have acquired agricultural and food waste in the last 3 months? ___________________________________

9.21 What is the total transport cost for agricultural and food waste acquired from dumpsites during the last 3 months? ____

10.0 Agricultural and food waste usage in enterprises

10.1 What quantity of agricultural and food waste (kg) has your household used in the vegetable's enterprise during the last 3 months? ___________________________________

10.2 What is the estimated value of agricultural and food waste (ksh) that your household has used in the vegetable's enterprise during the last 3 months? ___________________________

10.3 What quantity of agricultural and food waste (kg) has your household used in the fruit's enterprise during the last 3 months? ____

10.4 What is the estimated value of agricultural and food waste (ksh) that your household used in the fruit's enterprise during the last 3 months? _________________________________

10.5 What quantity of agricultural and food waste (kg) has your household used in the legume's enterprise during the last 3 months?

____

10.6 What is the estimated value of agricultural and food waste (ksh) that your household used in the legume's enterprise during the last 3 months? _______________________________

10.7 What quantity of agricultural and food waste (kg) has your household used in the cereal's enterprise during the last 3 months? ____

10.8 What is the estimated value of agricultural and food waste (ksh) that your household used in the cereal's enterprise during the last 3 months? _________________________________

10.9 What quantity of agricultural and food waste (kg) has your household used in the tuber's enterprise during the last 3 months? ____

10.10 What is the estimated value of agricultural and food waste (ksh) that your household used in the tuber's enterprise during the last 3 months? ______________________________

10.11 What quantity of agricultural and food waste (kg) has your household used in the fodder enterprise during the last 3 months? ____

10.12 What is the estimated value of agricultural and food waste (ksh) that your household used in the fodder enterprise during the last 3 months? ______________________________

10.13 What quantity of agricultural and food waste (kg) has your household used in the livestock enterprise during the last 3 months? ____________________________________

10.14 What is the estimated value of agricultural and food waste (ksh) that your household used in the livestock enterprise during the last 3 months? ___________________________

10.15 What quantity of agricultural and food waste (kg) has your household used in the agro-forestry enterprise during the last 3 months? _____________________________________

10.16 What is the estimated value of agricultural and food waste (ksh) that your household used in the agro-forestry enterprise during the last 3 months? ________________________

10.17 What quantity of agricultural and food waste (kg) has your household used in the tree and flower propagation enterprise during the last 3 months? _________________________

10.18 What is the estimated value of agricultural and food waste (ksh) that your household used in the tree and flower propagation enterprise during the last 3 months? ____________

10.19 What quantity of agricultural and food waste (kg) has your household used in the aquaculture enterprise during the last 3 months? __________________________

10.20 What is the estimated value of agricultural and food waste (ksh) that your household used in the aquaculture enterprise during the last 3 months? ______________________

11.0 Other inputs usage (other than agricultural and food waste)

11.1 Other than agricultural and food waste and labour, which other inputs have you acquired during the last three (3) months for use in the market-oriented enterprises?

- o Inorganic fertilizer
- o Pesticides
- o Livestock commercial feeds
- o Livestock fodder
- o Livestock drugs
- o Veterinary services
- o None of the above (if they practice organic agriculture)

11.2 What is the quantity of fertilizer (kg) purchased by the household during the last 3 months

____

11.3 What is the expenditure on fertilizer (ksh) for the last 3 months

____

11.4 What is the quantity of pesticides (kg or L) purchased by the household during the last 3 months ________________________

11.5 What is the expenditure on pesticides (ksh) for the last 3 months

____

11.6 What is the quantity of livestock commercial feeds (kg) purchased by the household during the last 3 months _______________________________

11.7 What is the expenditure on livestock commercial feeds (ksh) for the last 3 months

____

11.8 What is the quantity of livestock fodder (kg) purchased by the household during the last 3 months ________________________________

11.9 What is the expenditure on livestock fodder (ksh) for the last 3 months

____

11.10 What is the quantity of livestock drugs (kg) purchased by the household during the last 3 months ___________________________

11.11 What is the expenditure on livestock drugs (ksh) for the last 3 months ______________

11.12 What is the expenditure on veterinary services (ksh) for the last 3 months ___________

11.13 What is the estimated household labour input usage (total man days) in the CROPS enterprises over the last three (3) months? ________________________

11.14 What is the estimated household labour input usage (total man days) in the LIVESTOCK enterprises over the last three (3) months? ________________________

11.15 What is the average labour cost per man day (ksh) in crop activities? _____________

11.16 What is the average labour cost per man day (ksh) in livestock activities? __________

12.0 Agricultural and food waste safety risk management

12.1 For how long has your household been using agricultural and food waste in urban agriculture? (years)___________________________

12.2 During the time your household has been using agricultural and food waste in urban agriculture, what risk issues have you identified and associated with agricultural and food waste utilisation?

- Pathogens, pests and diseases
- Injurious elements (glass, wire, plastics etc.)
- Health (and poisoning) risk
- Death and or investment loss
- Pollution (soil, water and air)
- Costly treatment of the affected

12.3 From your experience using agro-food waste what is the estimated level of pests and pathogen risk?

- Very low
- Low
- Moderate
- High
- Very high

12.4 From your experience using agro-food waste what is the estimated level of injurious elements risk?

- Very low
- Low
- Moderate
- High
- Very high

12.5 From your experience using agro-food waste what is the estimated level of health and poisoning risk?

- Very low
- Low
- Moderate
- High
- Very high

12.6 From your experience using agro-food waste what is the estimated level of death and or investment loss risk?

- Very low
- Low
- Moderate
- High
- Very high

12.7 From your experience using agro-food waste what is the estimated level of pollution risk?

- Very low
- Low
- Moderate
- High

- Very high

12.8 From your experience using agro-food waste what is the estimated level of costly treatment of the affected risk?

- Very low
- Low
- Moderate
- High
- Very high

12.9 Has any member of the household been trained in agricultural and food waste safety risk management?

- Yes
- No

12.10 In order to ensure safety while utilising agricultural and food waste generated within your household and or acquired from other sources, what safety risk management practises have you adopted?

- Sorting/segregation
- Cleaning (using water)
- Heat treatment (drying, cooking or boiling)
- Composting
- Mixing with common salt, minerals or other feeds
- Specific sourcing (habit of acquiring from one or a few sources where either one or all the above safety practices are practiced)

12.11 What is the household's average experience (years) in practising agricultural and food waste safety risk management? ____________________________

13.0 Household income

13.1 How much did your household spend on consumption (ksh) during the last 3 months?

____

13.2 How much did your household spend on school fees (ksh) during the last 3 months?

____

13.3 How much did your household spend on health (ksh) during the last 3 months?

____

13.4 How much did your household spend on rent (ksh) during the last 3 months?

____

13.5 How much did your household spend on energy (ksh) during the last 3 months?

____

13.6 How much did your household spend on clothing (ksh) during the last 3 months?

____

13.7 How much did your household spend on servant wages (ksh) during the last 3 months?

____

13.8 How much did your household spend on gifts/contributions (ksh) during the last 3 months? ________________

13.9 How much did your household spend on entertainment (ksh) during the last 3 months?

____

13.10 How much did your household spend on individuals transport (ksh) during the last 3 months? ____________________

13.11 How much did your household incur on OTHER expenses? _______________

13.12 How much did your household save (ksh) during the last 3 months? ____________

13.13 What is the household head employment status? _____________________

13.14 What is the woman of the household employment status? ____________________

14.0 Other details (observe where necessary)

14.1 Dis-aggregated agri-enterprises that the household has been involved in during the last 3 months?

____

____

____

14.2 GPS location of the household ____

THANK YOU FOR YOUR TIME

Appendix 8: Key informant interviews guide

1. Type of outlet/actor……………………………………………………….
2. What typologies of agro-food waste do you commonly generate/collect on a weekly basis?

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3. Do you reuse, recycle or recover the agro-food waste that you generate/collect? How?

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4. Describe how you manage the agro-food waste generated/collected?

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5. Who are the main beneficiaries of the agro-food waste that you generate/collect?

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6. In case you sell the agro-food waste typologies generated/collected, how do you do it?

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7. How would you describe the demand of agro-food waste that you generate/collect?

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8. What is your experience in the food industry? What has been the trend of agro-food waste utilisation over the period you have been in operation?

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9. What safety concerns are associated with the agro-food waste you generate/collect?

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10. For the agro-food waste that you generate or collect, how would you rate its usability safety?

a. As animal feed

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b. As fertilizer

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11. On average, what time does it take for agro-food waste to be picked from the time it is generated? Does it contribute to safety concerns?

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12. How do you treat agro-food waste that you generate/collect before giving out, selling or utilising?

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13. What safety practices would you recommend for users of the agro-food waste that you generate/collect?…………………………………………………………

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14. What strategies would you recommend for management of agro-food waste generated/collected by other agro-food waste supply chain actors?

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15. How can the agro-food waste that you generate/collect be used in commercializing urban agriculture?

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16. How can the agro-food waste acquisition and utilisation be formalized in urban areas?

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17. Any other relevant information on agro-food waste?

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Thank you for your response

Appendix 9: Research permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **566769**

Date of Issue: **19/March/2020**

RESEARCH LICENSE

This is to Certify that Mr.. charles Gichimu karani of Egerton University, has been licensed to conduct research in Nairobi on the topic: Behavioural analysis in management and commercialization of agro-food waste among urban agro-producer households in Kenya for the period ending : 19/March/2021.

License No: **NACOSTI/P/20/4406**

566769

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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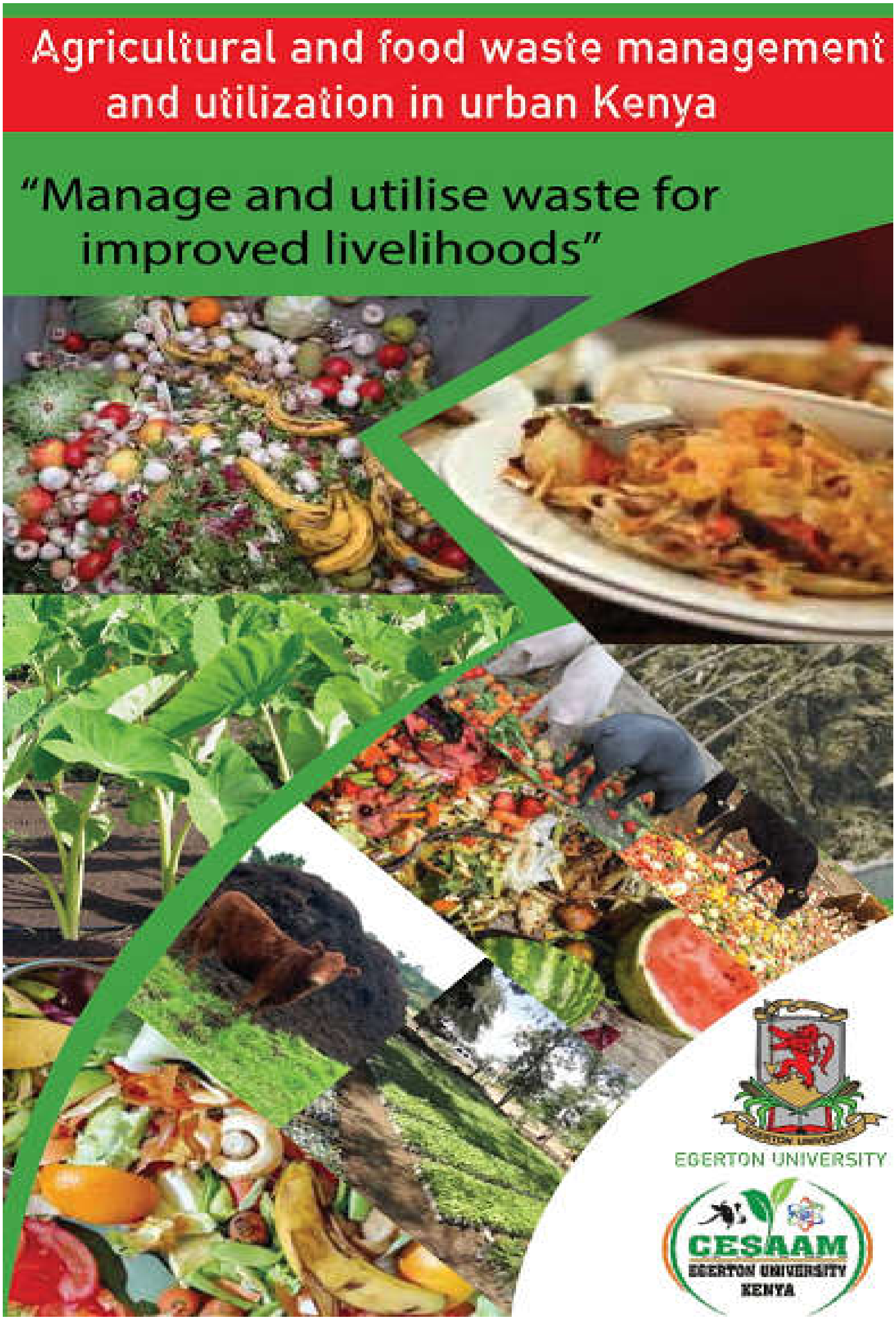
Appendix 10: Agro-food waste brochure



Agricultural and food waste management and utilization in urban Kenya

Agricultural Waste refers to waste resulting from operations such as production, distribution and processing of raw materials from agriculture, forestly and fishery resources. For instance, manure and slaughterhouses waste, animal carcasses , crop waste due to weather, pests and diseases, harvest waste etc.

Food waste encompass food that is acquired for human consumption but drawn out from the food supply chain with the intention of disposal or for recovery and may include edible and inedible parts of food. For instance, it arises through spoilage, discarding food, uneaten left overs food that stick on cooking pans, and and parts of food that are generally considered as inedible.

Waste as a resource: 'One man's waste is another man's wealth'

Most often waste has been considered to be useless but economically it presents lost time, effort and other productive resources. Increasingly there is a shift from considering waste as a problem to waste as a resource across the world

Management and utilization of agricultural and food waste

What is the current urban agriculture status?

What types of agricultural and food waste are generated in urban agro-producer households?

How do urban agro-producers manage agricultural and food waste emanating from their households and that which they acquire from external sources?

Do agro-producers use agricultural and food waste in production?

Is safety risk an issue in agricultural and food waste management and utilization?

What influences the behaviour of agro-producers in agricultural and food waste utilisation?

What determines the demand for agricultural and food waste in urban agriculture?

Appendix 11: List of publications

Journal of Agricultural Economics and Rural Development

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AJAE 1

Research Article

What Drives Generation of Agro-Food Waste Typologies among Urban Agro-Producer Households? Insights from a Developing Country

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[2]School of Agricultural Sciences and Agribusiness, Pwani University, Kenya

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The aim of this study was to evaluate the drivers of agro-food waste typologies generation among urban agro-producer households in Kenya. To accomplish this, an electronically-structured questionnaire was administered to 456 agro-producer households to collect disaggregated self-reported data. Descriptive and Fractional Response models were employed for data analysis. The results revealed significant disparities of waste generation profiles among livestock and mixed agro-producers; age of the household head, number of enterprises, inability to sell produce frequency, home ownership and market guarantee. The daily per capita food waste generated was 0.67kg while the daily per capita agricultural waste was 10.75kg. The regression results indicated both socioeconomic (age and number of enterprises) and behavioural attributes (perceived behavioural control and attitude) were among the most important drivers in agro-food waste typologies generation. Number of mature agri-enterprises were consistently the highest contributor of predicted marginal changes in agricultural, food, edible, inedible, crop and animal waste portions generated among urban households. Results implied that agricultural education and behavioural interventions meant to foster enterprise specialization and adoption of effective methodologies in exploitation of benefits associated with agro-food waste meant to support the urban food system are urgently required. Findings could instil micro-level self-awareness in generation and self-regulation in management of agro-food waste for betterment of the urban agroecology.

Keywords: *Agro-food waste, Fractional response, marginal changes, short-run, self-awareness, self-regulation*

INTRODUCTION

Waste generation is on the rise globally (Elks, 2018; Kaza *et al.*, 2018). Estimates indicate that 2.01 billion tonnes of solid waste was generated in 2016. The quantity is expected to grow by 70 percent to 3.40 billion tonnes by 2050, accelerated by population growth and urbanization (Kaza *et al.*, 2018). Waste generated globally emanate from households, restaurants, shops, healthcare outlets, offices, academic institutions, industries and markets among others. Whereas literature does not expressly indicate the contribution of waste generated globally from each of these sources, households are potentially the major contributors. Quantities and typologies of waste differ from one household, neighbourhood, region or nation to another (UN, 2000). This being the case, then understanding and prediction of typologies and quantities of waste that households generate is crucial in devising effective management practises (Kumar and Samadder, 2017).

Across the globe, the overall and urban areas daily per capita waste generated is estimated to be 0.46(0.74)[1], 0.52(1.5), 1.18(1.28), 2.21(3.13), and 0.81(1.38) kg in sub-

[1] Figures in parentheses represent the daily per capita waste in urban areas for respective regions

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

ORIGINAL RESEARCH PAPER

Management and safety practices in utilization of agro-food waste among urban agro-producer households

C. Karani[1,2,*], E. Gido[1], H. Bett[1]

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Self-management
Urban agriculture
Waste utilization

ABSTRACT

BACKGROUND AND OBJECTIVES: Whereas management of waste in urban areas across the globe is essentially a public service, there is dearth of knowledge on waste management efforts at the household level in developing countries. The study aimed to avail crucial information on the largely informal management of agro-food waste that is practiced in low- and lower middle-income countries. Insights of safety measures adopted in the utilization of agro-food waste among urban agro-producers were explored empirically.
METHODS: An electronically-structured questionnaire was administered on a sample of 456 urban agro-producer households for data collection. Descriptive as well as Multivariate Probit models were employed for analysis.
FINDINGS: The results indicated significant disparities in management options and safety risk management practices between the participating and non-participating livestock and mixed producers. Waste reduction (86%), utilization (86%), segregation (63%) and composting (58%) were the most preferred waste management practices. Waste disposal (18%) and mixing with salt/dry feeds (24%) were lowly preferred methods. Whereas the regression models showed disparities in the contextual factors influencing management options and safety risk measures, the knowledge variables (waste sorting and urban agriculture knowledge) had greater influence across these agro-food waste aspects. This implies that implementation of education programs in agro-food waste management and safety risk management practices among urban agro-producer households by urban authorities would enhance sustainable food safety in urban food supply chains.
CONCLUSION: The findings could inform self-management efforts of agro-food waste in small-urban agribusinesses thus increasing economic benefits and improving environmental wellbeing.

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NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
77	1	4

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Note: Discussion period for this manuscript open until January 1, 2022 on IJHCUM website at the "Show Article.