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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]

[1]*Department of Agricultural Economics and Agribusiness Management, Egerton University, Kenya*

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

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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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*Corresponding Author:
Email: *karani.char@gmail.com*
Phone: +254 725 916 145
Fax: +2541 7522128

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INTRODUCTION

Environmental and health-related risks make management of waste an issue of global concern (Wilson *et al.*, 2015; Ferronato and Torreta, 2019). Perhaps in order to make its management efficient, waste is generally handled as a public service component (Beigl *et al.*, 2008; Abrate *et al.*, 2014). However, this has not translated to admirable results in 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 and 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 inefficiency. In cases where city authorities are unable to address waste issues in a feasible way, they contract private service providers; 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 privatize 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 *et al.* (2006) and Zohoori and Ghani (2017), urban centers of developing countries face the same municipal solid waste problems; illegal dumping, limited services, non-structured neighborhoods 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 practices 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 (World Energy Council, 2016; Dubbeling *et al.*, 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 utilization of waste in urban agriculture have often been preferred. 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 worth of resources concealed in waste (Menyuka *et al.*, 2020).

Waste management options

In Bahir Dar City, Ethiopia, Wegedie (2018) established that households' waste management practices included burning, burying and or dumping generated waste within their compounds. Dumping waste in undesignated places such as roadsides, river banks, and or vacant lands was also common. Some household adopted these practices notwithstanding that they received local authority services but were either considered undependable or inefficient. Notably, some households utilized waste for composting and as animal feed. Similarly, Brown (2015) indicated that in Tanzania, households managed waste through improper disposal (throwing along roads and drainage channels), designated place within their compounds, taking to public landfill, and/or handing to waste collectors. In Ghana, Adu-boahen *et al.* (2014) findings on waste management practices study indicated that burning was the most prominent choice although recycling and burying were practiced to a lesser extent. Waste management

practices in Kenya were found to be similar to those in Ethiopia, Ghana and Tanzania, where dumping was dominant though reuse, recycling and burning were practiced (Nthambi, 2013). Afroz *et al.* (2011) and Nigussie *et al.* (2015) brought in a perspective of selling agro-food waste as a management practice. 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 practices. Mu'azu *et al.* (2018) in their study 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 utilization 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 under 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 neighborhoods. In this regard, Knussen *et al.* (2004) indicated that past behavior was crucial in waste handling. 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. From another perspective, Kim et al. (2000) cited the role of women in food waste management in Korean society. Zakianis and Djaja (2017); Hellwig *et al.* (2019) and Loan *et al.* (2019) findings indicated the importance of knowledge in waste management. 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. However, Ali and Song (2016) indicated that knowledge does not necessarily contribute to concern in waste management. Similarly, Alemayehu *et al.* (2017) cited rampant unauthorized dumping of waste in Ethiopia. Almost three-quarters of households practiced improper waste disposal. Guerrero et al. (2013) argued that provision of waste management information to residents may translate to improved waste recycling. 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. The findings indicated that gender, education level, marital status, residential neighborhood, household earnings and access to permitted dumpsite (distance) were significant factors in choice of good and poor management practices. Furthermore, Gutiérrez-macías et al., (2015); Bakshi *et al*. (2016); Truong *et al.* (2019) associated the low cost appeal for agro-food waste with its choice as an input. 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 utilization 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 aspect 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.

Safety risk management practices

Literature shows that waste management practices can help to mitigate the likely negative effects of waste or possibly amplify them (Mamady, 2016). It was also evident that in utilization 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 practices at source have been minimal in most developing countries' waste management systems (Ferronato and Torreta, 2019; Kassaye, 2018). However, where practiced 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, and 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 behavior (hygiene, proper disposal and child care) 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 behavior although Ashenmiller (2006) and Basev (2016) indicated mixed findings in regard to income effect in waste management. Likewise, past studies have expressed agro-food waste safety risk concerns especially in their utilization 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 practice 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 using waste as animal feed but chopping, drying, ensiling, mineral and common salt mixing can be employed as risk management practices. 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 utilization. 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 practices on food waste such as cooking, mixing garbage with grains and forage. Likewise, Haapapuro *et al.* (1997) indicated that there were likely health risks associated with using food waste on both livestock and humans. Drechsel *et al.* (2015) stresses the need for nutrient recovery in organic waste utilization in urban agriculture and in the process managing the likely safety risk of waste. Alike, Sabiiti (2011) delved on utilization 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. Sánchez-bascones *et al*. (2008) and Gamroth (2012) identified livestock waste as a composting catalyst in crop residue. Waste segregation, composting and energy generation from agro-food waste were identified as critical in safety risk management (Saravanan *et al.*, 2013; Mamady, 2016; Jouhara *et al.*, 2017; Kassaye, 2018; Mu'azu *et al.*, 2018; Wegedie, 2018; Ferronato and Torreta, 2019). Whereas addressing safety risk issues in the utilization of agro-food waste may contribute to improved food safety in the urban food supply chain, the assessment of choice of safety risk management practices is remarkably scarce in literature. In Nairobi, Kenya, over 2,400 tons of waste are generated daily. About 30-40 percent of the waste

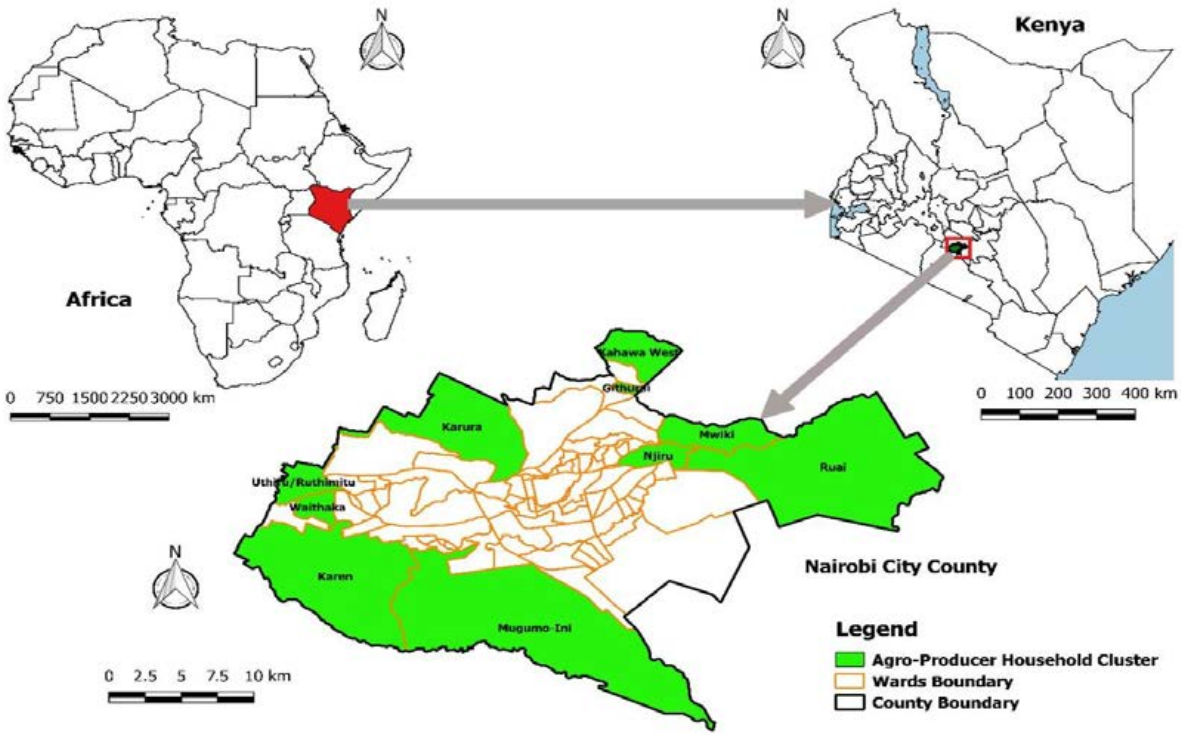

Fig. 1: Geographic location of the study area, Nairobi City County in Kenya

is not collected since only about 50 percent of urban population are served with waste collection services (NEMA, 2015; Kaza *et al.*, 2018). 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 management efforts at the household level, although it is limited (Karanja *et al.*, 2010; FAO, 2012). 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 from elsewhere. The findings of the study would be of interest to urban center 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 commercialization 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. For this study, agro-food waste refers to agricultural and food waste. The agro-food waste typologies considered for this study included food, livestock and crop waste generated by households, restaurants, markets and processors as well as waste recovered from dumpsites in urban areas. The current study was carried out in Nairobi City County in 2020.

MATERIALS AND METHODS

Study area

The study was conducted in Nairobi City County (Fig. 1), 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, 2014 (RoK, 2014). The area is an important center for agricultural trade (local, imports and exports), processing, distribution and consumption thereby contributing to the amount of agro-food waste generated. 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, 2019) compared to other major Kenya's urban areas, the area was projected to portray a higher diversity of agro-food waste management practices.

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 products and sold some or all of it during the three months preceding the survey and (c) freely consented to participate in the survey. Agro-producer refers to a household producing agricultural products (and selling a portion of the produced products) in Nairobi City County. 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. Although a smaller sample size of 356 had been estimated, a sample of 456 was used 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 centered 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 designed in the Kobo Humanitarian platform under KoBoToolbox was implemented in the KoBoCollect 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 in order 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 inform potential respondents on their rights regarding their involvement in the study and subsequently consent to participate was obtained. The data collected were downloaded from KoBoToolbox in Microsoft Excel and exported to Stata 15 for cleaning and analysis.

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, utilizing, giving out or selling, and disposing. In managing agro-food waste through utilization, 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 utilization. In literature, a common practice in choice of waste management practices has been the assumption

of mutually exclusiveness of waste management alternatives where Multinomial Logit (MNL) has been applied (Launio *et al.*, 2014; Nthambi, 2013; Molem and Enjema, 2017). 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 and 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 and 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/practice 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.

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/practices. The choice set could be made up of several management alternatives. Considering each agro-producer household can choose one or more management option/practice, then $k=(Y_1,Y_2,Y_3,\ldots Y_n)$ depending on the choice set constitution. From this, the net benefit for the i^{th} household was as depicted in Eq. 1.

$$Y_{ik}^{*}=U_{k}^{*}-U_{0}>0 \quad (1)$$

Where Y_{ik}^{*} 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 using Eq. 2 in which the unobserved choices are in a binary outcome (adopted = 1 or otherwise = 0) form for each of the management option/practice choices;

$$Y_i=\begin{cases}1 if\ Y_{ik}^{*}>0\\ 0 otherwise\end{cases} K=Y_1,Y_2,Y_3,Y_4 \quad (2)$$

Where, $Y_i\ is$ the management option and K is options/practices choice set. Eq. 3 is a system of j equations which can be expressed as (Dessie *et al.*, 2018);

$$Y_{ik}^{*}=X_i^{'}\beta_k+\mathcal{E}_i \quad (3)$$

Therefore, the anticipated agro-food waste general management options (choice set) were coded as waste reduction Y_1), utilize Y_2) give out or sell Y_3) and or dispose Y_4). The MVP model for the choice of agro-food waste management options are portrayed by Eq. 4, Eq. 5, 6 and 7.

Where β_k is a range of parameters to be estimated, $X_i^{'}$ are contextual and Extended Theory of Planned Behaviour construct variables, and $\mathcal{E}_i$ is the disturbance term. Given Eq. 3, the choice of individual household agro-food waste management options/practices can be presented as;

$$\text{Waste reduction} \quad Y_{1i}^{*}=X_{1i}^{'}\beta_1+\mathcal{E}_{1i} \quad (4)$$

$$\text{Utilise} \quad Y_{2i}^{*}=X_{2i}^{'}\beta_2+\mathcal{E}_{2i} \quad (5)$$

$$\text{Give out or sell} \quad Y_{3i}^{*}=X_{3i}^{'}\beta_3+\mathcal{E}_{3i} \quad (6)$$

$$\text{Dispose} \quad Y_{4i}^{*}=X_{4i}^{'}\beta_4+\mathcal{E}_{4i} \quad (7)$$

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 $\mathcal{E}_i$ is the error term with a multivariate normal distribution $\left[MVN \sim (0,\Omega)\right]$ with a mean of zero and respective variance-covariance matrix V using Eq. 8. The values of V are one on the leading diagonal and correlations that is $p_{11}, p_{22}, \ldots, p_{66} = 1$ (Rodríguez-Entrena and Arriaza, 2013; Tarekegn *et al.*, 2017; Dessie *et al.*, 2018).

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

Where, p is probability.

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. Similar to 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 similar to those of safety risk practices with a slight difference on the number of equations and the variance-covariance matrix. These are specified as Eqs. 9, 10, 11, 12, 13, 14 and 15.

Segregation / sorting $$Y_{1i}^{*} = X_{1i}^{'}\beta_1 + \mathcal{E}_{1i} \quad (9)$$

Cleaning $$Y_{2i}^{*} = X_{2i}^{'}\beta_2 + \mathcal{E}_{2i} \quad (10)$$

Heating $$Y_{3i}^{*} = X_{3i}^{'}\beta_3 + \mathcal{E}_{3i} \quad (11)$$

Composting $$Y_{4i}^{*} = X_{4i}^{'}\beta_4 + \mathcal{E}_{4i} \quad (12)$$

Mixing $$Y_{5i}^{*} = X_{5i}^{'}\beta_5 + \mathcal{E}_{5i} \quad (13)$$

Specific sourcing $$Y_{6i}^{*} = X_{6i}^{'}\beta_6 + \mathcal{E}_{6i} \quad (14)$$

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

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. Likewise, post estimation tests that included Wald chi-square and Likelihood ratio tests were conducted as shown in Tables 3 and 4.

Descriptive analysis

The descriptive results 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 Table 2. The chi-square (χ^2) results showed that utilization of agro-food waste between crop production participants and non-participants were significantly different at p≤0.05.

Participants and non-participants in livestock production had significant differences in the choice of waste reduction, utilization and disposing at p≤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, utilizing and giving out than non-mixed producers. Proportion wise, this implies that urban agro-producers were more likely to adopt waste reduction, utilization and giving/selling agro-food waste upon generation than disposing but preferred waste reduction and utilization. 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 2 indicate that segregation and composting of waste were the most preferred safety risk management measures. Comparatively, heat treatment and mixing

Table 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)

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 from agro-food waste utilization. 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 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≤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

Table2: Percentage choice of agro-food waste management options and safety risk management practices

N=456		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	
Utilize	85.53	85.71	0	5.92*	93.35	60.91	70.97**	93.44	66.91	54.25**
Do not utilize	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**
No specific sourcing	67.32	67.25	100		70.81	56.36		72.50	55.15	

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

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

Variables	Waste reduction	Utilize	Giving out/sell	Dispose
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
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)
Constant	-4.9228(2.6069)	-0.7489(2.5276)	0.3354(1.9872)	-0.7997(2.1582)
N=456; 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				

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

households would have been biased (Tarekegn *et al*., 2017; Dessie *et al.,* 2018). Therefore, the null hypothesis that ρ (rho) values = 0 was rejected. This confirms the appropriateness of the MVP model for the study. The MVP model results (Table 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 in regard to 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. Further, Secondi *et al*. (2015) established that women were likely to waste more food than men. Contrary, Barr (2007) revealed that women were associated with higher likelihood of reducing waste. 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 findings concurred with Brown (2015) that knowledge is critical in waste management. The behavioural intention towards utilization of waste had an inverse effect in adopting waste reduction. This imply that urban agro-producer households' intentions to utilize 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 that 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, utilization, giving out/selling, and disposing. More knowledge in waste sorting in households was likely to increase waste reduction and utilization but reduced the likelihood of giving out/selling and disposing. In other words, agro-producer households that practiced waste sorting were more likely to utilize 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 contradict 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 utilize waste generated in their households. Probably, these materials were used to feed on their animals in an effort 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 utilization. The choice may be in favour of alternative agricultural inputs especially when agro-food waste was associated with filth and likely risks of its utilization. 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 utilized 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 utilization of agro-food waste was a likely hindrance in its adoption as a waste management option. Past perceived challenges associated with agro-food waste utilization may have had a stake in forming present behaviour. Therefore, where minimal or no utilization of agro-food waste had been practiced in the past it would have likely contributed to lesser utilization 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 utilization 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 and as such inclined towards utilizing 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

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

Variables	Segregation	Cleaning	Heating	Composting	Mixing	Specific sourcing
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
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)**
Constant	-1.7247(0.6462)	-2.9937(0.6054)	-3.0343(0.6427)	-0.9837(0.5025)	-2.5921(0.6689)	-0.3418(0.5102)
N=456; 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						

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

implies that the more positive the past behaviour in utilizing waste, the higher the likelihood for the agro-producers to give out/sell the waste generated. Probably, this indicates that experience gained in utilizing 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 Gutierrez-macias *et al.* (2015); Bakshi *et al.* (2016) 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.

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

The MVP model (Table 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 null hypothesis that the ρ (rho) values = 0 was 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. 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 utilize 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 increase in 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 utilization. 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 this study's significance of waste separation knowledge. Increased access to agricultural extension services among agro-producer households enhanced adoption of segregation and specific sourcing management strategies in utilization 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. By limiting the sources of waste, agro-producers may have minimized the likely sources of risk. This implies that through extension advice, agents may encourage limiting of agro-food waste sourcing to contain likely pathogens and disease factors. 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 utilization 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) under 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 Westendorf et al. (1996) and Haapapuro *et al*. (1997), 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. Sanchez-bascones *et al.* (2008) and Gamroth (2012) 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 feed portions. The findings were similar to Rivin *et al.* (2014) and Bakshi *et al.* (2016) recommendations in mixing dry feeds and common salt in utilization of agro-food waste to manage moisture and contaminants respectively. The findings concurred with Saravanan *et al.* (2013); Mamady, (2016); Jouhara *et al.*, (2017); Kassaye, (2018); Mu'azu *et al.*, (2018); Wegedie, (2018); and Ferronato and Torreta, (2019) that waste management contributes to safety risk mitigation. Adoption of cleaning, heating and mixing practices were likely to rise with increased experience in implementing safety risk measures while utilizing agro-food waste. Accumulated

experience in utilizing 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 commercialization 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 utilization 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 waste users a platform to clean it which reduced the likelihood of causing nuisance on others. This may also imply that non-home owners 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, higher 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 with livestock production, this implies that it is an appealing practice in addressing their susceptible nature to pests and pathogens. Past behaviour of agro-producers in utilization of waste was associated with lesser 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 utilization inclination thus were not vigilant 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.

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. Requisite methods of analysis were employed to reveal the differences, similarities, associations and implications of agro-food waste management. Findings from the study indicated that management options and safety risk management practices varied between the participating and non-participating crop, livestock and mixed categories of producers but were more pronounced among the livestock and mixed production groups. The adoption of utilization and disposal options as well as segregation, cleaning, heat treatment, composting, mixing of waste with salt and feeds, and specific sourcing management practices were significantly different among participating and non-participating households in both livestock and mixed production systems. Reduction and utilization of agro-food waste were the most preferred management options at 86% adoption while segregation (63%) and composting (58%) were the preferred safety risk management practises. These results implied that these management aspects could be enhanced as avenues for promoting sustainable agro-food waste management in urban areas. The results further revealed that contextual factors for choice of agro-food waste management options differed but waste sorting knowledge of agro-producer households was largely a common factor. Similarly, variations in the

determinants of choice of safety risk management practices were recorded but urban agriculture and waste sorting knowhow had a cross-cutting effect. This implied that knowledge and awareness were 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 utilized by small-urban farm business practicing households. A further implication is that although waste management is generally a public service, self-management may be a fairly 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. As such enhanced self-management of agro-food waste would propel safety issues in urban agriculture at the household level.

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 utilization would avail critical knowledge into the limelight.

AUTHOR CONTRIBUTIONS

C. Karani performed the literature review, research design, analyzed and interpreted the data, prepared the manuscript text and edited it. E. Gido and H. Bett were the academic supervisors for this study.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

ABBREVIATIONS

CESAAM	Centre of Excellence for Sustainable Agriculture and Agribusiness Management
Eq	Equation
FAO	Food and Agriculture Organization of the United Nations
KES	Kenya shillings
KNBS	Kenya National Bureau of Statistics
LR	Likelihood Ratio
MNL	Multinomial Logit
MVN	Multivariate Normal Distribution
MVP	Multivariate Probit
NEMA	National Environment Management Authority
N	Sample Size
NACOSTI	National Commission for Science, Technology and Innovation
p	Probability
ROK	Republic of Kenya
SE	Standard Error
SIANI	Swedish Agricultural Network Initiative
χ^2	Chi-square

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