Original Paper

Improving household waste management through a door-to-door collection in Ruaka Town, Kenya

Sylvester Ngome Chisika, Chunho Yeom

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Correspondence: Chunho Yeom, e-mail: chunhoy7@uos.ac.kr

Extended author information available on the last page of the article

Keywords: citizen participation; door-to-door waste collection; financial constraints; sustainable development; technology; willingness to pay.

Abstract. *This study explores ways of improving household waste collection in urban areas through a door-to-door waste collection system in Ruaka town, Kenya, by comparing the collection practices between households served by door-to-door waste collection and those without it. Literature review, random sampling technique with semi-structured questionnaires, and direct observation were used. The case results confirm that door-to-door solid waste collection at households has the capacity to induce positive behavioural changes towards sustainability at waste generation points. Waste separation and recycling, which accompanies this system, can help improve revenue streams in the waste management value chain, which may help to plug the waste financing gap facing many governments. However, the study notes that in Ruaka town, the current practice of door-to-door waste collection is unsustainable and could reinforce inequality amongst users seeking to access waste collection facilities. Apart from more household surveys to document the correlation between individual household demographic attributes and effectiveness of door-to-door waste collection, the study calls for developing robust regulations for door-to-door service, increased citizen participation in waste management matters, including the need for waste separation at the source to measure the system's maximum impact.*

1. Introduction

The dual existence of urban areas as centers for economic growth and innovation as well as hotspots for waste accumulation and pollution continues to challenge and bemuse city planners and environmentalists alike. The concept of sustainable development, which requires a balance between the social, economic, and environmental aspects of human development, forces many cities to navigate the problems and paradoxes facing sustainable urban development. Sustainable

development aims to integrate environmental conservation and economic objectives following the commencement of large-scale industrialization and urbanization experienced in the 21st-century. These aims involve key action points necessary to realize sustainable consumption and production practices that reduce the accumulation of waste and pollution as envisaged under Sustainable Development Goal 12.

All over the world, the challenge of accumulated municipal solid waste (MSW) deposits is an indication of societal lifestyle and how well solid waste management (SWM) practices and production technologies are performing (Roberts, 2010). In some societies, development has led to stagnation due to inadequate waste management policies, leading to the proliferation of disease, environmental degradation, and loss of livelihoods (UN, 2020). It is, therefore, considered imperative for developing countries to rethink policies and practices that could enhance sustainable development. Effective solid waste management policies should be 'good,' sound, and aimed at improving service delivery for people. Sound policy management involves defining public participation and giving people a voice (UN-Habitat, 2016).

In contrast, ineffective or 'bad' policy management could impose heavy social and public administrative burdens on citizens (UN-Habitat, 2014). It has been established that in many developing countries, these 'policy failures' are attributed to the highly segmented nature of some environmental policies, including those that govern solid waste. In addition, the complex application context driven by unclear technical objectives sometimes considered in isolation affects the effectiveness of policies (UN-Habitat, 2016). Consequently, there are growing criticisms that sustainable development policies have somehow led to negative impacts on solid waste management because the threat of waste accumulation appears to be real and threatens to continue, increasing to unsustainable levels with the growing urban population (Hoornweg and Bhada-Tata, 2012; UN Habitat, 2014; UN Habitat, 2012). If the status quo remains, many environmental and biological systems could be disrupted, thus distorting the balance between the various components of sustainable development (Roberts, 2010).

The door-to-door management of household solid waste is increasingly being promoted as a feasible method for promoting sustainable development in developing countries by improving the management of household wastes. This household-level waste management approach is increasingly being promoted since it induces behavioural changes at waste generation points in the long term (Laurieri et al., 2020). A typical door-to-door system of solid waste collection entails vehicles visiting specific waste collection points following a precise schedule as wastes

are collected (Laurieri et al., 2020). Remarkable achievements have been realised with this practice since both the demand and supply sides of waste generation are targeted during implementation (Hoornweg and Bhada-Tata, 2012; UN-Habitat, 2014). In addition, this approach increases the participation of users in the sorting and collection of household wastes (Laurieri et al., 2020; Ibanez et al., 2018; European Commission, 2015).

In general, there is a need to further explore the door-to-door waste collection system across regions and countries in order to document and share experiences on how to improve it and hence the need for this study. Existing literature shows various methods can be used to improve the door-to-door solid waste collection system. But, with inreasing budgetary constraints on governments, there is a growing tendency towards improving solid waste management by imploring citizens to contribute a portion of their income towards sustainable solid waste management. The contingent valuation method has thus gained popularity amongst policymakers and scientists interested in the sustainable management of solid waste because of its application in gauging people's attitudes towards waste. It has proven particularly useful when implemented alone or jointly with other valuation techniques for non-market goods, such as the travel cost method or hedonic approaches. However, it remains the only technique that is capable of placing a value on commodities that have a large non-use component of value and when the environmental improvements to be valued are outside the range of available data. The goal of contingent valuation is to measure the compensating or equivalent variation for good in question.

Other household demographic features have been found to have different influences on solid waste management. For instance, household education, age, and homeownership have a significant influence on the decision to pay and the amount to be paid by a household targeted by a waste improvement project (Banga et al., 2011; Coaffey and Coad, 2015). However, in general, individuals in high-income groups tend to generate more waste at a much higher rate (Zia et al., 2017). Education and knowledge levels on the health impacts of waste have positive impacts on waste management, whereas income was a decisive economic factor of knowledge and attitudes (Seng et al., 2018). Illegal dumping of waste was higher in communities with low employment rates (Matsumoto and Takeuchi, 2011). Knowledge, attitudes, and people's practices of people affect solid waste management (Kiran et al., 2015). Income level, age, number of children, a quantity of waste generated have an influence on solid waste management by households (Awunyo-Victor et al., 2013).

Kenya is also experiencing the challenges of unsustainable solid waste accumulation due to rising urbanization, rapid population growth, and limited budgetary allocation for waste management. However, unlike other parts of the world, urbanization in Kenya has attracted a large population both of informal settlement dwellers and the middle class. Moreover, increasing affluence has increased waste generation and the complexity of waste streams. In attempts to remedy the waste situation in the country and embrace the concept of sustainability, Kenya's environmental policy on waste management highlights that the government will develop an integrated national waste management strategy and promote the use of economic incentives to manage waste (Mutiso, 1994). To this end, following the Earth Summit on sustainable development, Kenya initiated the National Environment Action Plan (NEAP), which was completed in 1994. The NEAP recommended a national policy on laws pertaining to the environment. The policy-making process culminated in 1999, with Sessional Paper No. 6 entitled 'Environment and Development.' In the same year, the legislative process produced the Environmental Management and Coordination Act (EMCA) No. 8 of 1999, which was Kenya's first framework environmental law implemented by a state corporation under the Ministry of Environment called the National Environment Management Authority (NEMA). Both the sessional paper and the act added to a large number of existing sectoral laws and policies on various facets of the environment, such as water, forest, and minerals. It has created a diffuse system of environmental laws and policies to achieve sustainable development as set out in Kenya's development blueprint, Vision 2030. Other national environmental management reforms included developing a task force report, The National Solid Waste Management Strategy, prepared by the National Environmental Management Authority (NEMA) in February 2015, whose aim was to apply the 'zero-waste' principle and recommend methods for creating wealth and employment and reducing environmental pollution while satisfying the minimum conditions for waste generation, collection, transportation, and disposal based on statistics from five fast-growing urban areas in Kenya, namely Kisumu, Thika, Eldoret, Nakuru, and Mombasa. Interestingly, even with these policy reforms and the devolved governance that followed the implementation of the 2010 constitution, many challenges that faced the previous waste management regimes still persist.

Nonetheless, urban residents appear to be shifting focus towards implementing variants of the door-to-door waste collection system, including in Ruaka, a rapidly urbanizing satellite town in the outskirts of Nairobi City County, the capital of Kenya. Waste management is carried out by both the County Government of Kiambu, which has distributed mixed waste collection bins in certain locations

of the residential town, and private waste handlers who are currently providing a form of door-to-door waste collection service. The private waste handlers provide waste bags to tenants (Kiambu County CIDP 2018-2022). Once the bags are full, the tenants deposit them in large waste boxes located outside their apartments from where the private waste handlers load them on lorries for transportation to the dumpsite. Even though door-to-door waste collection appears to be serving the purpose, there is limited information on how it could be improved for maximum societal benefits (Kiambu County CIDP 2018-2022). Moreover, there are limited studies on residents' perception and participation in a door-to-door waste collection system. As such, this study seeks to apply qualitative research approaches to explore ways of improving the current door-to-door household solid waste collection in Ruaka town in order to draw lessons for a wide array of stakeholders on the future of household solid waste management. In order to respond to these research needs, this paper will first review the concept of solid waste management from the theoretical perspective of sustainable development. Secondly, using primary data collected by simple random sampling of households, a comparison will be made for individuals who receive door-to-door waste collection services and those who do not in order to formulate the practical implications of the system. Ruaka town is a particularly suitable study site because it represents one of the rapidly urbanizing areas in the outskirts of Nairobi City County, which is currently characterised by increased production and consumption and infrastructural development. It will be important to investigate whether the rapid growth in Ruaka town is accompanied by an attendant growth and development in sustainable waste management systems.

2. Materials and methods

2.1 Study area: Ruaka town in the outskirts of Nairobi City

Ruaka is located approximately 12 km from the city center of Nairobi and is named after the Ruaka River. The name 'Ruaka' is derived from the local language meaning a place where 'women used to bathe.' The land was once owned communally. During colonial times, the people were regrouped into villages. The first village was in Ruaka shopping center, where the people worked on the white settlers' coffee farms. Some shops were built in the current Ruaka shopping center. The land was subdivided into private plots on which most people practiced agriculture as the main source of livelihood. Urbanization has slowly caused land-use changes, and thus people have been developing residential and commercial shelters (Kiambu County Integrated Development Plan 2018-2022).

According to the KNBS (2009) census, the population of the larger Karuri area in which Ruaka is located stood at 129,000 in 2009, which is a 41.7% increase from the figure in the 1999 census (Cytonn Investment Website, 2020). KNBS (2009) projected that by 2025, the population would be 176,191, an annual population growth of 1.97%. Ruaka's population comprises both local middle-income earners and foreign residents and is a real estate investment satellite town. The town is close to Nairobi's central business district and has two prime commercial retail developments in its vicinity, namely Two Rivers Mall and Rosslyn Riviera Mall. The area's high immigration rate results in a high population growth rate. In turn, this has led to very high demand for housing. Among other reasons, the two main incentives for people to move to this area are cheaper housing compared to other major urban areas and the search for employment, (Cytonn website, 2020). It will thus be interesting to investigate how a door to door waste management is being practiced given these seemingly rapid socio-economic developments in Ruaka town.

2.2 Study design

The current household door-to-door solid waste collection practices in Ruaka town were evaluated in terms of sustainable development by comparing respondents' answers from two waste generation groups, those served by a door-to-door waste collection service and those who do not have such a service, identified by the random sampling technique. Simple random sampling (SRS) is a sample selection method comprising n number of sampling units out of the population and having N number of sampling units, such that every sampling unit has an equal chance of being chosen. SRS was chosen as the most appropriate study design because it is cost-effective, easy to use, and it is normally used to accurately represent a larger population, such as the one in Ruaka satellite town. It was used to select a sample of 166 respondents from a population of 129,000 people with a 92.25% confidence level. Caution was exercised to ensure that all respondents came from different households in the study area.

$$n_{smallest} = \frac{n_e}{1 + \frac{n_e}{N}}$$

If N is large, then the required n is $n \geq n_e$ and $n_{smallest} = n_e$.

This was calculated as follows:

$$n = \frac{129{,}000}{1 + 129{,}000(0.0775)^2}$$

2.3 Data collection

In this study, both primary and secondary data were collected in order to respond to the research questions. Primary qualitative data were collected using a household survey questionnaire (Appendix 1). The survey questionnaire covered three thematic areas (i.e., the demographic characteristics of respondents, the current status of door-to-door household solid waste management, and how the door-to-door solid waste collection could be improved). The survey questionnaire was initially pre-tested on ten respondents. The pre-test was important because there was a need to guarantee the quality of responses from the study given the diversity of the surveyed respondents, especially in terms of differences in education levels. After verifying the quality of the responses, the survey questionnaire was revised and administered as the principal tool for collecting primary data. Up to five research assistants were trained on the objectives of the study as well as how to administer the data collection tool. Both English and Kiswahili, which are widely spoken by residents, were used as the medium of communication.

In addition, observation was used to record some of the daily events that the research assistants witnessed during the course of this study. Observation entailed walking through the town and observing how individuals were disposing of their wastes. Through observation and note-taking, photographic data was also collected to show the different practices in waste collection and management. The data obtained was then passed on to the principal researchers for further processing.

There was no need to develop an ethical checklist for this study because it did not involve the extraction of samples on humans or animals, nor did it introduce foreign materials into the country. Moreover, during the data collection process, the research assistants walked through the town and interviewed respondents in the place where they met them during the day. Data collection was challenging due to the current COVID-19 pandemic, which required observing stringent rules such as social and physical distancing as well as the wearing of face masks whenever in public space. In addition, some respondents were not willing to participate in the study because of a lack of cash incentives, and some were uncomfortable with the question relating to weekly income due to the suspicion that such information could be used against them during the fulfillment of statutory tax obligations. However, in order to reduce this suspicion and eliminate

potential legal issues about people's private information, the surveys were conducted anonymously.

Secondary data were collected through a review of the literature, office visits, and desktop searches on official websites. The key documents reviewed are summarized in Table 1.

No.	Document	Key Information	Source
1.	National Environment Action Plan 1994	The key proposed activities, policies, plans, and programmes for sustainable solid waste management	National Environment Management Authority (NEMA)Website
2.	Environment Management and Coordination Act, 1999	Enforcement of policies and programmes for solid waste management	Kenya Law Reporting Website
3.	Constitution of Kenya 2010	The overarching policy provisions on the right to a clean and healthy environment	
4.	Vision 2030	Kenya's development aspirations on becoming a middle-income economy by 2030	Vision 2030 Website
5.	National Environment Policy 2013	Policy provisions on sustainable solid waste management	Climate Laws Website
6.	National Solid Waste Management Strategy 2015	Information on household waste generation per capita for Ruaka town and Nairobi city county	National Environment Management Authority (NEMA)Website
7.	National Waste Regulations of 2006	Directives and rules for handling wastes	National Environment Management Authority (NEMA)Website
8.	Kiambu County Integrated Development Plan, 2018-2022	Context information about Ruaka town	Kiambu County Government Website

Table 1. Key documents Reviewed

2.4 Data analysis

The quantitative aspects of both primary and secondary data were elaborated using a Microsoft Excel spreadsheet, as shown in Appendix 2 and 3, both for with and without door-to-door service. Data were cleaned and sorted then used for statistical analyses and to create the visualizations used in this study, including tables and bar charts. Furthermore, since the reviewed literature indicated a correlation between income levels and waste generation per capita, this study conducted a correlation analysis (r) for the two categories of households investigated

to compare case study results with the literature. Particularly noteworthy was the considerable difference in the door-to-door waste collection between individuals with low incomes and high incomes. The income comparison was based on Kenya's taxable income threshold of US$ 300, where earners whose monthly income was less than US$ 300 are exempted from the 30% monthly income tax.

3. Results

3.1 Respondent characteristics and influence on door-to-door waste collection

In total, 166 survey questionnaires were distributed, out of which 102 were received back. This represents 61% of the target respondents. The survey indicates that there is a marked difference in demographic attributes between households with door-to-door waste collection services and those without them. In terms of gender, results from Figure 1 indicate there were marginally more male respondents (37) with door-to-door waste collection services than female respondents (32). This may signify a relatively equal level of awareness or consciousness on the issue of solid waste management amongst residents of Ruaka town. More female respondents (19) were without the door-to-door service compared to male respondents (14). This outcome may be attributed to the existing income and employment inequalities between men and women in the town.

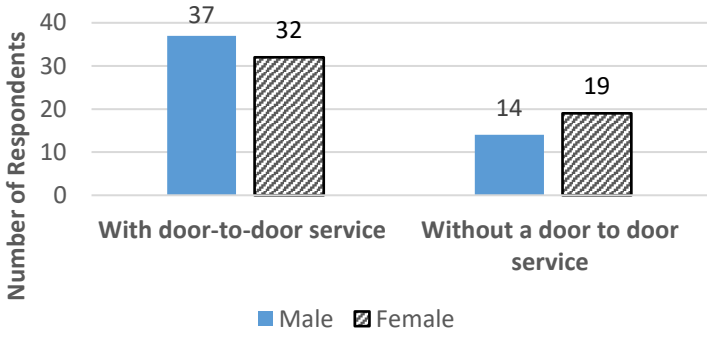

Figure 1. Gender and waste collection category.

There were more respondents in the age bracket 29-39 years (34) with door-to-door service compared to 16 without door-to-door service (Figure 2). Ruaka town is populated by a relatively young population whose members appear to be more conscious about solid waste issues.

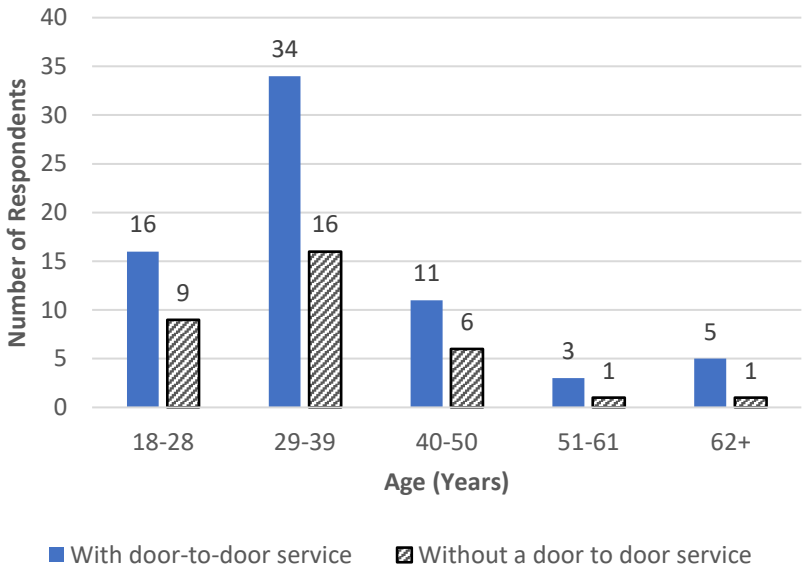

Figure 2. Age and waste collection category

There are more respondents (30) with a secondary level of education currently receiving door-to-door service compared to 11 with a secondary level of education without door-to-door service (Figure 3). This outcome implies a good proportion of households with an education level that is likely to contribute to their understanding of the impacts of an improper solid waste management system.

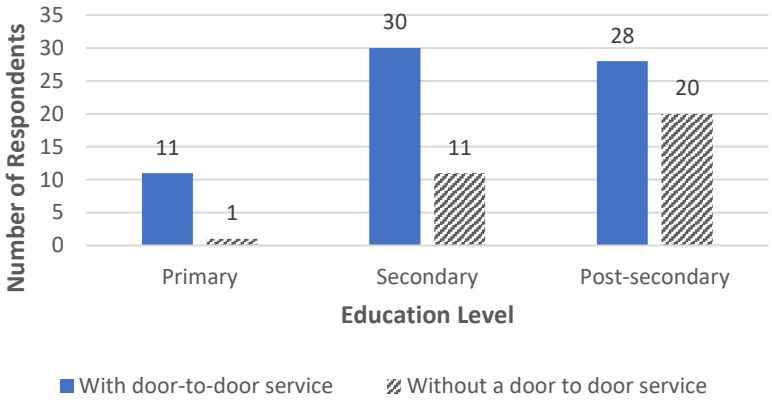

Figure 3. Education and waste collection category

There were more respondents (50) earning a monthly income of more than US$ 300 compared to 13 in the category without a door-to-door service earning the same amount of income (Figure 4). This outcome indicates there may be a high likelihood of finding individuals with a good portion of disposable income who could contribute a portion of their income towards improving the current waste collection system in Ruaka town.

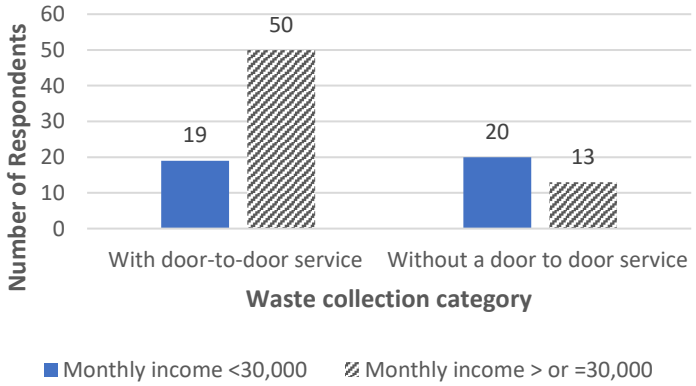

Figure 4. Income and waste collection category

In terms of family size, there were 65 respondents with family size of 1-4 members compared to 29 without a door-to-door service but with similar family size (Figure 5).

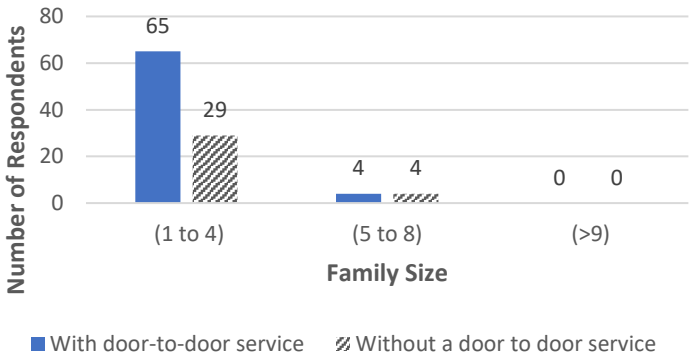

Figure 5. Family size and waste collection category

There were 27 respondents in self-employment in the category with door-to-door service compared with 9 in the category without. Similarly, there were 27 respondents in private employment with door-to-door service compared to 14 in the category without the service, as shown in Figure 6. Since private and self-employment are closely related and could be grouped as private employment, it could be concluded that most Ruaka residents are privately employed.

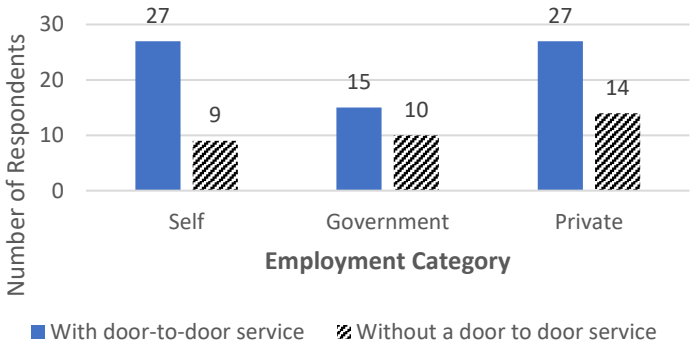

Figure 6. Employment and waste collection category

3.2 The current status of door-to-door household solid waste collection

3.2.1 Waste generation characteristics

Weekly household waste by residents of Ruaka is composed of four major ingredients: food waste, electronic waste, paper, and plastic. Food waste and paper dominate waste generation and composition among residents with a door-to-door waste collection service and those without it, as shown in Figure 7. However, there is more food waste (76%) among residents with door-to-door collection than those without it (46%), as shown in Figure 7. For both categories of study respondents, paper constitutes the second highest waste product by proportion. Paper and food waste together constitute up to 90% of the waste that is generated by respondents with a door-to-door waste collection service. For those without the service, paper and food waste constitute about 82%. On average, those with door-to-door service generate 1.94 kg of waste per day, while those without it produce approximately 1.86 kg per day.

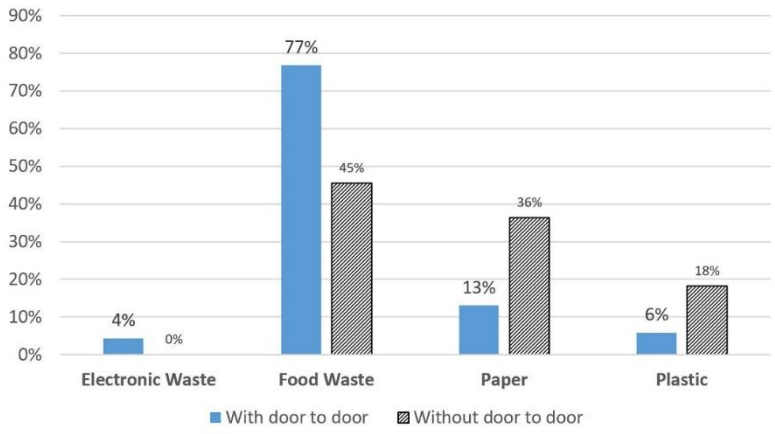

Figure 7. Waste generation per week

Moreover, the correlation (r) between monthly income and waste generated per week indicates a weak positive association (0.05665) amongst respondents with door-to-door service. In contrast, the correlation is relatively strong and positive (0.328866) amongst residents without a door-to-door service for waste collection. Nonetheless, 63 out of 102 surveyed respondents have a monthly income greater than or equal to Kshs. 30,000 (US$ 300).

3.2.2 Door-to-door Household Waste collection

Waste collection from households in Ruaka town is largely similar for both residents with door-to-door and those without it. Waste collection from tenants with door-to-door service is organized so that the landlord contracts a private waste collection service provider who, in turn, provides waste collection bags to households. These waste bags are distributed to tenants with door-to-door service twice per month or at the landlord's discretion and timing in some cases. The size of the waste bag is 'standard' for all households and measures approximately 60-liters (Figure 8). Waste from those with door-to-door service is collectively dumped into the waste bag without being sorted or separated into various constituents. Once the waste bag is full, it is tied at the top or sometimes never tied, and the tenant with door-to-door service deposits it into a concrete waste box in front of the apartment. However, sometimes, if the landlord or his agent has locked the waste box, the tenant with door-to-door service usually leaves the waste on top of or adjacent to the concrete waste box. In some cases, especially where the waste boxes are left open, both human and animal scavengers (ravens, wild cats, and stray dogs) often get into the boxes and may dig and spill the contents out of the waste box.

There is no regulation that limits the size of waste bags, the size of concrete waste boxes, or the number of waste containers. If needed, all tenants can easily buy the readily available extra containers from mobile merchants who roam and sell waste containers around residential areas in order to accommodate more waste. When the extra mixed-waste containers are full, tenants are free to buy more, or they can decide to take the waste into the concrete waste boxes or leave them beside the concrete box if it is full. Most apartments are not fitted with electronic lifts or the opportunities for such technological upgrades, so tenants who live on higher floors have to walk down the narrow winding stairs to take their waste to the concrete box outside the apartment building. This becomes challenging for people living with physical disabilities, the sick, and the elderly who have to contract another person to carry their wastes to the concrete box at an extra cost. For tenants who receive door-to-door collection service, the cost of waste bags is included in the monthly rent payment. The waste collection fee varies, but it is typically Kshs. 250 (US$ 2.5) or below.

Figure 8. A standard waste bag from a private waste collection service provider.

For those households that receive door-to-door waste collection service, once the waste collection bag is ready for disposal, the residents must take it out and dump it into one of the concrete waste boxes located at the gates of most residential apartments. There are various waste box designs; some have lids that can be locked (Figure 9), and others are lidless (Figure 10). Similar facilities are available for those without door-to-door service in some apartment buildings.

Figure 9. A waste box with a lid mostly found in relatively high-income neighborhoods.

Figure 10. A waste box without a lid found in relatively low-income neighborhoods.

3.2.3 Waste transportation to the dumpsite

In some cases, garbage collectors walk around the neighbourhood with a drum or a cart, collecting trash from each household, especially in relatively low-income neighbourhoods. Still, mostly, the trash that is placed in waste boxes is collected monthly by private waste collection trucks for a fee, which is normally paid by the landlord. There are other collectors who simply take the trash away in the plastic bags that individual households provide for waste disposal.

After collection, all trash is brought to the nearest collection point. In addition to County government workers, certain CBOs and informal garbage collectors also provide waste collection services. It costs around US$ 1 per day to rent a cart, and the availability of this option makes it more convenient for households to dispose of their waste, especially in low-income areas. However, the garbage collectors have to deal with poor working conditions, which involve certain health risks. Most collectors, including those who work for Kiambu County and private companies, were observed not wearing any protective gear, such as gloves and masks.

There are certain residential areas that are neglected in that they do not receive any service from Kiambu County. Residents who are excluded in this way are likely to solicit private services, while others who are not able to afford that alternative must manage their waste personally. Often, illegal dumping sites arise when such residents accumulate their waste in a particular spot before setting it all on fire after a few days of storage. In some cases, once a tenant realizes that their waste composition is paper or plastic, they burn it beside the concrete box. Sometimes, smoke billowing from burning waste finds its way into the homes of nearby tenants and other neighbours thus exposing many people to environmental and health risks.

3.3 Improving door-to-door solid waste collection system

Results appear to indicate that surveyed residents would like to improve the current door-to-door system of waste management in Ruaka town, albeit with a few differences between those with door-to-door service and those without. Amongst study respondents with door-to-door waste collection, 40 out of 69 expressed their willingness to pay for an improved service. In contrast, 24 out of 33 among those without the service were willing to pay for improved waste collection, as shown in Table 2 below. In total, 64 respondents from both categories are willing to pay for improved waste collection. It represents approximately 60% of all study respondents. Moreover, 36 respondents indicate that they are willing to pay more than US$ 3 for improvements to the current waste collection service in Ruaka satellite town, as shown in Table 2.

Door to door collection	**The maximum amount (Kshs.)**			
	<100	200~300	>300	Total
Yes	0	17	23	40
No	0	11	13	24

Table 1. WTP Willingness to pay results

4. Discussion

Many developing countries have recognized that proper management of solid waste is important for human advancement within the context of sustainable development goals. Many countries are implementing policy instruments that target

behaviour change at the household level in favour of sustainable solid waste management of waste. In this regard, improving the door-to-door collection of household wastes has emerged as a feasible approach.

Similarly, the government of Kenya is keen on promoting sustainable solid waste management in the country. It has purposefully put in place somewhat robust environmental management reforms to tackle solid waste in its quest for sustainable development, as evidenced by the reviewed policy documents. Generally, there is a convergence of thought that efficient solid waste management is essential as governments strive to deliver services to their citizens (National Environment Action Plan, 1994; Environmental Management and Coordination Act, 1999; National Environment Policy, 2013; National Solid Waste Management Strategy, 2015).

The door-to-door collection of solid waste amongst urban residents is thus fast emerging as an improved waste collection method. The residents of the satellite town of Ruaka on the outskirts of Nairobi City exemplify this government commitment. They show a desire to enjoy the benefits of sustainable development through proper solid waste management. Case results show that out of 102 study respondents, 69 have signed up for door-to-door waste collection, which involves being provided with a polythene bag for waste collection and storage (Figures 1-8). The socio-economic characteristics of the residents appear to have an influence on the sustainability and effectiveness of door-to-door household solid waste collection. Case results show that the family size and employment status were important factors in describing the influence of demography on door-to-door waste management. In particular, private employment appears to be related to an increased desire for door-to-door waste management, as demonstrated by those with door-to-door service. At the same time, it would be important to see if different results might emerge from a study conducted in the post COVID-19 period.

Moreover, a survey of their perceptions on improving the current door-to-door service shows that many study respondents, including those without the service, are willing to pay a fraction of their income in order to improve the current door-to-door waste collection method, as shown in Table 2. These results demonstrate a positive attitude towards proper solid waste management amongst the residents who were studied. The favourable attitude could arise from the consciousness of the effects of accumulated solid waste, especially health risks and environmental risks. Moreover, the results could also imply favourable conditions and opportunities for creating collaborative social networks for financial partnerships towards appropriate waste management in Ruaka town, which appears to be a big

challenge. The literature reviewed has emphasized the importance of understanding local attitudes and the existing situation, focusing on financial partnerships with citizens for improved waste management (Coaffey and Coad, 2015; Sumukwo and Cheserek, 2012; Banga and Mkenda, 2011; Kounani et al., 2020).

In general, the maximum willingness to pay for improved waste collection varies between those who have a door-to-door waste collection and those who do not have the service. Results indicate that no respondent was willing to pay less than Kshs. 100 (US$ 1) to improve waste management. Furthermore, as shown in Table 2, a majority of residents are willing to pay more than Kshs. 300 (US$ 3) for improved waste management, but there are more residents amongst those with a door-to-door collection service who are willing to pay Kshs. 300 (US$ 3) than those without one. However, the quest for a higher premium amongst those with a door-to-door collection service may indicate a certain level of dissatisfaction amongst them since many of them could feel that they are not being served well. Nevertheless, it will be important to conduct more household surveys to further investigate these speculations in the future.

The results appear to have indirectly identified some reasons behind this dissatisfaction among residents with door-to-door service. First, the waste collection charge is fixed by an agreement between the landlord and the private waste collector (company) without tenants' participation. This circumstance is concerning given that the literature review has confirmed that citizen participation is the key to successful waste management (Altaf and Deshazo, 1996; National Solid Waste Management Strategy, 2015; UN-Habitat, 2014; UN-Habitat, 2016; Laurieri et al., 2020; Ibanez et al., 2018; European Commission, 2015). Secondly, waste bags are only provided twice per month, which may be upsetting to this group of residents. Thirdly, the concrete waste boxes outside most apartments are only emptied occasionally, once per month, and this sometimes encourages littering, causes bad odours, and encourages illegal dumping.

In addition, the authors observe that even though door-to-door waste collection may have many advantages, the current form of implementing door-to-door collection practice in Ruaka town is incentivizing increased environmental degradation risks by encouraging an endless generation of waste amongst residents besides entrenching inequality in access to waste collection facilities. First, providing tenants with high-capacity (60-litre) waste bags encourages waste generation at the source (Figure 8). Indeed, on average, residents with the door-to-door collection have a higher daily rate of waste generation (1.94 kg) compared to those without it, who, on average, only produce approximately 1.86 kg per day in comparison with Nairobi City's projected 0.7 kg/capita/day. Secondly, the landlords'

or houseowners' practice of discretionarily allowing apartment tenants to buy extra waste containers reverses the gains that could have been achieved through the door-to-door collection and the transition to a zero-waste society as envisioned in the National Solid Waste Management Strategy of 2015 and other key environmental policy documents already discussed. Thirdly, the current system does not encourage waste sorting and separation at the source, thus complicating waste handling, transportation, and eventual disposal. Fourthly, the fixing of the waste collection fee is non-participatory because tenants are not involved.

Moreover, contracted private collectors' low waste collection frequency indicates that Kiambu County could only be minimally enforcing private companies' waste collection contracts. This may be attributed to limited budgetary allocations, amongst other reasons, as indicated in the National Solid Waste Management Strategy of 2015 and other policy documents. Finally, the apartment building technology, which excludes important facilities such as lifts, could hinder proper solid waste collection on the part of physically disadvantaged groups (especially the sick, people living with disabilities, and the elderly) and is likely to disproportionately escalate their waste collection costs because they may be required to hire another person to help them take their wastes to the concrete boxes. These findings may support the UN-Habitat's (2016) findings, which attribute policy failures to the highly-segmented nature of some environmental policies, including those that govern solid waste, as well as the complex application context, which is driven by unclear technical objectives that are considered in isolation from other factors that determine effectiveness. Our study shows ho some environmental policies are adopted on a foundation that is entirely comprised of ad-hoc assumptions rather than collectively investigated realities, which could then enable policy implementation. Moreover, door-to-door waste management appears to be affected by factors that can be controlled both by the existing waste management strategies such as environmental consciousness amongst residents and factors that are beyond the waste management strategies such as family size, building technology, and socio-cultural factors. On this account, this paper calls for more household surveys that would help to address these waste problems. Notably, Altaf and Deshazo (1996) call for similar actions in the case of Pakistan in efforts aimed at investigating these waste management realities.

In the case of Ruaka, waste separation at the point of generation has the potential to reduce waste collection costs and the risk of health and negative environmental impacts, as Coaffey and Coad (2015) have indicated. Waste separation combined with composting of biodegradable wastes could yield many benefits, including boosting soil fertility for local agricultural productivity and promoting

urban farming as well as rural-urban integration and development. This study's results have expressly confirmed these possibilities, as shown in Figure 7, which indicates that household waste in Ruaka is dominated by food waste and paper, both of which are largely biodegradable and could be composted to produce manure for food production and other functions. Composting and recycling have been recognized as feasible methods of managing waste in Kenya in reviewed policy documents and could offer many benefits in the case of Ruaka town. First, the more waste that is composted or recycled, the less waste there is to be disposed of. It can significantly reduce waste collection costs by reducing disposal fees, time loss at dumpsites, and distances that must be traveled to access remote dump sites. Secondly, selling recyclable materials from separated wastes to recycling industries can generate additional revenue in the waste management value chain and reduce waste collection costs. Thus, the promotion of composting and recycling can help make waste collection more affordable Afroz and Masud (2011).

5. Conclusion and recommendation

This study has reviewed and provided insights on how the current door-to-door system of household solid waste management in Ruaka satellite town in the peri-urban region of Nairobi could be improved. Case study results have shown that proper solid waste management is linked to improved human health and sustainable development. The door-to-door collection of wastes from households, if properly implemented, could accelerate sustainable management of solid waste and even generate new revenue streams for financing waste management programmes. Case results from Ruaka town have also shown that people desire to have improved waste management and are willing to devote a portion of their income to a program that implements these wishes. This offers an opportunity for the County Government of Kiambu to address the current budgetary constraints facing waste management.

At the same time, in the case of Ruaka town, the results of this study lead us to recommend increasing the involvement of residents in issues of waste collection through the formation of resident associations, reviewing the current waste management regulations to clearly define the maximum size of a waste bag, size of concrete waste boxes, providing incentives for waste separation at source, improving the working conditions of waste collectors, improving equity in access to waste collection facilities by redesigning buildings, outlawing the hawking of extra waste containers which is rampant in Ruaka town, and reviewing the tenant-

landlord contract to include provisions that could encourage the minimal waste generation and waste separation. These steps are important for supporting the technical analyses conducted by various waste management stakeholders and providing opportunities for developing an environmentally sustainable waste collection system. In the future, more household surveys are needed to explore better ways of securing a high rate of citizen participation and the application of smart technologies for home waste management.

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Appendix 1: Survey Questionnaire

Part 1: Demographic characteristics
What is your gender?
What is your age?
What is your highest education level?
What is your average weekly income?
What is your family size?
What is your employment status?
Do you have a door-to-door service for collecting your household solid waste?

Part 2: Current Status of household solid waste collection in Ruaka Town
Is the accumulation of solid waste an issue of concern to you as a resident of Ruaka town?
Approximately how much Kg of waste do you generate per day in your house?
Approximately, what is the highest percentage per waste component?
Would you separate waste into the various components if you were told to do so by the waste collection company?
What are the main challenges of the current door-to-door waste collection system in Ruaka?

Part 3: Improving household solid waste collection through the door-to-door system
Are you satisfied with the current door to door to door system of collecting waste?
How much are you charged for waste collection per month?
Do you think government policies have been adequate in promoting door-to-door solid waste management in Ruaka town?

Your household currently pays _____ Kshs. per month as a tariff for door-to-door solid waste management. However, there is a certain level of dissatisfaction regarding service provision. If you were to receive a proper door-to-door waste collection (five days per week), weekly cleaning of intermediate waste bins, and safe disposal of generated waste, would you be willing to pay Kshs. 100 per month for such a service? NB: this amount would be in addition to your current monthly household expenditure, but you have than nothing extra to pay in this regard.

If yes, would you be willing to pay Kshs. 200?
If yes, would you be willing to pay Kshs. 400?
If no, why?
What would be your maximum willingness to pay for improved door-to-door service?

Appendix 2: Results from those with door-to-door service

Questionnaire Survey No.	Gender	Age	Education level	Monthly income	Weekly Income (Kshs.)	Family size	Employer	Approximate waste generated per week (Kg)	Main Composition (Food waste, paper, bones, etc.)	Have door to door collection or not (Yes/No)	WTP for improvement (Yes/No)	If yes, how much (Kshs.)?
95	F	34	Secondary	32,000	8000	1	Government	3	Electronic Waste	Yes	No	0
11	M	28	Secondary	40,000	10000	1	Government	2.5	Food Waste	Yes	No	0
23	F	26	Tertiary	4,000	1000	2	Government	1.5	Food Waste	Yes	No	0
12	F	36	Secondary	20,000	5000	2	Government	1.8	Paper	Yes	No	0
65	M	38	Tertiary	26,000	6500	2	Government	1	Food Waste	Yes	No	0
9	M	35	Secondary	104,000	26000	2	Government	2	Food Waste	Yes	No	0
10	M	26	Tertiary	12,000	3000	3	Government	1.5	Food Waste	Yes	No	0
43	F	35	Secondary	120,000	30000	3	Government	2	Food Waste	Yes	No	0
71	M	26	Secondary	400	100	3	Private sector	1.3	Food Waste	Yes	No	0
83	F	22	Tertiary	320,000	80000	3	Private sector	2	Food Waste	Yes	No	0
32	F	44	Secondary	2,000	500	4	Private sector	1	Paper	Yes	No	0
34	M	43	Secondary	40,000	10000	4	Private sector	3	Paper	Yes	No	0
31	M	42	Secondary	48,000	12000	4	Private sector	1	Food Waste	Yes	No	0
55	F	26	Tertiary	56,000	14000	4	Private sector	1	Food Waste	Yes	No	0
33	M	46	Primary	80,000	20000	4	Private sector	2.3	Food Waste	Yes	No	0
30	F	39	Tertiary	120,000	30000	4	Private sector	1	Food Waste	Yes	No	0
101	F	49	Tertiary	180,000	45000	4	Private sector	1.3	Food Waste	Yes	No	0
35	M	42	Tertiary	14,000	3500	5	Private sector	3	Electronic Waste	Yes	No	0
61	M	38	Primary	60,000	15000	1	self	1.3	Food Waste	Yes	No	0
22	M	54	Secondary	3,400	850	2	self	1	Paper	Yes	No	0
44	F	72	Tertiary	40,000	10000	2	self	2	Paper	Yes	No	0
77	F	30	Tertiary	40,000	10000	2	self	1.3	Food Waste	Yes	No	0
51	M	22	Tertiary	48,000	12000	2	self	6	Food Waste	Yes	No	0
89	M	35	Primary	100,000	25000	2	self	2	Food Waste	Yes	No	0
4	F	45	Secondary	80,000	20000	3	self	0.9	Paper	Yes	No	0
36	M	35	Secondary	100,000	25000	3	self	4	Plastic	Yes	No	0
17	F	44	Tertiary	120,000	30000	3	self	2	Food Waste	Yes	No	0
2	F	22	Secondary	32,000	8000	4	self	1.5	Paper	Yes	No	0
37	M	55	Tertiary	40,000	10000	6	self	3.5	Food Waste	Yes	No	0
69	M	33	Tertiary	80,000	20000	1	Private sector	1	Food Waste	Yes	Yes	200
63	F	56	Tertiary	12,000	3000	3	Private sector	1.2	Food Waste	Yes	Yes	200
67	M	30	Tertiary	4,000	1000	4	self	1.8	Food Waste	Yes	Yes	200
81	M	30	Tertiary	76,000	19000	1	Private sector	2	Food Waste	Yes	Yes	250
57	F	34	Secondary	64,000	16000	2	Private sector	1.3	Food Waste	Yes	Yes	250
53	M	65	Tertiary	76,000	19000	2	Private sector	3	Food Waste	Yes	Yes	250
27	F	34	Secondary	80,000	20000	2	Private sector	1.3	Food Waste	Yes	Yes	250
73	M	23	Secondary	40,000	10000	5	Private sector	1.4	Food Waste	Yes	Yes	250

Questionnaire Survey No.	Gender	Age	Education level	Monthly income	Weekly Income (Kshs.)	Family size	Employer	Approximate waste generated per week (Kg)	Main Composition (Food waste, paper, bones, etc.)	Have door to door collection or not (Yes/No)	WTP for improvement (Yes/No)	If yes, how much (Kshs.)?
75	F	35	Primary	20,000	5000	1	self	1.8	Food Waste	Yes	Yes	250
79	M	30	Tertiary	140,000	35000	2	self	2	Food Waste	Yes	Yes	250
42	F	39	Tertiary	40,000	10000	1	Government	2	Paper	Yes	Yes	300
19	F	25	Primary	4,000	1000	2	Private sector	1	Food Waste	Yes	Yes	300
25	M	31	Secondary	72,000	18000	3	Private sector	1.5	Electronic Waste	Yes	Yes	300
49	M	35	Tertiary	100,000	25000	3	Private sector	4	Food Waste	Yes	Yes	300
59	M	36	Secondary	52,000	13000	4	Private sector	0.5	Food Waste	Yes	Yes	300
45	F	35	Secondary	400	100	1	self	2	Food Waste	Yes	Yes	300
3	F	33	Primary	40,000	10000	1	self	2	Food Waste	Yes	Yes	300
1	M	18	Secondary	120,000	30000	2	self	1	Food Waste	Yes	Yes	300
85	M	45	Secondary	24,000	6000	3	self	2	Food Waste	Yes	Yes	300
39	F	36	Secondary	60,000	15000	3	self	4	Food Waste	Yes	Yes	300
15	F	37	Tertiary	52,000	13000	1	Government	3	Food Waste	Yes	Yes	350
13	F	38	Primary	800	200	4	Government	1.5	Food Waste	Yes	Yes	350
93	M	36	Tertiary	60,000	15000	6	Government	2	Food Waste	Yes	Yes	350
20	M	23	Tertiary	14,400	3600	2	self	1	Food Waste	Yes	Yes	350
38	F	26	Secondary	60,000	15000	2	self	3.6	Food Waste	Yes	Yes	350
40	F	35	Primary	100,000	25000	4	Government	2.5	Food Waste	Yes	Yes	400
21	M	65	Secondary	52,000	13000	2	Private sector	1	Food Waste	Yes	Yes	400
47	M	23	Primary	60,000	15000	4	Private sector	2	Food Waste	Yes	Yes	400
24	M	32	Secondary	72,000	18000	2	self	1.5	Paper	Yes	Yes	400
6	M	70	Secondary	4,800	1200	1	Private sector	2.5	Plastic	Yes	Yes	500
28	F	37	Tertiary	8,000	2000	3	Private sector	1	Food Waste	Yes	Yes	500
29	F	38	Secondary	40,000	10000	3	Private sector	1	Food Waste	Yes	Yes	500
16	F	39	Tertiary	40,000	10000	1	self	1.6	Plastic	Yes	Yes	500
91	M	26	Tertiary	52,000	13000	2	self	2	Food Waste	Yes	Yes	500
26	F	33	Primary	64,000	16000	3	self	1.9	Plastic	Yes	Yes	500
41	F	35	Secondary	32,000	8000	2	Government	2	Food Waste	Yes	Yes	600
99	M	46	Tertiary	40,000	10000	4	Government	4	Food Waste	Yes	Yes	600
7	M	23	Secondary	60,000	15000	1	Private sector	1	Food Waste	Yes	Yes	600
97	M	44	Primary	800	200	1	self	3	Food Waste	Yes	Yes	600
87	M	70	Secondary	56,000	14000	1	self	1.5	Food Waste	Yes	Yes	600

Appendix 3: Results from those without door-to-door service

Questionnaire Survey No.	Gender	Age	Education level	Monthly Income	Weekly Income (Kshs.)	Family size	Employer	Approximate waste generated per week (Kg)	Main Composition (Food waste, paper, bones, etc.)	Have door to door collection or not (Yes/No)	WTP for improvement (Yes/No)	If yes, how much(Kshs.)?
74	F	35	Secondary	2,800	700	1	Government	1.7	Paper	No	No	0
84	F	33	Tertiary	4,400	1100	1	Government	2	Paper	No	Yes	250
5	F	26	Tertiary	3,200	800	2	Government	0.8	Food Waste	No	Yes	450
14	F	35	Secondary	10,000	2500	2	Government	2	Paper	No	Yes	400
66	F	31	Tertiary	12,000	3000	2	Government	1.5	Plastic	No	Yes	250
88	M	23	Secondary	2,000	500	3	Government	1	Food Waste	No	Yes	500
80	M	30	Tertiary	3,200	800	3	Government	2	Food Waste	No	No	0
94	F	36	Tertiary	92,000	23000	3	Government	3	Paper	No	Yes	300
64	F	22	Tertiary	60,000	15000	4	Government	1.5	Paper	No	Yes	300
100	M	48	Tertiary	18,000	4500	5	Government	3	Food Waste	No	Yes	500
50	F	26	Tertiary	400	100	1	Private sector	5	Food Waste	No	No	0
70	F	45	Tertiary	800	200	1	Private sector	1	Food Waste	No	Yes	250
58	M	36	Tertiary	2,000	500	1	Private sector	1	Food Waste	No	Yes	250
54	F	32	Tertiary	8,000	2000	1	Private sector	2	Paper	No	Yes	250
92	M	33	Tertiary	40,000	10000	1	Private sector	2	Paper	No	No	0
8	M	35	Primary	2,400	600	2	Private sector	1	Food Waste	No	Yes	500
18	F	45	Primary	2,400	600	2	Private sector	2.3	Food Waste	No	No	0
72	F	70	Tertiary	40,000	10000	2	Private sector	1.5	Paper	No	Yes	250
86	M	26	Tertiary	52,000	13000	2	Private sector	1.3	Plastic	No	No	0
56	F	23	Tertiary	40,000	10000	3	Private sector	1.2	Plastic	No	No	0
52	M	35	Tertiary	260,000	65000	3	Private sector	5	Paper	No	Yes	250
62	M	34	Secondary	240,000	60000	4	Private sector	1.2	Paper	No	Yes	250
46	F	56	Secondary	60,000	15000	5	Private sector	2	Plastic	No	Yes	400
102	F	50	Tertiary	64,000	16000	5	Private sector	1.5	Paper	No	Yes	500
68	F	22	Tertiary	800	200	1	self	1.2	Food Waste	No	No	0
60	M	37	Secondary	2,000	500	2	self	1.2	Food Waste	No	No	0
48	F	35	Secondary	2,800	700	2	self	1	Food Waste	No	Yes	300
96	M	45	Secondary	4,000	1000	2	self	3	Plastic	No	Yes	500
82	F	18	Tertiary	76,000	19000	2	self	2	Paper	No	Yes	250
76	F	26	Secondary	40,000	10000	3	self	1.5	Plastic	No	Yes	250
90	M	35	Secondary	4,000	1000	4	self	2	Food Waste	No	Yes	600
78	M	30	Tertiary	4,000	1000	4	self	2	Food Waste	No	Yes	250
98	M	41	Secondary	36,000	9000	5	self	1.3	Food Waste	No	Yes	600

Authors

Sylvester Ngome Chisika, International School of Urban Sciences, University of Seoul, 02504 Seoul, Korea; sylvesterchizika@gmail.com

Chunho Yeom, International School of Urban Sciences, University of Seoul, 02504 Seoul, Korea; chunhoy7@uos.ac.kr

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