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Capturing Household Preferences on Solid Waste Management Services in Urban Areas of Developing Countries

Daudi Bigirwa, Felister Mombo*

Department of Forest Economics, Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture, Morogoro, Tanzania

Email address:

davebigirwa@gmail.com (D. Bigirwa), fmombo@yahoo.com (F. Mombo)

*Corresponding author

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Abstract: Solid waste generation is an increasing global problem. The problem is more pronounced in developing countries due to experienced budget constraints and lack of strong institutions in the management of waste collections and disposals. Local government authorities in Tanzania have made efforts to ensure proper solid waste management especially in urban areas. Despite these initiatives solid waste management is still a key environmental problem in most urban areas of the country. This may be due to non-inclusion of household preferences on solid waste management when designing solid waste management services. A Choice Experiment Method was used in this study to determine household preferences on solid waste management services in order to design sustainable solid waste management services in Kinondoni municipality. The results showed that both low and high income households in Kinondoni Municipality prefer solid waste management services. The mostly preferred solid waste management service attributes were frequency of solid waste collection and use of vehicles while provision of polythene bags attribute was not preferred by households. The findings showed that are high variations in household preferences for solid waste management services caused mainly by socio-economic characteristics such as income. In order to improve solid waste management in Kinondoni municipality, policy makers and solid waste management service providers should incorporate household preferences on solid waste management services when designing these services.

Keywords: Choice Experiment, Household Preferences, Solid Waste Management Service, Solid Waste Management Service Attributes, Willingness to Pay, Implicit Price

1. Introduction

Solid waste generation is an increasing global *environmental and public health problem* particularly in developing countries [1]. In urban areas of the developing countries, the totality of solid waste generated is not collected and disposed to appropriate place. Most of the generated solid waste is haphazardly thrown in streets, roadsides, river banks and open spaces which have aggravated environmental and health challenges. Since the early 1990s, many governments in developing countries showed a great deal of concern in improving urban solid waste management (SWM) [2]. However, most efforts to improve solid waste management in developing countries are not successful as they are mostly directed at the service providers and less attention is given to service receivers. In most instances, household preferences for SWM services are not clearly known to service providers, which hinder the design and delivery of appropriate SWM services. Improvement in SWM services requires a concerted action of both the service providers and the service receivers, especially households which are the primary producers and generators of significant proportion of solid waste [3].

In Tanzania, the local government authorities have been responsible for providing solid waste management services to their citizens. However, the increased human population overwhelmed the capacity of local government authorities to provide SWM services to the growing urban population [4-5]. This made the local government authorities such as the Dar es Salaam City Council to privatize SWM services and introduce refuse collection charges in 1994. Privatization of SWM services was anticipated to be a solution of solid waste

problems in Dar es Salaam City as it would increase the coverage and delivery of SWM services to many places within the City. Likewise, the introduced refuse collection charges would ensure a participatory approach in managing solid waste as services receivers (households) would pay for provision of these services [5].

Regardless of this initiative, solid waste management is still among the key environmental problems in Dar es Salaam City, Kinondoni municipality in particular. Only 41% of the generated solid waste per day in Kinondoni municipality are collected and disposed off the dumpsite while the rest are haphazardly thrown in streets, road sides, drainage channels, commercial centres and open spaces [6]. Researches were not done to identify household preferences on SWM services before privatization of SWM services in Dar es Salaam City [7-8]. This might be a reason of poor SWM in Kinondoni municipality since household preferences on SWM services are not clearly known by SWM service providers and policy makers. Furthermore, it is not even clear whether there are variations in household preferences on SWM services. A clear understanding on household preferences for SWM services would help in designing appropriate and sustainable SWM services which could easily be appreciated and supported by households. It is against this background the current study was carried out in Kinondoni municipality to determine household preferences on SWM services in order to improve the existing SWM in the area.

2. Material and Methods

2.1. The Study Area

The study was conducted in Kinondoni municipality which is a fastest growing municipality in Dar es Salaam region, Tanzania. According to the National Census of 2012, Kinondoni municipality covers about 531 km^2 and has a population of 1 775 049 with an annual growth rate of 4.1%. Kinondoni municipality (Figure 1) covers a wide range of informal settlements, where solid waste is a great threat. Kinondoni municipality generates the highest volume of solid waste in the region (2 026 tonnes/day), and about 60% of the generated solid waste per day in the municipality is not attended [6]. This necessitates the need to establish effective strategies for improving the availability and delivery of SWM services in Kinondoni municipality.

Figure 1. *A map of Dar es Salaam region, showing Kinondoni, Ilala and Temeke municipalities.*

2.2. Sample Size and Sampling Procedures

Stratified sampling was used to stratify wards in Kinondoni municipality into two strata based on the amount of solid waste generated in each ward per day. Mwananyamala ward was randomly selected from wards generation below 50 tonnes/day while Kawe ward was randomly selected from wards generating 50 tonnes and above/ day. Simple random sampling was used to select 4 *mitaa*/streets from each ward, making a total of 8 *mitaa,* namely, Msisiri A, Kopa, Kambangwa, Mwinjuma, Ukwamani, Mzimuni, Mbezi Beach A and Mbezi Beach B.

Again, simple random sampling was used to select 30 households from each *mtaa*/street. Purposive sampling was employed to select key informants.

2.3. Sampling and Analysis

The main data collection tools used were focus group discussions, choice cards, semi structured questionnaire and checklists.

2.3.1. The Choice Experiment

Choice Experiment method has its theoretical grounding in Lancaster's model of consumer choice [9], and its econometric basis in random utility theory [9-10] asserted that the utility derived from a good comes from the attributes of that good, and not from the consumption of the good itself. The basic idea behind random utility theory is that in a given choice set, an individual will choose an alternative which gives him/her the highest utility. Choice Experiment method is a multi-attribute stated preference elicitation technique in which each alternative is described by a number of attributes [11]. In choice experiment, individuals are given a hypothetical setting and asked to choose their preferred alternative among several alternatives in a choice set [12]. A monetary value is included as one of the attributes, along with other attributes of importance. The inclusion of a monetary value allows the calculation of individual's marginal willingness to pay for a change in each of the other non-marketed attributes [13].

A first step in executing Choice Experiment is to define the choices to be presented to the interviewees. Secondly, an optimal design is needed to limit the number of choices given to each interviewee and to, at the same time, maximize the information obtained from the experiment. Thirdly, the interviewees are selected and the experiment can then be undertaken [13].

2.3.2. Defining the Choices

Any Choice Experiment study necessitates focus group discussions and consultations to be conducted prior the actual data collection so that respondents can select or suggest their most relevant attributes and levels to be used in the Choice Experiment [14]. In this study focus group discussions and consultations were done during a preliminary study, which involved households and key informants such as municipal, ward and *mtaa* officials, providers of SWM services. From the focus group discussions and consultations, the following attributes and levels (Table 1) were suggested and were used in this Choice Experiment during actual data collection.

The first attribute was concerned on use of vehicles in transporting solid waste from the households to disposal site. Majority of the respondents argued that their municipality does not have enough vehicles for collecting solid waste from their streets, and most streets do not have formal SWM service providers. This has made most of them to rely on informal waste pickers known as *mateja* or *viroba* guys. Their over reliance on informal waste pickers has escalated solid waste management problems in their areas. Practically, informal waste pickers cannot transport the collected waste to Pugu dumpsite which is located about 30 km from Kinondoni municipality, as they use push carts, wheel barrows and *viroba* to collect waste from households. Few households who are serviced by solid waste contractors pointed out that the contractors are using poor vehicles which do not have a covering material for securing the waste when they are being transported to disposal place. Use of vehicles without a covering material litters solid waste on roads when they are being transported, thereby complicating solid waste management. They suggested vehicles with a covering material such as nets, tarpaulins to be used for collecting and transporting solid waste. This attribute was also supported by key informants. This attribute was also used by [3, 15].

A second attribute was concerned on storage of solid waste. Respondents ascertained that they do not have appropriate storage facilities for storing solid waste while waiting for collection services. They wanted polythene bags to be provided by providers of SWM services. Provision of polythene bags would ensure proper storage of waste at the household and could increase the efficiency of solid waste collection as it will save time during waste collection. Provision of polythene bags was also supported by ward officials and SWM service contractors who insisted that given the economic situation of most of their households it is very economical to provide households with polythene bags so that most of them can afford the payment of SWM services. Polythene bags are cheaper in comparison to other storage facilities such as dustbins.

A third attribute was concerned on the frequency of solid waste collection. This was considered important to the households because only 40% of the generated solid waste in Kinondoni municipality is collected [6]. Most households believed that increase in frequency of solid waste collection will improve solid waste management in their area as great volume of solid waste will be collected and taken to disposal sites. Few respondents who are serviced by SWM service providers in their streets revealed that existing solid waste management services are not effective as most solid waste management contractors are not reliable. SWM service providers do not have a regular routine for collecting waste which makes most households to stay with solid waste in their backyards for a long period of time for instance, more than two to three weeks. Other similar studies which included this attribute are those of [3, 15-18].

A fourth attribute was related on the monthly payment for SWM services. This attribute helps in estimating the marginal willingness to pay/ implicit price for each non market attribute. Respondents and key informants suggested the prices to be low and should base on household's socio economic status so as to allow many households to afford the services. Most respondents suggested the prices to be based on the prices they are currently paying to either street waste pickers or solid waste management service contractors.

Table 1. *Solid waste management service attributes and levels (choices).*

Attribute	Description	Levels
Vehicles with a covering material for transporting solid waste	Vehicles with a covering material such as nets should be used for carrying the generated solid waste from households to the disposal site	No (status quo) and Yes (vehicles with covering materials will be used)
Provision of polythene bags for storing solid waste	Polythene/plastic bags for storing solid waste at households while waiting for collection services	No (status quo), yes (polythene bags will be provided)
Frequency of solid waste collection	The number of times solid waste are collected from the households	Once per week regular and twice per week regular
Payment	The price for SWM service per month in TZS	1 000, 3 000, 5 000 and 10 000

2.3.3. Creating the Choice Experiment Design

The number of options that can be created from four SWM service attributes, three with two levels and one with four levels is 2^3x4^1 (32). JMP software was used to construct 6 choice cards from the SWM service attributes and their levels. Each choice card consisted of 2 SWM options and an opt out/ neither option. The neither option was introduced as an alternative in the choice sets, to enable household to choose no change in solid waste management by keeping the current solid waste management situation. This enables estimation of welfare measures that are consistent with demand theory [11]. To reduce the burden upon the respondents, the 6 choice cards were blocked into 2 blocks each with 3 choice cards so each household had to complete 3 choice cards. An example of a choice card (choice card 1) which was designed and used in the study is shown in table 2 below.

2.3.4. A Sample Card Used in the Study

Table 2. *Given solid waste management options, with their preferences.*

Card No.	Attributes	SWM option I	SWM option II	Neither SWM option I nor SWM option II
1	Vehicles for transporting solid waste	No	Yes	
	Provision of polythene bags for storing solid waste	Yes	No	
	Frequency of solid waste collection	Once per week regular	Twice per week regular	
	Cost of solid waste service per month in TZS	1 000	3 000	
	I prefer			

2.4. Data Analysis

Responses from Choice Experiment were analyzed using conditional logit model in Limdep 9.0 NLOGIT 4.0 software. The conditional logit model assumes homogeneous preferences among respondents. It is modeled based on choice specific attributes and not on characteristics of individuals which allows estimation of trade-offs between solid waste management attributes [19]. Conditional logit model also assumes independence of irrelevant alternative, which states that the relative probabilities of two options being chosen are unaffected by introduction or removal of other alternatives [10]. The following conditional model was used;

$$U_{njt=}ASC + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \ldots \beta_n Z_n \quad (1)$$

Where; U_{njt} is the is indirect utility function of alternative *j* for individual *n* at choice situation *t,*

ASC is the alternative specific constant which captures individual's intrinsic preferences for alternative *j,*

$Z_1 - Z_n$ are solid waste management service attributes,

$\beta_1 - \beta_n$ coefficient parameters for solid waste management service attributes.

The random parameter logit (RPL) model was used to examine variation in household preferences on solid waste management services. This is because the CL model used above assumes homogeneous preferences among respondents and holds the IIA assumptions hence it cannot examine variation in respondents' preferences. Choices made in CL depend on the characteristics or attributes of an alternative and not on individual characteristics so it cannot tell whether there are variations in respondents' preferences on a given product/ services such as SWM services [14, 19]. In order to examine the variations in respondents' preferences, models which relaxes CL model assumptions are used for instance the RPL model. The RPL model assumes individual have heterogeneous or varying preferences and does not hold the IIA assumption [19]. The RPL model estimates the mean of the population which is the mean weight utility parameter of a given attribute in the population, and it estimates the standard deviation of the coefficient parameter which measures how an individual deviates from the population mean [14]. The following equation was used;

$$U_{njt=}\alpha_{nj} + \gamma_j S_n + \beta_n X_{njt} + \varepsilon_{njt} \quad (2)$$

Where;

U_{njt} is indirect utility function of alternative *j* for individual *n* at choice situation *t*

α_{nj} is the alternative specific constant which captures the intrinsic preference for SWM alternative

S_n respondents' socio-economic characteristics

X_{njt} SWM service attributes

β_n coefficient for SWM service attributes.

γ_j coefficient parameters for households' characteristics

$\gamma_j S_n$ captures systematic preference heterogeneity as a function of individual characteristics

ε_{njt} is the error term.

3. Results and Discussion

3.1. Household Socio-Economic Characteristics

Table 3 shows that households' age were between 29-77 years, and gender distribution was almost even, with female respondents representing 57.1% of the respondents. 70% of the respondents were married. The mean household's size was 5.05 in which the minimum and maximum household size was 2 and 12 respectively. Most (41.2%) of the respondents had attained primary education, 28.3% had attained secondary education, 26.3% had attained tertiary education whilst 4.2% had no formal education. Majority of the respondents (45.8%) were engaging in business activities whereas 29.2% were employed in government and private sector, 13.3% of the respondents were casual laborers, while 11.7% included respondents who are not employed, house wives and retired persons. Again, Table 3 depicts that majority of the respondents earn between TZS 100,001- 300, 000 per month. The mean monthly earning was TZS 448 885.41whilst the minimum and maximum monthly income was TZS 30 000 – 3 500 000 respectively.

Table 3. *Respondents' socio-economic characteristic.*

Socio-economic characteristic	Frequency	Percentage	Mean	Min	Max	S. ddeviation
Age						
15-30	7	2.9	47.53	29	77	10.218
31-45	105	43.8				
46-60	100	41.7				
>60	28	11.7				
Sex						
Male	103	42.9				
Female	137	57.1				
Marital status						
Single	25	10.4				
Married	168	70.0				
Widow/er	34	14.2				
Divorced	13	5.4				
Household size						
<5	102	42.5	5.05	2	12	1.971
5-7	113	47.1				
8-10	19	7.9				
>10	6	2.5				
Education level						
No formal education	10	4.2				
Primary	99	41.2				
Secondary	68	28.3				
Tertiary	63	26.2				
Main occupation						
Employed	70	29.2				
Business	110	45.8				
Casual labour	32	13.3				
Others	28	11.7				
Income per month						
<100000 TZS	22	9.2	448885.41	30000	3500000	471800
100001-300000 TZS	90	37.5				
300001-500000 TZS	66	27.5				
500001-700000 TZS	26	10.8				
> 700000 TZS	36	15.0				

3.2. Household Preferences on Solid Waste

As the study findings in Table 3 show a great variation in income earnings among respondents (standard deviation of income is 471 800), Choice Experiment data were grouped into two groups, in which one group included households earning below TZS 500 000 per month (low income) while the other group included households earning TZS 500 000 and above per month (high income).

Table 4. *Preference of the respondents (low income households).*

	Conditional logit model (high income)		
Variable	**Coefficient**	**Standard Error**	**P > [Z]**
Vehicles	.39586365	.46495301	.0394
Storage	-.18983953	.00693105	.0000
Collect	1.34882931	.33407454	.0000
Payment	-.00014589	.00009043	.0000
ASC	-.958825873	.78224691	.0000

Number of observations=1449, no. of parameters=5, log likelihood=-113.0724, Info.criterion AIC=0.9338, Info.criterion BIC=1.00321, Info.criterion HQIC=0.96147, Pseudo R^2=0.33504

Where - vehicles (vehicles with a covering material), storage (provision of polythene bags), collect (frequency of solid waste collection), payment (cost of SWM services), ASC (Alternative specific constant)

Results in Table 4 show that coefficients of vehicles and frequency of solid waste collection attributes were both significant at 1% level while the coefficient of provision of polythene bags for storage of solid waste was insignificant. The estimated coefficients of vehicles with a covering material for transportation of solid waste and frequency of solid waste collection have positive signs (Table 4). The positive signs on these attributes advocate that improvements in the levels of these attributes will increase the utility of the respondents. The significance and positive signs on these attributes imply that these SWM service attributes are significant/important factors in the choice of a SWM option. Frequency of solid waste collection is the most preferred attribute as it has a higher coefficient value (Table 4). The negative sign and insignificance of the coefficient of provision of polythene bags for storage of solid waste implies that, this attribute is not important and is not preferred by the households. The estimated coefficient for the cost of SWM service (payment attribute) has a negative sign, indicating a decrease in utility of respondents as the monthly SWM service charge increases. This means that respondents become less willing to pay for changes as SWM service costs keep increasing. The ASC which captures the element of the choice which cannot be explained by the SWM service attributes is negative and insignificant. In this Choice Experiment the ASC was specified to account for the proportion of participation in SWM services.

Table 5. *Preference of the respondents (high income households).*

	Conditional logit model (low income)		
Variable	**Coefficient**	**Standard Error**	**P > [Z]**
Vehicles	1.39861671	.58247026	.0000
Storage	-.19618494	.19920632	.3247
Collect	5.10689614	.77118824	.0000
Payment	-.00132442	.00018112	.0000
ASC	-.78260459	.1535146	1.000

Number of observations=711, no. of parameters=5, log likelihood=-186.5828, Info.criterion AIC=1.62358, Info.criterion BIC=1.69697, Info.criterion HQIC=1.65317, Pseudo R^2=0.29715

Where - vehicles (vehicles with a covering material), storage (provision of polythene bags), collect (frequency of solid waste collection), payment (cost of SWM services), ASC (Alternative specific constant)

The coefficients for vehicles with a covering material in transporting solid waste and frequency of solid waste collection attributes were significant at 5% and 1% level of significance respectively and both have positive signs (Table 5). The significance and positive signs on these attributes means that these SWM service attributes are important factors in a choice of SWM option and inclusion of these attributes in a SWM option will increase the utility of the households. The attribute of frequency of solid waste collection is most preferred than use of vehicles in transporting solid waste as it has higher coefficient value (Table 5). The coefficient of provision of polythene bags for storage of solid waste had a negative sign and was significant at 1% level (Table 5). This implies that this attribute was not preferred by the households. The estimated coefficient for the cost of SWM service (payment attribute) has a negative sign, indicating a decrease in utility of respondents as the monthly SWM service charge increases. This means that households become less willing to pay for changes as SWM service costs keep increasing. The ASC is negative and significant.

3.3. Variations in Households' Preferences for SWM Services

Random parameter logit model were run for low income households, high income households and for both groups (combined low and high income households). For each SWM service attribute (non-market attributes), the estimated coefficient for the mean of the distribution and the variance (coefficient standard deviation) of the distribution are given. The associated standard errors are given between brackets, so that standard inferences about the significance of the coefficient can be drawn. If the estimate of the variance is insignificant, and thus not different from zero, then one can infer that the preference parameter is constant across the population. If the mean coefficient is insignificant, and thus not different from zero, but the variance estimate is significant, it does not mean that the attribute does not affect choice, but rather that there is a diversity of preferences, both positive and negative. If both the estimate of the mean and of the variance is found to be insignificant, and thus not different from zero, then it can be said that this attribute has no impact on choices [15]. The RPL model results are shown in Table 6, 7 and 8.

Table 6. *RPL model for low income households.*

RPL model (low income households)		
Attribute	**Coefficient (S. E)**	**Coefficient std (S. E)**
Vehicle	1.7475*** 0.3690	0.1658*** 1652.8925
Storage	-0.0475 0.1894	0.8830** 1330.9273
Collect	2.0068*** 0.3104	0.2212*** 614.7591
Payment	-0.0067*** 0.7033	
ASC	-0.8159*** 0.1397	

No of observations=1449, log likelihood=-421.8818, Pseudo R^2=0.14492, Chi^2=143.011***, Df=3, Info criterion AIC=0.96822, Info criterion BIC=1.01136, Info criterion HQIC=0.9847 **significant at 10% level, ** significant at 5% level, *** significant at 1% level.*

The coefficients for vehicle and collect attributes are positive and significant, meaning that low income households positively value these attributes (Table 6). Provision of these attributes in SWM services will add utility to the respondents. The attribute of storage is not significant and is negatively preferred by the respondents indicated by its negative coefficient. However, estimates of its variance (0.1658) is significant meaning that there is diversity in preferences for this attribute among low income households. The attribute of payment has negative and significant coefficient meaning that higher prices of solid waste reduces the probability of SWM options being chosen. Table 6 shows that there is low variation in households preference for SWM services among low income households indicated by low values of the variances (coefficient std).

Table 7. *RPL model for high income households.*

RPL model (high income households)		
Attribute	**Coefficient (S. E)**	**Coefficient std. (S. E)**
Vehicle	2.2124*** 0.4438	90158.3182*** 1783.4734
Storage	-0.5306*** 0.2030	62786.6408*** 1352.3531
Collect	0.1416** 0.3768	8505.7266*** 598.2866
Payment	-0.00015** 0.7393	
ASC	-1.7712*** 0.1698	

No of observations=711, log likelihood=-307.273, Pseudo R^2=0.13995, Chi^2=100.005***, Df=3, Info criterion AIC=0.8868, Info criterion BIC=0.9382, Info criterion HQIC=0.90669, **significant at 10% level, ** significant at 5% level, *** significant at 1% level*

Explanations on the sign and significance of coefficients for SWM service attributes in high income households is the same like those explained in low income households. However, storage attribute is significant, meaning that this attribute is important though it is negatively preferred. This may be due to the fact that this group recognizes the importance of having storage facilities for solid waste but they are not contented on using polythene bags as waste storage facilities. The estimated variances/coefficients std (Table 7) are very high and significant meaning that there is high variations in preferences for SWM services among high income households.

Table 8. *RPL model for low and high income households (combined).*

RPL model (low and high income households)		
Attribute	**Coefficient (S. E)**	**Coefficient std. (S. E)**
Vehicle	0.6291** 0.3226	470159.695*** 1576.957
Storage	-0.1764 0.1664	165468.821** 1208.971
Collect	1.3601*** 0.2836	18261*** 526.212
Payment	-0.00047*** 0.5960	
ASC	-0.8699*** 0.1279	

No of observations=2160, log likelihood=-439.269, Pseudo R^2=0.1887, Chi^2=204.417***, Df=3, Info criterion AIC=1.0073, Info criterion BIC=1.0504, Info criterion HQIC=1.0238, **significant at 10% level, ** significant at 5% level, *** significant at 1% level*

When all respondents were combined in one group (Table 8), the coefficients for vehicle and collect were positive and significant meaning that they are positively valued by all respondents. However, the collect attribute is most preferred than vehicle attribute as it has the highest coefficient. The storage attribute is not significant but its variance (coefficient std) is significant meaning that there is diversity in preferences for this attribute among the households. Combination of low and high income households increased the variations in preferences for SWM services indicated by high values of coefficient standard deviation/variances (Table 8). This signifies that there are high variations in households' preferences for SWM service attributes and it was logical to categorize respondents into two groups (low and high income households) so as to get better estimates of marginal willingness to pay/ implicit price of SWM services attributes. Also income is a significant factor affecting respondents' preferences/choices for SWM service options.

4. Conclusion

The study concludes that it is very important to identify household preferences for SWM before designing SWM services. Identification of household preferences on SWM helps in designing sustainable solid waste management programs which can easily be appreciated and supported by households. The study revealed that both low and high income households in Kinondoni municipality have preferences on SWM services and they prefer most improvements in frequency of solid waste collection and use of vehicles with a covering material in transporting solid waste. However, both low and high households do not prefer provision of polythene bags for storage of solid waste. The findings also ascertained that there is high variations in households' preferences on SWM services, the variation increases when the groups (low and high income households) are combined together and the variation reduces when the groups (low and high income households) are separated. In order to improve solid waste management in Kinondoni municipality, policy makers should integrate information on household preferences on solid waste management services when preparing solid waste management policies. Formal SWM service providers in Kinondoni municipality should consider the households preferences on SWM services when designing and delivering solid waste management services to

households. For instance, they must provide the mostly preferred SWM attributes in their solid waste management services. This will help to improve and create more markets for solid waste services since the household preferences on SWM are clearly known to the SWM service providers. furthermore, household preferences on SWM services is influenced by socio-economic characteristics such as income which cause variations in preferences, hence policy makers and providers of SWM services need to consider these variations when designing appropriate SWM services in a given area.

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