The Role of Sub-Saharan Africa Countries’ Households Waste Charges on Sustainable Cities Development

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Abstract

Most developing countries especially Sub-Sahara Africa often lacks financial resources to provide solid waste management in urban areas. Despite this, little has been done in the region to investigate the amount of income which can be collected from households to support provision of proper solid waste management. This paper estimated the amount which can be raised from households to support delivery of sustainable solid waste management. The study identified solid waste recovery alternatives which can help to turn the generated solid waste into useful resources. The findings revealed an estimate of about TZS 4,555,582,529 (1 USD = 2140.65 TZS) can be collected per month from the households. The collected can be sued to purchase equipment including collection trucks and covering materials, as well as to pay for operational costs. The purchased solid waste equipment can collect and dispose up to 36% of the total solid waste generated by all households per day. Recycling of plastic, paper and metal scraps from households’ solid waste stream can transform about 25% of the total solid waste generated by households into useful products. Composting and bio fuels generation can convert 70.06% of the biodegradable waste such as food and garden wastes into useful products. Solid waste recovery alternatives have a great potential to turn waste into values thereby increasing the economic value of wastes, saving landfill space needed to dispose solid waste, encourage establishment of solid waste recovery industries or projects and create employment opportunities to people.

Keywords: Wastes; Households; Equipment; Recycling

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 properly managed [2]. Most of the generated solid waste in developing countries is haphazardly thrown in streets, roads sides, river banks and open spaces which have escalated environmental and health challenges to the people [3]. Most of the developing countries cities often lack financial resources to provide required municipal infrastructures for adequate solid waste management, despite their citizens’ demand for waste management services [4]. Most these municipalities spend between 20 and 40% of their revenues on the collection, transport, and disposal of solid waste. However, this budget is often unable to keep pace with the scope of the problem of solid waste that is generated [5]. Furthermore, most attempts to improve Solid Waste Management (SWM) in cities of developing countries like Tanzania have focused on the technical aspects of different means of collection and disposal little has been done to investigate the demand side perspectives on solid waste management [6].

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 [7,8]. Like other developing countries, local government authorities in Tanzania lack enough financial resources to provide needed SWM services to their citizens. Most attempts to improve solid waste management in the country like privatization of solid waste management services and introduction of waste charges have concentrated on the supply side of the problem; the demand side is often not considered [7,9]. This has negatively impacted on the success of solid waste management in most urban areas of the country, for instance only 41% of the generated solid wastes in Kinondoni municipality are collected and disposed off the dumpsite while the rest are not attended [3]. Little has been done in the country to study the extent in which households can support their Municipalities financially to manage the escalated solid waste volumes, including how much households are willing to pay to ensure provision of solid waste management services; How much can be raised from household payments of solid waste charges; Which solid waste management equipment can be purchased from the collected household solid waste charges; How will the purchased solid waste equipment improve solid waste management in respective areas and what solid waste recovery alternatives can be put in place to manage solid waste. It is against this background the current study was conducted in Kinondoni municipality to estimate the amount which can be collected from households to support provision of solid waste management services, how the collected amount can be used to improve SWM in the area and to identify solid waste recovery alternatives which can add value to the generated solid waste.

Methodology

The study area

The study was conducted in Kinondoni Municipality (KM) which is a fast growing Municipality in Dar es Salaam region, Tanzania. According to the National Population and Housing Census of 2012, KM covers about 531 km² and has a population of 1 775 049 with an
annual growth rate of 4.1% and 446 504 households. KM covers a wide range of informal settlements, where solid waste is a great threat (Figure 1). KM generates the highest volume of solid waste in the region (2026 tonnes/day), and about 60% of the generated solid waste per day in the Municipality is not attended [3]. This necessitates the need to establish effective strategies for improving the availability and delivery of SWM services in the KM. It is also imperative to find out alternative ways of turning volumes of generated solid waste in KM into useful resources.

Sample size and sampling procedures

Stratified sampling method 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 tones 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, Ulkwamani, Mzimuni, Mbezi Beach A and Mbezi Beach B. Again, simple random sampling was used to select 30 households from each mitaa/street, making a total of 240 households used in this study. Purposive sampling was employed to select key informants. The key informants included local government officials and local organized groups dealing with wastes collection.

Data collection

The main data collection tools used were focus group discussions, semi structured questionnaire, checklists and direct measurements on the amount of solid waste generated in each household per day. The value perceived for the Willingness to Pay (WT) was determined through Choice Experiment (CE), the details of the experiment is in [10]. Conditional Logit Model was used to estimate of perceived value of SWM attributes from the respondents.

Data analysis

Both quantitative and qualitative methods were used to analyze the collected data. Quantitative data were analyzed using STATA and SPSS software. STATA was used to analyse CE while SPSS was used to run the normal descriptive statistics. Microsoft excel was also employed for data entry for variables analyzed using STATA software. Qualitative data were analyzed using content analysis method.

CE model specification: The conditional logit (CL) model was used

\[ V_i = ASC + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \ldots + \beta_n Z_n \]   \hspace{1cm} (1)

Where;

\[ Vi \] is the utility of individual for option i;

\[ Z_1 \] – \[ Z_n \] SWM service attributes such as covered trucks for transporting solid waste, provisional of polythene bags for storing of solid waste, frequency of solid waste collection and payment of SWM services per month;

\[ \beta_1 \ - \ \beta_n \] Coefficient parameters for SWM service attributes;

\[ ASP \] Alternative specific constant.

Estimation of implicit prices: The implicit prices were calculated using the coefficient parameters from results of CL model in equation 1. The implicit price/ marginal WTP for each SWM service attribute was estimated by:

\[ \text{MarginalWTP} = \frac{\beta \text{attribute}}{\text{monetary}} \] \hspace{1cm} (2)

Where;

\( \beta \) attribute is the estimated coefficient on the non-market attribute (SWM service attribute) such as covered trucks for transporting solid waste, provision of polythene bags for storing solid waste and frequency of solid waste collection. \( \beta \) monetary is the estimated coefficient on the cost attribute (cost of SWM service per month).

Results and Discussion

Household willingness to pay for solid waste management services

The household’s willingness to pay (WTP) for solid waste management services were estimated for low income households in KM was TZS 7192.944 per month whereas, the WTP per month for high income households was TZS 16 313.682. The attributes of importance in the solid waste management services were; use of vehicles with covering materials such as nets to minimize littering of waste on road and improvements in frequency of solid waste collection from households to disposal sites. Low income households included households earning below TZS 500 000 per month while high income households included households earning TZS 500 000 and above. The households were categorized into 2 income groups so as to get better estimates of households’ WTP for solid waste services.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Available</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tipper trucks</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Compactor trucks</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Skip containers</td>
<td>0</td>
<td>250</td>
</tr>
<tr>
<td>Skip loaders</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Tractors</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Trailers</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>Wheel loaders</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Semi- trailers</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1: Existing and required solid waste management equipment in Kinondoni municipality.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tipper</td>
<td>12</td>
</tr>
<tr>
<td>Compactor trucks</td>
<td>4</td>
</tr>
<tr>
<td>Skip containers</td>
<td>0</td>
</tr>
<tr>
<td>Skip loaders</td>
<td>0</td>
</tr>
<tr>
<td>Tractors</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2: Solid waste management equipments owned by contractors in Kinondoni municipality.
The findings revealed that KM has inadequate solid waste management equipment as shown in Tables 1 and 2 above. The available solid waste equipment cannot afford to manage properly all the generated solid waste in the Municipality. Moreover, the few available Municipal solid waste management equipment are used to collect solid waste from public places such as markets, roadsides, commercial centers and few households located along the roads, hence households are required to find their own means of managing their solid waste. Budgetary constraints was cited by respondents to constrain the Municipality to purchase enough solid waste management equipment. Besides, the existing solid waste contractors do not have adequate facilities for managing solid waste as portrayed in Table 2. This activates the need to find sustainable ways of rising finances to support the purchasing of required solid waste management equipment.

### Households’ financial supports for solid waste management

From the study it was found out that a total of TZS 4,555,582,529.124 can be collected per month from all households in KM to support provision of solid waste management services (Table 3). This tells that a significant amount of income can be contributed from the households to support solid waste management in KM. The monthly solid waste charges can be given to solid waste contractors who deliver SWM services to households as the municipality necessitates the need for each ward to find its own solid waste contractor. Contrary to this, the monthly solid waste charges can be paid direct to the municipality for each ward to find its own solid waste contractor. Contrary to this, the municipality for example opt to use the estimated collection to purchase the proposed number (12 trucks) of collection trucks, each solid waste collection truck will provide services in three wards, but later on as solid waste charges will be collected every month, more solid waste collection trucks will be purchased and given to wards. From the study we learn that preferably, each ward should have its own solid waste collection truck.

The skip containers can be distributed to respective streets, and they should mainly be used to encourage communal collection of solid waste prior to waste collection exercise especially in areas which cannot be easily accessed by roads. Use of skip containers encourages collection and transportation of solid waste to disposal site [11]. The skip loaders will help in off-loading waste from the skip containers to collection trucks. Again, depending on the nature of the area, providers of SWM services can also opt to use wheel barrows to collect solid waste from houses which are not easily accessible by roads.

Furthermore, a total of 56 persons will be employed to work as drivers and waste collectors/assistants who will help in the collection of solid waste from households and transportation of the collected waste to a disposal place. Their number will keep on increasing as more waste collection trucks will be purchased from the households’ monthly collections of solid waste charges.

### Solid wastes equipment and improvement of solid waste management in urban areas

**Solid waste generation rate:** The study findings ascertained that the amount of solid waste generated by each household per day is 4.030 kg/household. On average, the per capita solid waste generation rate was estimated to be 0.804 kg/person/day in which the amount of solid waste generated per person per day in Mwananyamala ward was estimated to be 0.675 kg/person/day whilst in Kawe ward was 0.932 kg/person/day. The difference might be attributed due to the difference in income levels between the two wards, where the former is categorized as medium income area while the latter is categorized as high income area. This is regarded to be, since it was hypothesized in this study that income influences consumption and generation of solid waste. The
Additionally, Kasozi and Blottnitz [12] reported that the per capita solid waste generation in middle income settlements in Nairobi was 0.82 kg/capita/day. However, the study finding on solid waste generation rate exceeds the World Bank standards for developing countries which ranges from 0.4-0.6 kg/person/day. This justifies that solid waste generation is among the key environmental problems in KM. Community interventions are highly needed to support the collection, transportation and disposal of the generated solid waste. Table 5 below summarizes daily solid waste generation rate in the study area.

### Improvement of solid waste management

The findings of this study reveal that on average each household in KM generates 4.03 kg of solid waste per day (Table 5). This implies that a total of 1799 tons of solid waste are generated per day from 446,506 households present in the Municipality. On the other hand, it is anticipated that each solid waste collection truck will carry 3 trips per day to the disposal site. Considering this estimation then in each trip, 18 tonnes of solid waste will be carried, so each truck will carry 54 tonnes of solid waste per day to the disposal site. A total of 13,395 tons of solid waste can be recycled from a total amount of solid waste generated in KM.

### Recycling option

Recycling of solid waste could help to turn a volume of solid waste into useful resources which can be used in other production activities. According to the study findings in Table 8, about 24.82% of solid waste can be recycled; this constitutes plastic materials, papers and metal wastes. As households in KM generate 1799 tons of solid waste in a day (Table 6), about 447 tons (24.82%) of the generated solid waste can be recycled. A total of 13,395 tons of solid waste can be recycled from a total amount of solid waste generated by households in a month (53,970 tonnes).
Further, recycling programs will also have a financial motivation to households as they will be selling recyclable materials such as plastic bottles, polythene bags, aluminium among others to people engaging with recycling activities. In doing this households can recover some money from the generated solid waste which they can in turn use for payments of solid waste charges at the end of the month.

**Composting and energy generation options:** Biodegradable solid waste can be used for composting and generation of bio fuels. Mbuligwe and Kassenga [16] reported that composting can avail a reduction in landfill space exhaustion rate by more than 50%. Since 70.06% of household solid waste in KM comprised compostable waste such as food and garden waste (Table 6), this can be considered significant enough to warrant further planning of composting and bio fuel generation options rather than disposing in the landfill or dumpsite. Composting of biodegradable solid waste will result in generation of green manure which can be used by farmers in crop production. However, composting programs will require a large portion of land for composting the waste, given the congestion in the KM there might be limited space to establish composting programs as most of the available land is allocated for residential uses; the reduced volume to be dumped into landfills can provide such space for composting. On the other hand, biodegradable waste can be used to generate bio fuels such as bio gas [17]. Generation of bio fuels will help to reduce the volume of solid waste disposed to the landfill creating more space to be used for composting. Given the increased demand of energy especially in urban areas, bio fuel generation will supplement on the availability of energy. Bio fuel generation will also attract establishment of bio fuel industries thereby creating employment opportunities to people specifically youths. For all these options to be pragmatic action research is needed to learn on the practical outcomes.

**Conclusion**

This study investigated on the extent in which households in developing countries especially those in Sub-Saharan Africa can support their Municipalities in ensuring sustainable solid waste management. This is because most Municipalities lack financial resources to invest in solid waste management. The findings reveal that a total of TKS 4 555 582 529. 124 can be collected per month from households in KM to support delivery of solid waste management services suggesting that, the Municipalities can well support in sustaining their growing cities in SWM. The collections from the households can be used in several beneficial ways including purchase of solid waste equipment. The purchased equipment would help to collect about 36% of the solid waste generated per day to the disposal place considering the situation of KM which is revealed to have high rate of waste generation when compared to the average rate suggested by the World Bank. Besides, recycling programs would help to turn 25% of the solid waste generated per day into useful resources whereas composting and bio fuel generation would turn 70.06% of the solid waste generated per day into other useful products thereby saving landfill space needed to dispose biodegradable waste. Policy and decision makers in developing countries specifically those with similar settings to that of KM should use the findings of this study in establishing sustainable ways of managing solid waste in their respective urban areas. The findings of this study agree that households can have a significant impact toward sustainable solid waste management in urban areas once they are being involved in planning of SWM services. Recycling, composting and bio fuels generation programs can have huge impacts toward sustainable solid waste management in most urban areas of the region.

**References**


<table>
<thead>
<tr>
<th>Waste category/component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food waste</td>
<td>67.23</td>
</tr>
<tr>
<td>Plastic materials</td>
<td>18.63</td>
</tr>
<tr>
<td>Paper waste</td>
<td>3.65</td>
</tr>
<tr>
<td>Garden waste</td>
<td>2.83</td>
</tr>
<tr>
<td>Metals</td>
<td>2.54</td>
</tr>
<tr>
<td>Other waste</td>
<td>5.12</td>
</tr>
</tbody>
</table>

Table 8: Physical composition of household solid waste.
municipality, Dar es Salaam. AJIS 2: 1-12.

