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Residential Solid Waste in Dar es Salaam

*Survey and Measurement Evidence
from Four Informal Settlements*

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Abstract

Household solid waste management in Dar es Salaam's informal settlements presents myriad challenges, and public officials, waste haulers, non-governmental and community-based organizations, residents, and the donor community have undertaken numerous efforts to address these. In this short report, we seek to provide information to inform these efforts. We draw on a half-dozen investigations we organized in 2017 that studied four informal settlements in the city. These investigations examined characteristics of household solid waste itself and of waste collection, as well as attitudes and perceptions of residents regarding solid waste conditions and their preferences for different waste management schemes. While including such objective features as waste composition measurements, collection schedules, and collection fees, we focus on behavioral aspects of solid waste management that relate to household-level decisionmaking. We conclude by offering several observations related to risk communication.

Key Words: solid waste, waste composition, waste collection, waste payment, decision making under uncertainty, behavioral economic, behavioral public policy, risk perception, choice experiments, informal settlements, Dar es Salaam

Discussion papers report findings from research, policy analysis, and outreach, and are circulated to share information and promote discussion. They have not undergone formal peer review.

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Introduction

Dar es Salaam faces a well-known ongoing trash problem, with rampant illegal disposal of household solid waste evident to every resident and visitor in the city who travels outside the city center or Masaki. Accurate and precise estimates of the scale of the problem—the gap between generation of waste and its regular collection and disposal in a landfill—are not readily available, to the best of our knowledge, but widely-cited reports indicate that at least 2,000 tons per day find a fate in unsanctioned disposal. This includes illegal burning, burying, and dumping along roads, across open areas, and in stream courses. Such illicit disposal can exacerbate ground- and surface-water contamination, facilitate breeding habitat for disease vectors, and contribute to a higher frequency and magnitude of local flooding. Without question, it also degrades residential quality-of-life in the City.

We assume in circulating this short discussion paper that the reader already recognizes the above, and needs no convincing that household solid waste management in Dar lies in a perpetual crisis. Most of you know the issues well, given that this specialized brief aims at a specialized audience. Many organizations and individuals are already working assiduously and successfully on intervening in the crisis at multiple scales, from large-scale projects to develop a multi-million USD regional integrated waste management system to local, volunteer- cleanups lasting a few hours, and everything in-between. These efforts also have included data collection of both objective and subjective information related to household solid waste, much of it unfortunately scattered around offices like rubbish because no one has time to collect and deposit the information properly in a modern Word- or Excel-sanitary fill.

The simplicity of our paper's title—*Residential Solid Waste in Dar es Salaam*—belies its venture into multiple aspects of waste generation, collection, and management. We aim to add to the body of both objective and subjective information on solid waste in Dar, to augment technical “facts” and provide insights into attitudes and perceptions. We focus on:

- ✓ solid waste generation, weight and volume
- ✓ basic facts of household waste collection, including cost, frequency, and payment mechanics
- ✓ residents' satisfaction with waste collection and perceptions of its problems

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- ✓ residents' preferences for alternative payment collection schemes
- ✓ residents' attitudes and preferences regarding source separation

Some of our information covers what is already known and some ventures in new directions. We strive to remain terse, hoping this will encourage investing 20 minutes to read the whole. Our choice of brevity means that we do not fully excavate the data that we have gathered, but we encourage readers to follow-up with us via email on those topics that pique interest.

Most of what we share below centers on what we refer to for convenience as “behavioral” aspects of solid waste. This relates to how residents act out their preferences in solid waste practices, and what preferences they express when given a chance to think about practices they could undertake if given the chance. No hubris here, but we think the following could support changes or programs already underway and perhaps stimulate new thinking.

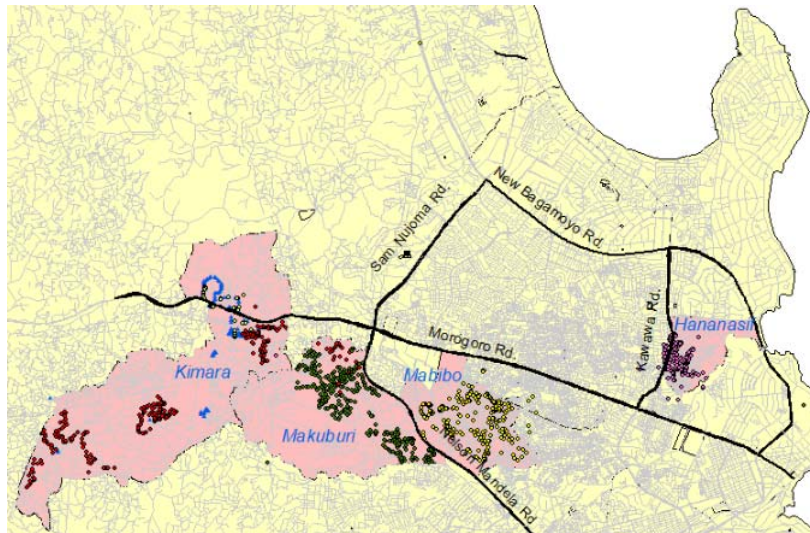


Figure 1: Location of Survey and Measurement Points

One last introductory comment. Our results come from six investigations in 2017—one measurement study ($n = 80$) and five surveys ($n = 1,239$)—in Dar on which we worked with Ardhi University affiliated individuals. We combine these investigations into five topics, **A-E** (some topics combine results from multiple investigations). In four of the six investigations, three then-current students used portions of the work to satisfy their Ardhi undergraduate thesis requirements (Pudensiana Paul, Oswald Oscar, and Isack Masha). In addition, one former Ardhi student (Clara John) worked with us. Students co-designed the investigations with us, so the studies represent a mix of perspectives, different levels of expertise and rigor in design and implementation, multiple research objectives, and varying experience in the field. This does not equate to a euphemism for “buyer beware,” but rather explains the variety of our solid waste themes and locations. Our investigations spread across Hananasi, Kimara, Mabibo, and Makuburi wards (Figure 1).

A. Solid Waste Weight and Volume Measurements

Dar lacks accurate and precise data on the total generation of waste, let alone a rigorous breakdown of its constituent parts. However, studies more-or-less consistently cite the figure of 4,000-4,500 metric tons/day (2014), or 0.9 kg/person/day (*e.g.*, Fecher 2016). We note Fecher's comment that this per capita estimate appears high by African standards, but Dar's non-residential waste stream may legitimately inflate this beyond comparable cities on the continent. In addition, most studies acknowledge that organic kitchen wastes constitute the largest single share of residential waste.

Topic A adds recent empirical evidence to prior estimates of waste generation. It presents field measurements by Oscar of the waste generated by each of 80 households in Kimara ward over a series of 6-day windows in April and May, 2017. Specifically, Oscar provided an empty bag to each household in day 0 of the study, asking each household to place all their waste in the bag for 2 days and recording the number of household members. On day 2, he returned to each household, separated the waste into ten different subcategories (column 1 in Table 1), and weighed and measured the volume of each subcategory, using weighing balances and 0.125-1.0 liter buckets. He repeated this procedure on day 4 and day 6, yielding three separate sets of measurement of two-day waste generation weights and volumes.

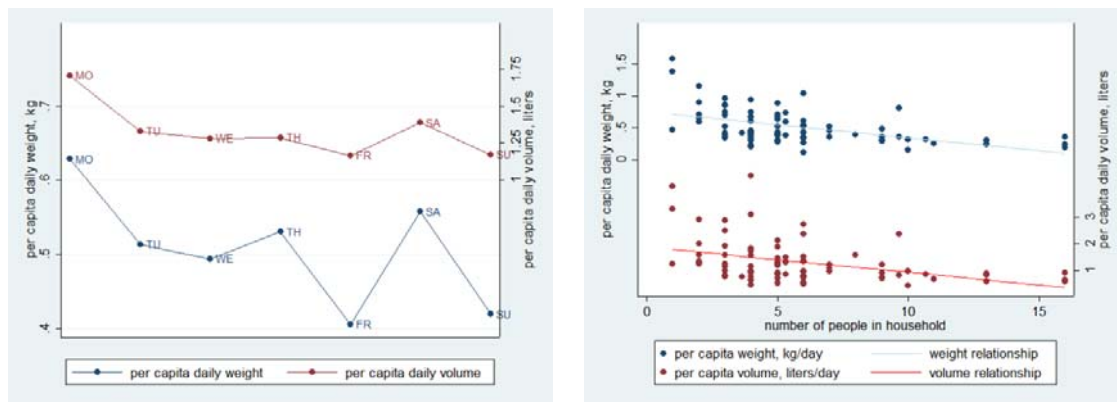
Table 1. Per-Capita Daily Waste Weights and Volumes: Kimara Ward, Ubungu

(1)	Waste Weight (kg/day/person)		Waste Volume (liters/day/person)	
	Mean (2)	Median (3)	Mean (4)	Median (5)
food	.31	.25	.60	.48
plastic	.05	.04	.22	.17
glass	.01	0	.02	0
paper	.03	.01	.14	.07
textile	.01	0	.04	0
aluminum	.01	0	.04	0
metal	.01	<.01	.05	<.01
pamper	.02	0	.03	0
e-waste	<.01	0	<.01	0
other	.07	.01	.19	.03
TOTAL	.51	.43	1.33	1.00
	25 th centile = .34 & 75 th centile = .64		25 th centile = .79 & 75 th centile = 1.57	

estimated from 3 measurements over a 6-day period at each of 80 households

Table 1 and Figure 2 show the results, normalized to daily averages per person. The two leftmost numeric columns in Table 1 presents the mean and median daily weight per capita for the overall waste stream, as well as for each of the ten subcategories of waste. The two rightmost numeric columns in Table 1 show analogous results for waste volumes. The bottom row lists the 25th and 75 centiles of the per capita overall weights and volumes. Food

waste not surprisingly makes up the majority of both overall waste weights and volumes. While it constitutes a significantly higher share of overall waste than in European and North American cities, it appears consistent with the greater share estimated in other east African cities (World Bank 2012, Pipatti and Vieira 2006, Karak, Bhagat, and Bhattacharyya 2012). Plastics, paper, and other (chiefly ashes and sweepings) comprise the bulk of the remainder. Per-capita overall mean weights and volumes are 0.51 kg/day and 1.33 liters/day, respectively, although some high waste households inflate this average. This overall figure lies close to estimated values from lower-income households in other African cities such as Accra (Miezah et al. 2015). Median weights and volumes lie significantly lower. Remember also that these waste generation estimates do not include non-residential waste streams.



A: Per-Capita Daily Weight/Volume, by Day of Week

B: Per-Capita Daily Weight/Volume, by HH Size

Figure 2: Per-Capita Daily Weights & Volumes, Day of Week and Household Size

Figure 2-A shows variation of weights and volumes over the course of the week. We do not know whether the high point on Monday reflects reflect profligate waste generation over the weekend or another feature that warrants attention in waste management system design (*e.g.*, to account for the higher weekend generation rates in pickup and disposal scheduling). Alternatively, it could derive from an artifact of the data collection design.

Figure 2-B shows a higher per-capita daily rate of waste generation in smaller households. This likely reflects other, uncontrolled for factors (such as income) in addition to likely economies of scale in waste generation resulting from increased household size. Regardless, if household size decreases have an independent effect on per-capita generation rates, this may have implications for waste loads in neighborhoods experiencing increasing populations with higher shares of smaller-sized households.

B. Waste Management

The practices and characteristics of waste collection and payment in Dar vary widely. **Topic B** documents this with results from five surveys that collected information from 1,239 residents.¹

Table 2 shows the mean and median values of three waste management measures:

- ✓ monthly cost to households of waste collection
- ✓ number of times household waste is collected per month
- ✓ number of household payments per month.

The table also displays the number of respondents supplying information on these measures in each ward, which differ among the measures; that is, the five surveys concentrated on different aspect of waste management and inconsistently overlapped on the three measure.

Table 2. Waste Collection Measures: Hananasif, Kimara, Mabibo, Makuburi Wards*

(1)	# Respondents (2)	Mean (3)	Median (4)
monthly fee, TSh	986	2,936	3,000
Hananasif	199	2,072	2,000
Kimara	285	3,074	3,000
Mabibo	240	2,977	3,200
Makuburi	262	3,405	2,000
collections/month, #	718	2.98	3
Hananasif	166	2.27	2
Kimara	49	3.96	4
Mabibo	239	2.23	2
Makuburi	264	3.94	4
payments/month, #	431	1.66	1
Hananasif	169	1.01	1
Kimara	--	--	--
Mabibo	240	2.28	2
Makuburi	--	--	--

*Located in Kinondoni (Hananasif) and Ubungo (Kimara, Mabibo, Makuburi) municipalities

The most commonly indicated (mode) monthly household waste collection cost is TSh 2,000/month, but this masks variety among the four wards. In general, households in our lowest

¹ We conducted two separate surveys in Kimara ward (John and Oscar). Mosha (Mabibo), John (Makuburi), and Paula (Hananasif) conducted the other three surveys.

economic status ward (Hanasif) have lower monthly collection fees and less frequent waste collection, while the opposite holds true for households in our highest economic status wards.² The current system involves a mix of payment at local government offices, payment to waste haulers, and payment to combined local government-waste hauler fee collectors (Table 3), often requiring multiple trips to individual households to find a responsible party at home. While over 93 percent of the 1,239 households we surveyed have at least one mobile phone in the household, none of our survey respondents used mobile money to pay waste collection charges.

Table 3. Waste Payment Collector: Hananasif, Mabibo, & Makuburi Wards*

who collects waste fee	Hanasif	Mabibo	Makuburi	Overall	Overall
(1)	%	%	%	%	count, <i>n</i>
	(2)	(3)	(4)	(5)	(6)
waste hauler	7.0	52.1	69.0	57.3	459
local government	87.8	26.5	4.2	27.2	218
waste hauler & local government	5.2	21.3	26.8	15.5	124
Total	100.0	100.0	100.0	100.0	801
<i>n</i> , ward sample	172	211	261	801	

*Located in Kinondoni (Hanasif) and Ubungo (Mabibo, Makuburi) municipalities

We lack reliable data on the proportion of households who regularly pay waste collection fees and therefore, by assumption, dispose of waste legally. However, qualitative evidence from one of Paul's interviews of a local government official in Hananasif indicate that in one mtaa in the ward, 40 percent of households do not pay for waste collection, relying instead on unsanctioned dumping, burying, or burning. As Table 4 shows, John's surveys of 260 and 328 households in Kimara and Makuburi wards, respectively, suggest that while the majority of households in each ward use a private waste hauler to dispose of their waste, a significant percentage burn, bury, or dump their wastes (over one-quarter of households in the two wards combined). These figures likely understate the prevalence of these illegal disposal methods since they rely on self-reporting.³

² We did not collect income data, but rather constructed an assets proxy by combining data reported by respondents on house ownership, ownership of other land, presence of non-family domestic help, number of sleeping rooms, presence of refrigerator in household, and whether the household shared their toilet with other households.

³ For instance, more than 90 percent of residents in Kimara that John asked about illegal dumping indicated that they saw illegal dumping in their ward at least one time in the previous month and nearly 20 percent reported seeing such dumping 5 or more times. In the lower income Makuburi ward, all residents asked about dumping had observed dumping in their mtaa and over one-half said they observed it 5 or more times in the previous month.

Table 4: Waste Disposal Means by Household: Kimara & Makuburi Wards, Ubungo

waste disposal method	Kimara	Makuburi	Overall	Overall
(1)	% (2)	% (3)	% (4)	count, <i>n</i> (5)
private waste hauler	60.4	79.6	71.1	418
burning	28.5	6.1	16.0	94
burying	10.0	4.9	7.1	42
dumping vacant area	1.2	9.5	5.8	34
Total	100.0	100.0	100.0	588
<i>n</i> , ward sample	260	328	588	

Finally, responses to Oscar's survey of 200 households in Kimara indicate that roughly one-half the ward's households must store their waste for two weeks or more before its pickup, sometimes for more than one month. They use a mix of sulphate bags, dustbins, buckets, and plastic bags for this storage. When waste pickup day arrives, most households he surveyed (61 percent) must bring their waste to the collection vehicle, rather than the more convenient option of leaving it on the street for pickup. Mosha's survey of Mabibo ($n = 240$) indicates 80 percent of households there must bring their waste to the collection vehicles.

C. Attitudes re Solid Waste Management

The preceding two sections provide largely objective data; that is, Topic A and Topic B both cover factual, verifiable characteristics of solid waste management in our study area. **Topic C**, in contrast, covers respondents' perceptions on solid waste management in their neighborhoods.

We start with information that Paul collected in Hananasif about perceived risks associated with solid waste. Over 80 percent of that ward's 200 respondents agree or strongly agree that solid waste in the ward threatens their well-being and environment; 40 percent that it has a high or extremely high impact on public health; and 20 percent that it likely or very likely contributes to flooding. These results represent perceptions about uncertain relationships, rather than actual observed physical conditions in the ward. However, such perceptions can influence behavior and because the situation entails uncertainty, well-recognized psychological factors may determine the decisions that residents take in response to their perceptions.

Detouring for a moment, we see an important example of one such psychological factor in a small exercise we asked our Hananasif sample residents to perform. Leaving aside most details, we asked one group of our respondents to select between two hypothetical options that would result in the loss of a large number of houses in their neighborhood from a hypothetical flood. One of the options would *guarantee* that some of the houses would be *lost* to flooding (and *guarantee* the other ones would not be *lost* to flooding). The other, uncertain option would have a 75 percent chance that all of the houses would be *lost* to flooding and a 25 percent chance that none of the houses would be *lost* to flooding. We provided enough information to the respondents to characterize the expected outcomes as numerically equivalent between the two options. Most respondents chose the second, uncertain option of gambling that they would not lose any of the houses to flooding (at the risk of losing all of the houses). This indicates a preference for risk taking. We then asked another group of our respondents a similar hypothetical situation with the same numbers, but described the options as a *guarantee* of *saving* some of the houses from flooding (and *guarantee* the other ones would not be *saved* from flooding) vs. an uncertain option of 25 percent chance of *saving* all of the houses from flooding and a 75 percent chance of *saving* none of the houses from flooding. Most respondents in this second group chose the first, guarantee option that they would save some of the houses from flooding. This indicates a preference for risk aversion. The two groups faced identical situations except for the choice of words to describe the outcomes. The preference for risk-aversion in the context of gains (saving houses) and risk-taking in the context of losses (losing houses) is a well-recognized and common phenomenon in decision-making under uncertainty. It may seem

irrelevant to waste management in Dar, but framing a choice as one of *gains* or as one of *losses* can influence the willingness of residents to undertake different waste management actions. We briefly return to this point in the final section of the report.

Going back to more familiar ground, Table 5 shows a general impression of household solid waste collection in our study wards.⁴ The level of satisfaction ranges widely across the four areas, with the higher-asset Kimara (column 3) clearly exhibiting the most general dissatisfaction (nearly three-quarters of respondents identify some dissatisfaction) and the most intense dissatisfaction. Well over one-half of Makuburi respondents (column 5) indicate some level of satisfaction with waste collection, in contrast, and over one-third self-identify as very or extremely satisfied. Aggregating across the 858 responses in the four surveys (column 6), similar proportions express dissatisfaction as satisfaction.

Table 5: Satisfaction with Waste Collection: Hananasif, Kimara, Mabibo, & Makuburi Wards*

	Hananasif	Kimara	Mabibo	Makuburi	Overall	Overall
(1)	%	%	%	%	%	count, <i>n</i>
	(2)	(3)	(4)	(5)	(6)	(7)
extremely dissatisfied	(a)	7.6	0.4	1.9	2.1	18
very dissatisfied	13.1	37.6	7.5	3.0	12.9	111
dissatisfied	32.3	28.0	30.0	15.2	25.6	220
neither dissatisfied nor satisfied	8.1	12.7	33.3	22.1	20.3	174
satisfied	37.4	11.5	28.7	22.8	25.8	221
very satisfied	9.1	2.5	0.0	25.5	10.4	89
extremely satisfied	(a)	0.0	0.0	9.5	2.9	25
Total	100.0	100.0	100.0	100.0	100.0	858
<i>n</i> , ward sample	198	157	240	263	858	

*Located in Kinondoni (Hananasif) and Ubungo (Kimara, Mabibo, Makuburi) municipalities

(a) measured on a 5-point scale

Our interviews with ward residents and government officials suggests dissatisfaction with solid waste collection typically reflects discontent with both its cost and effectiveness, the latter representing a basket of problems encountered in collection. To excavate this, Table 6 shows the significance that residents in Makuburi and Mabibo place on different solid waste challenges. We have condensed the results to ease presentation from a 7-point scale (extremely insignificant to extremely significant) to a 3-point scale that comprises highly insignificant (original scale 1-2), in-between significance (original scale 3-5), and highly significant (original scale 6-7). The

⁴ The four different surveys use slightly different wording to ask about household satisfaction with collection services (level of satisfaction with solid waste collection from household vs. level of satisfaction with the waste collection service provided). Three of the four surveys use a 7-point response scale (extremely dissatisfied to extremely satisfied) and one uses a 5-point scale (very unsatisfied to very satisfied).

most striking finding relates to the divergence between the two wards. Roughly two-thirds of respondents indicate high significance of the timing of collection, rain delays, and collection frequency problems in Mabibo, but less than one-third of Makuburi residents indicate high significance for any of these.

**Table 6: Perceived Significance of Collection Problems:
Mabibo & Makuburi Wards, Ubungo**

	Mabibo	Makuburi	Overall
	%	%	%
(1)	(2)	(3)	(4)
costs			
highly insignificant	9.6	73.4	41.7
in between significance	43.8	12.3	27.9
highly significant	46.7	14.3	30.4
<i>Total</i>	<i>100.0</i>	<i>100.0</i>	<i>100.0</i>
untimely collection			
highly insignificant	0.8	39.8	20.5
in between significance	33.3	29.9	31.6
highly significant	65.8	30.3	47.9
<i>Total</i>	<i>100.0</i>	<i>100.0</i>	<i>100.0</i>
rain delays			
highly insignificant	0.4	42.2	21.5
in between significance	36.3	34.8	35.5
highly significant	63.3	23.0	43.0
<i>Total</i>	<i>100.0</i>	<i>100.0</i>	<i>100.0</i>
collection frequency			
highly insignificant	0.4	80.7	40.9
in between significance	32.1	14.8	23.3
highly significant	67.5	4.5	35.7
<i>Total</i>	<i>100.0</i>	<i>100.0</i>	<i>100.0</i>
leftover waste			
highly insignificant	4.2	62.3	33.5
in between significance	67.1	20.5	43.6
highly significant	28.7	17.2	22.9
<i>Total</i>	<i>100.0</i>	<i>100.0</i>	<i>100.0</i>
collection noise			
highly insignificant	38.3	100.0	69.4
in between significance	61.7	0.0	30.6
highly significant	0.0	0.0	0.0
<i>Total</i>	<i>100.0</i>	<i>100.0</i>	<i>100.0</i>
<i>n, ward sample size</i>	<i>240</i>	<i>244</i>	<i>484</i>

We also see some differences between the two wards in the perceived significance of collection noise. All 244 Makuburi residents indicate that it an insignificant problem, whereas only a bit more than one-third of Mabibo residents note this. Furthermore, more than three times as many Mabibo respondents as Makuburi respondents indicate cost as a highly significant problem. In a separate question not included in Table 6, 80 percent of Mabibo respondents note they agree or strongly agree with a statement that collection costs are too high in the ward.

D: Preferences for Alternative Payment Collection Schemes

Ideally, public officials would address all of the concerns residents have with waste collection in their neighborhoods implied by Table 5 and Table 6. However, limited resources obviously necessitate tradeoffs among different elements of the system. We investigate these tradeoffs⁵ in **Topic D** with an approach relying on a series of so-called “choice experiments” that John conducted in Makuburi. We do not want to disappear into a rabbit hole explaining the intricacies of this technique or detailing the statistical model used to analyze the results of the experiments, but to motivate understanding of the results, we briefly describe the approach.

A waste collection system has characteristics that individuals care about directly, such as its cost to households and the frequency of waste collection. We call these characteristics “attributes.” Each attribute has different possible “levels.” For example, the cost could be 2,000 TSh/month, 3,000 TSh/month, and so forth, while the collection frequency could be 1 collection/month, 2 collections/month, or more. Households generally face a tradeoff between attributes. A desired higher frequency of collection likely requires an undesired higher cost, for example. Survey choice experiments present different hypothetical combinations of attributes and different levels of these attributes, and ask respondents to select the alternative combination they most prefer. Respondents cannot cherry-pick the attribute levels they most prefer in each experiment—the lowest cost and highest collection frequency—but instead must choose among the alternative combinations each experiment offers. By presenting multiple experiments with different combinations of attribute levels and recording the choice in each experiment, we can employ a simple statistical model to estimate the relative importance respondents place on each attribute.

Table 7 shows the solid waste collection system attributes that we examine in our Makuburi choice experiments. As displayed in Table 6 and accompanying discussion, many of our survey respondents indicate that untimely collection, rain delays, and/or the collection schedule pose highly significant problems, particularly in Mabibo. Nearly one-half of that ward’s respondents indicate collection costs also present a highly significant problem. This suggests the attributes related to the *cost, frequency, and reliability of waste collection* that appear in Table 7.

In addition, our earlier discussion in Topic B notes that fee collection in the wards requires personal visits to either individual households or mtaa offices by a mix of waste haulers, local

⁵ The word “tradeoff,” a fundamental concept in economic theory and practice, interestingly does not have a simple Kiswahili equivalent.

government officials, and residents. In interviews the students conducted as part of their studies, some subjects recommended a simpler system with a single entity collecting payment. Some also suggested larger, less frequent payments (such as monthly rather than weekly fee collection). Others, in contrast, advocated for smaller, more frequent payments, which lower-income households might find easier to accumulate funds to meet. This suggests the attributes *entity collecting payment* and the *frequency of payment collection* that appear in Table 7.⁶

Table 7: Attributes and Levels in Makuburi Waste Payment Choice Experiments

<i>Attribute/variable</i>	<i>Level 1</i>	<i>Level 2</i>	<i>Level 3</i>
<i>costcollect</i> : cost per month of waste collection...	1,000 TSh to 10,000 TSh (scaled in 1000s TSh)		
<i>payfreq</i> : # payments per month...	1	2	4
<i>collectfreq</i> : # times waste collected per month...	8	4	2
<i>entity</i> : entity collecting payments...	local government	both hauler and local government	private hauler
<i>reliable</i> : schedule payment collection guaranteed...	no	yes	

each alternative contains one level for each of the five attributes

Table 8 displays the output from our statistical analysis of the results from John’s choice experiments. The litany of numbers seems imposing, but interpretation focuses on the rows with “yes” in column 3 (indicating statistical significance at the 0.01 level) and whether the column 2 numbers in those rows fall above or below 1.0. These column 2 figures represent odds-ratios, which we will not formally explain here except to note that an odds-ratio below 1.0 indicates a dislike of higher levels of the attribute and one above 1.0 a preference for higher levels of that attribute. Our *costcollect* attribute exhibits a value of roughly 0.43, thus denoting the obvious, a dislike of higher monthly costs of collection (in an additional analysis, not appearing in Table 8, lower asset household dislike higher costs even more than do higher asset households). The next attribute with statistical significance, *payfreq-4*, exhibits a value exceeding 1.0 (1.39) indicating a preference for paying collection fees 4 times/month. It is not that individuals like to pay these fees, but rather that they prefer paying 4 times/month rather than the alternative of 1 time/month

⁶ In a more ideal world, the waste fee payment system could work automatically, or at least through a electronic mobile money arrangement. Evidence from Oscar’s Kimara and Paula’s Hananasif survey indicate half or more of households in those two wards already pay for electricity, water, or TV via mobile money, suggesting this could be a useful attribute to investigate for waste fee collection. However, we exclude a mobile payment attribute from our analysis because our qualitative interviews suggest that respondents currently have too little faith in the performance of waste collectors to be willing to actually prepay for services with mobile money, suggesting that answers to any hypothetical choice experiments that assume prepayment might prove unreliable.

or 2 times/month. The magnitude of the odds-ratios for *collect-freq2* and *collect-freq4* signal a dislike of 1 time/month collections, and a preference for 4 times/month collection, respectively. The final significant odds-ratio appearing in Table 8, *entity-govt* (1.39), evidences a preference for a local government official to collect payments rather than the alternatives of a private hauler alone or a combined private-government fee collector.

Table 8: Payment Choice Experiments: Makuburi Ward, Ubungo

<i>Attribute</i> ⁷ (1)	<i>Odds-Ratio</i> (2)	<i>Statistically Significant</i> (3)
<i>costcollect</i>	0.4271	yes
<i>payfreq-1</i>	0.9219	no
<i>payfreq-2</i>	0.8695	no
<i>payfreq-4</i>	1.3868	yes
<i>collectfreq-2</i>	0.0565	yes
<i>collectfreq-4</i>	3.3591	yes
<i>collectfreq-8</i>	1.0114	no
<i>entity-govt</i>	1.3878	yes
<i>entity-private</i>	0.9704	no
<i>entity-both</i>	0.8845	no
<i>reliable-yes</i>	1.0205	no
<i>reliable-no</i>	0.9607	no

n, ward sample, = 300 respondents (1,030 choices)

Much of this may seem obvious, but we can use the regression results to estimate both the relative priority of specific characteristics of the waste collection system compared to other characteristics, and the economic value that individuals place on specific characteristics. For the former, the relative ratio of regression coefficients (not the ratio of the odds-ratios appearing in Table 8, but rather the ratio of the regression coefficients from which we calculate the odds-ratios) reveals their relative weighting. For instance, our results suggest that having a governmental entity collect payment has about the same priority as collecting payment four times/month, but the waste collection schedule is over three times as important as each of these. With a bit more hand waving, we also can say that the average Makuburi resident we surveyed places an economic value of nearly 400 TSh/month on having a governmental entity collect the payment (rather than a private hauler or a combined private hauler-government entity).

⁷ We use weighted-effects coding in our analysis, which allows us to model all levels of our categorical variables.

E. Preferences for Source Separation Schemes

We utilize choice experiments again in **Topic E**, where we investigate household preferences for source separation interventions in Kimara. As we all know, Dar’s municipalities lack any significant, large-scale source separation program for households, with a number of obstacles impeding successful implementation of such programs at scale. Nonetheless, Oscar’s measurement and survey work in Kimara reveals opportunities to promote the separation of waste into different streams, both in terms of the potential efficiencies in doing so and the apparent prevalence of households that already undertake such actions.

Nearly 40 percent of the 200 residents surveyed by Oscar report they separate wastes on their own. The top row of results in Table 9 shows food waste as the most frequently separated waste (over 25 percent), accounting for nearly two-thirds of Kimara respondents who do any separation. Plastic represents the only other waste that at least 10 percent of households in the ward separate. Roughly 40 percent of the residents who separate give the separated waste to pickers/scavengers, another 40 percent re-use it within their household, and 20 percent sell it to waste collectors.

Table 9: Households Separating Different Waste Streams: Kimara Ward, Ubungu

type of waste separated (1)	Yes %	Yes Count, <i>n</i>
	(2)	(3)
<i>food waste</i>	25.5	51
<i>plastic</i>	10.5	21
<i>glass</i>	3.5	7
<i>aluminum</i>	2.5	5
<i>other metals</i>	3.5	7
<i>paper</i>	1.5	3
<i>overall</i>	39.0	78
items promoting separation	Agree %	Agree Count, <i>n</i>
<i>provision of bags for separation</i>	80.0	160
<i>provision of bins for separation</i>	84.5	169
<i>increase collection frequency</i>	55.0	110
<i>increase neighborhood collection points</i>	67.0	134
<i>decrease collection cost</i>	45.5	91
<i>charge only for collection of non-recoverable waste</i>	26.5	53
<i>mtaa receives revenues for recoverable waste</i>	41.0	82
<i>household receives revenue for recoverable waste</i>	72.5	145
<i>penalize households not separating</i>	45.0	90
<i>n, ward sample size</i>	200	

The bottom of Table 9 displays Kimara residents’ perspective on changes that might promote more waste separation in the ward. The figures in column 2 represent the percentage of all

respondents who agree, strongly agree, or very strongly agree that the item listed in column 1 “may promote solid waste source separation at your household.” More Kimara households agree that the provision of physical items to facilitate separation—specifically bags and bins—would promote separation than would waste management modifications such as changes to the frequency of collection or the way charges are assessed. A large percentage also agree that recycling of revenues from waste recovery to households would increase household separation.

We use the attributes listed in Table 10 to examine such intercessions via the same kind of hypothetical choice experiments as we described in Topic D. In particular, John presented different hypothetical combinations of attribute levels from Table 10, and asked respondents to select their preferred combination. The specific request stated if “your household were now required to separate its household waste, which of the below options would you prefer.”

Table 10: Attributes and Levels in Kimara Source Separation Choice Experiments

<i>Attribute/variable</i>	<i>Level 1</i>	<i>Level 2</i>	<i>Level 3</i>
<i>costcollect</i> : cost per month of waste collection ...	500 TSh to 5,000 TSh (scaled in 1000s TSh)		
<i>frequency</i> : # times waste collected per month ...	8	4	2
<i>penalty</i> : fine imposed for not separating ...	10,000 TSh or less	more than 10,000 TSh	
<i>revenue</i> : revenue from waste recovery ...	households receive some revenues	government receives all revenues	no revenues
<i>incentives</i> : carrot to promote source separation ...	free bins to households	neighborhood collection points	none

each alternative contains one level for each of the five attributes

Table 11 uses odds-ratios again to report the relationships our source separation choice experiments reveal. Remember, ratios under 1.0 indicate a dislike of higher levels of that attribute, and ones above 1.0 a preference for higher levels. Intuitively, the odds-ratio of 0.5 for *costcollect* confirms dislike of higher monthly costs of collection, with lower asset households once more disliking higher costs even more than do higher asset households. Similar results as before also appear with respect to the frequency of collection, namely a dislike of low frequency waste collection (the *collectfreq-2* odds ratio of 0.83). Directly germane to separation, residents favor the provision of bins and neighborhood collection points (*incentive-bin* and *incentive-neighbor*) and dislike the lack of incentives (*incentive-none*). They also prefer higher rather than lower penalties (*penalty-high* vs. *penalty-low*), a counterintuitive result possibly reflecting a belief that higher penalties will motivate neighbors to separate. Finally, the dislike of sharing revenues with the household or mtaa (*revenue-household* and *revenue-govt*) results from the

framing of the choice experiments, where *revenue-none* represents the status quo. We have found in much of our work that a large proportion of households indicate a preference for the status quo, an important risk averting strategy that will complicate any intervention in waste collection depending on changing respondents' behavior.

Table 11: Source Separation Choice Experiments: Kimara Ward, Ubungo

<i>Attribute</i> ⁸ (1)	<i>Odds-Ratio</i> (2)	<i>Statistically Significant</i> (3)*
<i>costcollect</i>	0.5017	yes
<i>collectfreq-2</i>	0.8275	yes
<i>collectfreq-4</i>	1.0405	no
<i>collectfreq-8</i>	1.0906	no
<i>penalty-low</i>	0.9199	sort of
<i>penalty-high</i>	1.1427	sort of
<i>revenue-household</i>	0.3239	no
<i>revenue-govt</i>	0.2792	yes
<i>revenue-none</i>	10.7424	yes
<i>incentive-bin</i>	7.1456	yes
<i>incentive-neighbor</i>	6.4612	yes
<i>incentive-none</i>	0.2081	yes
<i>n</i> , ward sample, = 300 respondents (1,198 choices)		

***yes** indicates significance at a 0.05 level, **sort of** indicates significance at a 0.10 level

We can perform the same kind of cheap parlor tricks interpreting these results as we did with the payment choice experiments in Topic D. The ratio of our regression coefficients in our Kimara source separation model indicate that offering separation bins to increase separation has about the same priority as establishing neighborhood collection points at which residents can deposit separated material. The likelihood of selecting a system that offers bins compared to an otherwise identical system that does not offer bins is nearly 90 percent. And both bins and neighborhood collection points appear more than 10 times as important as instituting a penalty to encourage separation. For those who like tradeoffs expressed in monetary terms, receiving separation bins offers an equivalent economic value of almost 3,000 TSh/month. In addition, cutting waste collection to two collections/month has an equivalent economic cost of roughly 300 TSh/month.

⁸ We again use weighted-effects coding, which allows us to model all levels of our categorical dummy variables.

Takeaways

We recognize that we have raced through the large amount of data that John, Mosha, Oscar, and Paul collected, presenting only some of the highlights. As already noted, we want this paper read. We also appreciate that the last two sections—Topics D & E—employ a statistical approach that some may find obscure or confusing. However, we undertake that analysis because it highlights an essential element of waste management that we believe does not get enough attention from the public sector, donor, and NGO community, namely behavioral elements of households and their preferences for different tradeoffs in the waste management system. In this vein of behavioral facets (and in the spirit of brevity!), we conclude with four quick observations, teasers really, to inform solid waste discussion moving forward.

- ✓ The household residents we surveyed in Hananasif, Kimara, Mabibo, and Makuburi appear unusually risk-averse; that is, most indicate a preference for retaining the status quo, even if they state that the status quo is undesirable and an alternative better than it on technical or scientific grounds. This does not equate to irrational behavior, but rather reflects the importance of trust, familiarity, and insecurity in shaping decisions in the face of uncertain situations. Ignoring these subjective, non-scientific risk factors paradoxically may mean losing the opportunity to take advantage of them.
- ✓ The presence of risk aversion and hesitation to deviate from the status quo suggests that proactive risk communication that takes advantage of recent insights into human behavior warrant more attention. While we see justified enthusiasm within the academic and donor communities for disseminating technical and scientific risk information to provide individuals with a more informed, “objective” base for household-level decision-making on solid waste, we see much less effort at interventions that “nudge” people to take actions advantageous to them and to society at large.⁹ Such ventures occupy the realm of behavioral economics and public policy. They make it easier for individuals to take

⁹ More frequent payment of waste charges represents one nudge that may impel beneficial behavior, as noted in our Topic D discussion, particularly if the payment mechanism itself becomes less burdensome (*e.g.*, mobile money). More prospectively, we have explored in two of our study wards support for a system where waste collection payments would go into a chance-based lottery that randomly awards cash prizes to participants. The more regularly an individual or mtaa pays for waste collection, the greater the chance of winning an award. The approach would be revenue neutral. This concept draws on lottery-linked savings accounts, an approach already implemented in parts of the world to increase household savings. Of the 484 residents we surveyed in Mabibo and Makuburi, 55 percent indicated potential interest in participating in the lottery system if it were implemented.

beneficial actions, exploit mental shortcuts individuals use in decision-making, or draw on social preferences and identity concerns (to appear as a good social actor) to motivate beneficial behavior. The legacy of *ujamaa* in post-independence Tanzania suggests optimism (and caution) that actions targeting behavior that draw on community-integrity and concepts of prestige, success relative to others, and/or self-esteem could improve solid waste conditions as communal efforts arguably have in other east African settings.¹⁰

- ✓ The framing of actions may make a difference in how well a solid waste intervention performs by influencing the willingness of households to undertake actions that change their behavior. We saw from our hypothetical exercise in Hananasif (Topic C) that residents express risk aversion when a choice is framed as one of balancing gains and a willingness to take risks when a choice is framed as one of balancing losses. Neither risk aversion nor risk taking are intrinsically better, but the social desirability of the outcomes from the two types of behavior may differ from a policy perspective. If so, then careful attention to the framing of waste interventions may lead to more desirable outcomes.
- ✓ The potential to recover economically valuable components from the solid waste stream needs continuing attention and openness to opportunities. It already takes place in some areas—as much as 4 out of 10 households as we saw from Oscar’s survey—with minimal or no programmatic support. The still on-going (as far as we know) efforts to develop the Kinondoni pilot compost plant at Mabwepande for market wastes could have positive effects on smaller-scale, residential waste composting efforts such as The Recycler’s black soldier fly project for high-protein, small-scale animal feed operations (nearly 10 percent of our 1,200 plus households in Hananasif, Kimara, Mabibo, and Makuburi keep 1 or more chickens). We recognize the high obstacles to source separation and maintaining uncontaminated single waste streams, and, in particular, the poor track record everywhere of maintaining the viability of composting on a large-scale. But the reality of organic waste dominating the waste stream (median of two-thirds of the total waste weight and one-half of the total waste volume on some days) points to opportunities as well as challenges in waste recovery.

¹⁰ For example, numerous commentators (Uwimbabazi 2012, Kulenovic and Cech 2015, Dagan 2011, Rwanda Environment Management Authority 2013) have pointed out that the the pre-colonial legacy and post-genocide practice of *umugandai* in Rwanda—loosely translated as “community work”—undergirds broadly successful collective efforts at community-based solid waste cleanups that have helped make Kigali largely clean and litter free.

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