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Practice and Determinants of Solid Waste Collection: The Case of Private Collectors in Five Ethiopian Cities

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Abstract

Forty private companies involved in solid waste collection (SWC) in five Ethiopian cities were studied to identify key factors affecting their service performance. Investments, operational management capability and regulation are the factors investigated. The major determinants of SWC according to a regression analysis are number and carrying capacity of vehicles, distance from disposal sites and (unobserved) city characteristics. Route planning and a more flexible contract substantially increase collection. Investments in SWC depend on access to capital by the private companies. Different experiences of regulation (scope of contract) on SWC have been noticed. Service contract arrangements are impediments in Mekelle. While, service zoning allows competition in Addis Ababa, Hawasa and Bahir Dar. Rectifying the challenging nature of the contracts for private sector involvement (PSI) in SWC is vital so that the cities with large heaps of solid waste left uncollected become clean. The study findings suggest that for a number of reasons the Ethiopian government needs to entrust private companies with opportunities for more meaningful and sustainable involvement in SWC. We recommend that the contract shall also have conditions concerning sustainability.

Keywords: Solid waste collection; Operational management; Route planning; Management capability; Private sector involvement; Regulation by contract

Introduction

Good living conditions require services to be provided and maintained appropriately, even though they may be costly [1]. Solid waste collection (SWC) is critical for public health, for protecting the urban environment and for the image of cities. Henry and Yongsheng [2] state that the primary targets of municipal SWC are protecting the health of the population, promoting environmental quality, developing sustainability and providing support to economic productivity. Kassim and Ali [3] add that inadequate collection and disposal of solid waste are major factors that spread disease and cause environmental degradation.

Current paper investigates the SWC carried out by private firms in five Ethiopian cities. In the last few decades, Public-Private Partnerships (PPP) have become prominent vehicles for investments in and the provision of SWC services in several countries. Chan et al. [4] argue that there are two main reasons behind this trend. One reason is the restrained capacity of public finance to bear the costs of new equipment. The other reason is the increased need for proper public services delivery which requires innovative capacity and management skills in private partners and more adequate risk and task-sharing among partners. Private partners have often been conducive to higher value for money in public policies [5].

The review of academic contributions on achieving integrated sustainable solid waste collection with PSI still shows a slit on the drivers to achieve sustainable solid waste management practice in the context of the developing countries. This article provides insights in the practice of private sector SWC and sheds light on the factors influencing SWC performance in five Ethiopian cities.

There are various definitions for sustainable solid waste management. Dorvil [6] states that sustainability aims at providing the best outcomes for the human and natural environment, both now and in the future. It is a concept relating to the continuity of economic, social, institutional and environmental aspects of human society. Sustainable SWM involves a system that is capable of maintaining itself over a long time without reducing the resources it needs [7]. Common to most definitions of sustainable SWM are the three important interrelated aspects of environmental (planet), financial (profit) and social (people) sustainability. Environmental sustainability requires waste, which currently imposes a great burden on the environment, to be considered as a resource that should be trans¬formed in a closed-cycle system. This can be done by restoring various natural cycles, which in turn leads to a smaller loss of raw materials, energy and nutrients.

Oduro-Kwarteng's [8] and Wilson et al. [9] forwarded a cycle, which contains four stages to improve SWM: (1) further institutional development and improved service performance; (2) improved customer satisfaction and public awareness; (3) improved cost recovery and financial performance; and (4) sustainable levels of investment. Besides, studies by Cointreau-Levine and Gopalan [10] and Dorvil [6], which focus on private sector participation in municipal SWM in terms of efficiency, are also considered for this study.

Our framework for analysing sustainable SWC has five components. The first component (C1) is the institutional arrangement for SWC, i.e., the details of the policy, legal and institutional framework for service provision [9]. The second, C2, provides an insight into the capacity of private collectors. The third, C3, is the analysis of the elements of regulation, the contractual rights and the contractual obligations of public and private sectors. The fourth, C4, is the analysis of private enterprises' performance, which aims to provide insight into factors

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affecting the amount of waste collected. Finally, the fifth, C5, leads to a feedback loop after investigating the components from C1 to C4, the drivers for sustainable waste management. The identification of these drivers for sustainability can provide feedback for capacity improvement and changes in the policy and legal framework. The conceptual framework is illustrated in Figure 1.

In the last few decades, PPP have become prominent vehicles for provision of SWC services in several countries. Barton et al. [11] and Cointreau-Levine [12] stated 20 years ago that the rationale for private sector involvement (PSI) in solid waste management (SWM) is that the private sector brings management expertise, technical skills and the ability to finance investment and achieve greater efficiency and lower cost. In addition, studies note that private sector participation is an opportunity to enhance efficiency and mobilise private investment [10,13-16]. Case studies of PSI in SWM in some developing countries [6,17-20] show increased PSI and coverage in some developing countries.

However, Batley and Larbi [21] and Koppenjan and Enserink [22] indicate the challenges facing PPP due to the private sector's focus on short-term returns on investment. Katusiimeh et al. [23] indicates the lack of regulation and transparency in Uganda for PSI. Tilaye and van Dijk [5] underline the importance of the consistency in policy of the state in shaping the developmental role of the private sector.

To achieve efficiency by private partners, competition, performance monitoring and accountability are compulsory [24]. In addition, the stimulation of competition for the market, a reduction of information asymmetry and reduction of transaction costs are required [8]. Some studies suggest that the efficiency of the private sector depends on the capacity of local government institutions to regulate and monitor performance and the capacity of the private companies to recover their cost [8,18,25,26]. Likewise, internal and external factors such as operational inefficiency, weak capacity and regulation, which could affect the service quality and sustainability of private sector service delivery, are important for improving SWC, indicates improving service delivery requires constant measurement against established standards of performance. The argument in performance evaluation literature indicates that performance is a multi-dimensional construct argue that most performance measurers center on four aspects on input measurement where the focus is on resources used to produce products and services: activity measurement focusing on actions taken to produce products; output measurement focusing on volume of products and services produced; and outcome measurement focusing on the impact of products and service produced.

The efficiency and effectiveness of SWC require system analysis

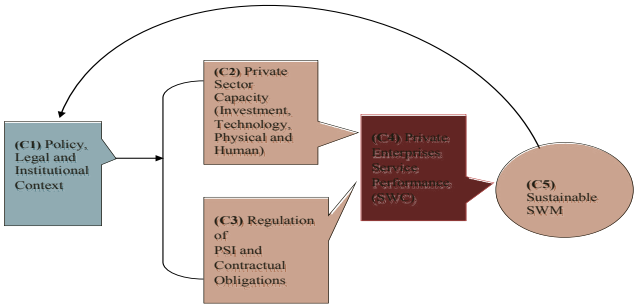

Figure 1: Conceptual framework for private SWC from sustainable SWM perspective.

and optimization of operations. The inability to do so usually leads to inefficient use of time and resources which, in turn, eventually results in high cost of collection service, low productivity and poor service quality.

Some indicators for SWC efficiency and effectiveness are calculated in terms of the amount of waste collected per vehicles used, population provided with collection services divided by total population; households provided with collection services divided by total households. In residential refuse collection, useful output measures are the number of tons collected, and the number of households serviced. These lead to the efficiency measures of cost per ton, cost per household per year, tons collected per man hour, and households serviced per man-hour.

The empirical finding shows that countries that establish separate regulation authorities prior to privatization saw increased investment compared to countries that did not.

Before setting the objectives of improving service delivery, private sector companies have to improve equipment holdings, upgrade their knowledge and skills, rationalize operations and maintenance, and be accountable, whereas the public sector has to ensure proper performance monitoring [8].

Some factors explaining private sector efficiency are identified by Batley and Larbi [21]. These include accountability for results, clear performance measures and no political interference.

Explanatory Factors of SWC Performance of Private Providers

Company size is conceptualized as a scale of operations [8]. The measures of organization size include the number of solid waste collection vehicles, the number of staff, and the customers. There is little empirical evidence that there is positive linear relationship between performance and size. However, Boyne [14] argues that there is non-linear relationship between organization size and performance. There is size effect on performance of firms, but in most researches size effect is not the focus of the studies and as such it is used as control variable. No matter how large the company size is its relationship with performance may vary since even medium size organization may perform better than a small or a large organization. To uphold this view, finding empirical evidence seems hard because empirical studies testing the relationship between size and performance had yielded mixed results. Regardless to the size of an organization, financial resources allow real resources to be purchased and this, in turn, influences service performance. The proposition is that the relationship between resources (financial and real resources) and service improvement is positive [14] that better technology (and larger trucks) among private solid waste collection providers in large cities enabled them to use smaller crews which contributed to efficiency. He further mentions that scale economies seem to be exhausted at a relatively low population level (20,000–50,000).

Organizational capability is defined as "a firm's ability to perform repeatedly a productive task which relates either directly or indirectly to a firm's capacity for creating value through effecting the transformation of inputs into outputs". Theory of public service improvement states more resources lead to better results providing that the resources are effectively managed in order to deliver the maximum potential benefits.

In their finding about operational capability and productivity, that older and larger equipment, larger crew sizes, and lower vehicle

productivity results comparatively high costs for the private sector. Private sector service costs can be lower due to rationalized operations. Higher labor and vehicle productivity results lower private sector service costs [11].

Management (operational and strategic processes) in private organizations has relationship with performance of the companies [27,28]. There are a number of issues considered to be treated as management variables. These variables include both strategic variables (strategy processes and content, leadership styles, and human resources management) and operational/tactical variables.

The quantification of the worker's skill and the valuation of its returns have been lying at the core of most of the recent debates in empirical labor economics. For instance, Oduro-Kwarteng [8] puts that the impact of managers on their firms' performance is likely to vary depending upon such factors as the knowledge, intelligence, and experience of the persons holding the managerial position. The management literature suggests several measures to capture the relative competence of managers and among them are: the level of qualifications, number of years of experience, lengths of managerial experience. "The quality of employees depends on the individual knowledge (creation of manuals, expert systems, team work, business code and so on), which is transformed into organizational knowledge". This could be also measured by the salary level. As an operational measure for the quality of employees average salaries are used as proxy. Using higher salaries to attract the best talents has become a common strategy in many industries. Private sector management has more flexibility to hire qualified staff, to pay staff according to their performance, to terminate the employment of unsatisfactory workers, and to adjust working hours according to service demand. The output and input that will be used in this study are the quantities of solid waste collected and number of vehicles of each company and operations management capability i.e., operations planning, supervision and maintain ace. Regulation in terms of the type of contract implemented for the involvement of private companies for SWC was also considered. In this study the dependent variable service performance is going to be assessed in terms of the amount of waste collected. Solid waste collected – meter cube of waste collected daily per vehicle (according to vehicle type and size). The effect of the scale of operation (investment on the number and type of SWDC vehicles and internal management and operational flexibility (crew size, labour conditions, vehicle routing and scheduling, are least explored and are examined in this paper for better understanding of the drivers of SWC performance.

Materials and Methods

This article is based on data collected during two fieldwork periods in five Ethiopian cities: Addis Ababa, Bahir Dar, Mekelle, Hawas and Adama, during the period of June 2014 to September 2015. Interviews were used for the primary data collection followed by visit and observation of disposal practices. A list of 20 registered private companies was taken from Addis Ababa Cleaning Administration Agency (CAA), and another list of 20 companies was taken from the Cleaning Administration Departments (CADs) of the municipalities in the remaining four cities. Offcila documetns i.e., strtagcid documnts and monthly office reports on SWC were taken from CAA and CADs in each city.

A structured questionnaire distributed to 40 companies was administered and filled out by the researcher. Prior to data collection the questionnaire was pre-tested for ease of understanding and content validity. Four private company managers were contacted and invited to fill the questionnaires in Mekelle city. Company managers were asked to criticize the questionnaire for ambiguity, clarity and appropriateness of the items used to operationalize each construct. The Mekelle city municipality official and experts were also requested to assess the extent to which the factors sufficiently addressed the topics investigated. Based on the feedback received, the instrument was modified accordingly and used to collect information about the study.

The questionnaire for private companies contains 107 questions of which 83 are measured on a five-point Likert- type scale with anchors ranging from strongly disagree, disagree, cannot tell, agree and strongly agree, very poor (1), poor (2) fair (3) good) (4) very good (5) and binary scale (Yes/No) 6 questions [8]. The interview guide for municipal officials and selected residents were 10 open ended questions and 7 yes / No questions.

In-depth interviews and focused group discussions (FGD) with key municipal officials and managers of private companies were also conducted. For the purpose of triangulation the researcher utilized several data sources: municipal officials, private company managers and city residents. In particular to the city resident interviews were conducted with individuals who have knowledge of the study area in each city. 5 individuals in each city were contacted. These respondents are contacted after knowing that they lived at least for more than five years and are knowledgeable enough about the issue under investigation.

There are 145 cities and towns with population of more than 15,000 inhabitants. Among these cities, the five cities of the country Mekelle, Bahir Dar, Awasa, Adama, Addis Ababa are chosen for the study. These cities have rapid urbanization and their municipal or metropolitan settings are expanding. More importantly these cities are chosen as they are the main regional cities of each region which has the largest urban population size. Therefore, comparative analysis can be made among cities and within cities to assess the solid waste collection performance by private companies.

All private companies in the first five high populated Ethiopian cities are taken for this study (unit of analysis). It is worth mentioning that cities with large population inhabitants would generate high solid waste which results more problems to manage it.

After detailed litterer review it was hypothesized that scale of operation and operational management capabilities has statistically significant effect on the amount of SWC. Moreover, it was also hypothesized that the contractual arrangement which is measured as a composite indicator taking the zoning and the service arrangement as a dummy variable. The contract is measured as a composite indicator taking the zoning and the service arrangement. The scope is considered as 'unlimited' if the nature of the contract is on the basis of unlimited zoning and the service arrangement covers both the house to house and the communal collection level. Otherwise, the scope is limited.

Information needed for the study are gathered and sorted in terms scale of operation, operational management capability and regulation elements. These includes type and number of vehicles, number of crew, route planning, distance from the disposal site, distance from the transfer station and experience of private companies. The issues concerning the regulation are captured in terms of the contractual arrangement implemented in each city i.e., the type of contact, the bidding process and access to capital for private companies.

Both quantitative and qualitative methods were used to analyse the data. A combination of the two methods provides the most accurate data for this study. Importantly the amount of waste collected and the inputs

used for SWC operational were quantified. Moreover to get accurate description of SWC practices, official documents and interview results were analysed qualitatively using narration. Blending both methods provided insights into the determinants of SWC in each city.

Quantitatively, SWC in the five cities is explained by a multiple regression model. Data distribution tests were made using box plots. The data were approximately symmetric and single-peaked. A diagnostic test of heteroscedasticity, Cronbach's Alpha, a model specification and an omitted variable bias test were applied. The analysis shows that the model was statistically significant and the regression model explains 97% (adjusted R square) of the variation in SWC.

Results and Discussion

Number of private companies and their sources of finance in Addis Ababa

There are both private companies and micro and small enterprises (MSEs) associations providing SWC service in Addis Ababa. Private companies have signed a service contract with the CAA to collect waste from households (house to house), hotels, institutions and communal containers. They transport it and dispose it at the disposal site. On the other hand, cooperative MSEs collect waste only from households (house to house) to the skip points (transfer stations in the neighbourhood). There are 560 MSEs in Addis Ababa, and they have signed a contract with the sub cities. All the SWM in the city is regulated and funded by the CAA.

There are 20 private companies in the city, 12 of which (60% of the sample) have only one vehicle each. Three companies have two vehicles each, but only one company has three vehicles (Table 1). The official report of CAA shows that two large companies together provide 44% of the SWC service. This suggests that having more vehicles equates to greater market share.

When interviewed, the private company mangers complained about the lack of adequate financial resources as a significant constraint to buying more vehicles so that they could achieve growth. Especially, MSEs that have scaled up to private companies have encountered financial limitations. Out of the 12 private companies, 9 (45% of the sample) have only one vehicle each, bought with their own limited capital. Moreover, they do not have assets to be used as collateral. One private company manager admitted generating income for the company by doing a broker and travel agent business. Three companies (15% of the sample) with only one vehicle each bought the vehicle with money collected from their families and friends. Four companies (20% of the sample) with two and three vehicles obtained their capital from iqub (a local system of saving money in which members collect their share in turn via a lottery system). The amount of money to be collected depends on the size of the iqub and the amount saved by each member. Three companies (15% of the sample) with more than three vehicles got their capital from large banks (Table 2). They used their fixed assets such as houses/condominiums as collateral.

Bahir dar: The types of SWC services in Bahir Dar are communal and house-to-house collection. The CAD in the city organises people who are granted reference letters from kebele (the lowest level in the hierarchy of the district administration) into MSE associations. This is to be approved later by the Micro Enterprises Offices (MEO). The MSEs must sign a service contract for house-to-house collection and for delivery to the skip points. Unlike the MSEs, the municipality deals only with the collection of SW from the transfer station to the disposal site.

There are six private solid waste collectors in this city. Five of them emerged from MSEs. The biggest company, Dream Light Sanitation and Service Plc (DLSSP), with seven vehicles, is the dominant one, providing services exclusively to four of the nine sub-cities. Others with one vehicle cover one sub-city each (Table 3). The source of the initial capital of two of the companies (40% of the sample) was personal. Two others (40% of the sample) received it from an iqub. CAD officials disclosed that the biggest company was granted a loan of 3.5 million ETB (16,5319 USD) from the city's municipality, allowing it to purchase seven SWC vehicles and to build up more capacity (Table 2).

Mekelle: There are four private companies in Mekelle, of which three have three vehicles and one has five (Table 1). Three MSEs that scaled up to private companies confirmed that they had gained access to 500,000 ETB (23,618 USD) from the Tigray Development Association (TDA). Only one private company said it owned its own capital for SWC (Table 2).

Adama: There are five private collectors in the city of Adama. Three of them (60% of the sample) have only one vehicle each and obtained finance from an iqub, while another one has two vehicles purchased with the collector's own capital. The remaining one has four vehicles and obtained the capital from a bank using the collector's house as collateral (Tables 1 and 2).

Hawasa: Six private enterprises are involved in SWC services in Hawasa. Among them, four (67% of the sample) have only one vehicle each. These companies used their own capital, and they complained about the challenges to getting credit, i.e., the bureaucratic process, inadequate loan size, the short loan duration that does not match gestation period and cash flow patterns, failure to disburse loans in a timely manner and group collateral requirements in case of MSEs (Tables 1 and 2). The remaining two companies (33% of the sample) have three and two vehicles, respectively, and have received a loan from the Omo Micro-Finance institution. Access to credit for these companies is based on their savings. If they save 20% of their income, they can request at least 100,000 ETB (4,000 USD).

Access to finance and contractual arrangement for SWC

One of the requirements in order to increase the number of waste collecting vehicles is a substantial investment. Large banks in Ethiopia are not willing to provide credit to MSEs. Therefore, these enterprises depend on microfinance and other traditional financial institutions such as iqub, which provide insufficient money to buy more SWC vehicles. The Ethiopian government has decided that the credit supplied by large banks should be permitted only for enterprises that produce for exports, are engaged in the construction sector or in producing import substitution products (GFDRE 2011). Enterprises in different business fields, including waste collection, are considered secondary. This hinders MSEs involved in SWC from getting access to credit. To get a loan from a financial institution, MSEs are required to prepare a business plan that will be implemented, as well as to have to have a transparent bookkeeping system.

Microfinance institutions require group guarantees for MSEs. Our interview with MSEs disclosed that they only received their loan after they organised a group guarantee. This means every individual is equally responsible for repaying the unpaid principal loan and its interest rate for every other individual in the group. This presents a risk of being charged for others' failure to repay in time. Many MSE owners face problems in finding collateral and they also face high interest rates. The remedy, according to private companies, is to be

Dependent Variable	Waste collected per day	Waste collected per day	Waste collected per day	Waste collected per day
Vehicles	0.795***	0.745***	0.932***	0.994***
	(0.00)	(0.00)	(0.00)	(0.00)
Crew	-0.060	-0.0768	0.420	
	(0.88)	(0.864)	(0.330)	
Computers	0.052	0.105	-0.078	
	(0.04)	(0.509)	(0.608)	
Capacity/load	0.551**	0.487*	0.891***	0.685***
	(0.04)	(0.068)	(0.004)	(0.00)
Route plane	0.241**	0.237**	0.236***	0.223***
	(0.01)	(0.020)	(0.003)	(0.00)
Supervisor	0.034	0.042*	0.007	
	(0.17)	(0.068)	(0.822)	
Experience	-0.002	0.026	-0.049	
	(0.96)	(0.765)	(0.368)	
Distance	-0.054*	-0.03	-0.094**	-0.069***
	(0.05)	(0.173)	(0.022)	(0.00)
Regulation				
Scope	0.21***			0.122*
	(0.00)			(0.04)
Duration	0.130 (0.13)	0.170 (0.038)	-0.057 (0.565)	
Zoning		0.357**	0.005	
		(0.043)	(0.973)	
Service		-0.087*	0.016*	
		(0.383)	(0.868)	
City				
Mekelle	-0.296**	-0.365***		-0.295***
	(0.01)	(0.001)		(0.001)
Hawasa	-0.186	-0.178		-0.162
	(0.142)	(0.222)		(0.222)
Bahir Dar	0.161	0.125		0.123
	(0.105)	(0.228)		(0.218)
Adama	0.107	0.173		0.143
	(0.672)	(0.573)		(0.373)
Population			-0.843	
			(0.184)	
Density			0.032 (0.447)	
Constant	2.380	2.063	2.107	
	(0.01)	(0.026)	(0.197)	
N	39	39	39	
R^2	0.97	0.97	0.97	

Note: Source: Field survey result analysis by author, 2016. P value in parentheses ** p < 0.05, *** p < 0.01, *p < 0.1. The reference city is Addis Ababa. The log transformed variables are waste collected per day, vehicles, crew and load capacity.

Table 1: Regression result of private company capacity, capability, technology, regulation, company location, population and density on waste collection (dependent variable).

granted tax-free import of SWC vehicles. But this has not happened so far, and there are restrictions in the access to credit. In Mekelle, for example, the maximum amount of loan that MSEs could receive from a Micro Finance Institution is 500,000 ETB (23,000 USD), which is not enough to buy more than two vehicles. Such conditions hinder private companies and thus the expansion, diversification and development of MSEs.

Another factor that impedes investment in SWC is linked to types of contracts. The survey results show that 13 (33%) of the 39 companies surveyed are engaged in SWC service under contracts with unlimited scope, whereas the remaining 26 (67%) of the companies are engaged in service under contracts with limited scope (Tables 4 and 5). This indicates that most of the companies are operating under limited scope contracts. Limited scope contracts restrict the service area and service arrangement (either communal or house to house collection, not both). The FGD with private companies in the cities of Mekelle, Bahir Dar and Hawasa revealed that company managers believe that the application of delineated service areas impedes them from reaching out to wider areas despite their potential. This, in turn, precludes the necessary competition for the market among private companies and degrades the service coverage of SWC. This has an investment risk involving loan repayment, default chances and the inability to recover funding cost. Moreover, PSI in some Ethiopian cities has proven to imply legal risks, which involves new legislation and regulation after the transaction that affects the partnership. In this regard, Tilaye and van Dijk [5] note unpredictable policy changes in Addis Ababa city. The government

No of vehicles	Addis	Mekelle	Hawasa	Bahir Dar	Adama	Total
1	12	0	4	4	3	23
2	3	0	1	0	1	6
3	1	3	1	0	0	5
4	0	0	0	0	1	1
5	0	1	0	0	0	1
7	0	0	0	1	0	1
8	1	0	0	0	0	1
12	1	0	0	0	0	1
Total	18	4	6	5	5	39

Table 2: Private companies' solid waste collecting vehicles in the five cities.

Source of income	Addis Ababa		Mekelle		Hawasa		Bahir Dar		Adama	
Own capital	9	45%	1	25%	4	67%	1	20%	1	20%
Relatives	3	15%	-	-	-	-	1	20%	-	-
Iqub	4	20%	-	-			2	40%	3	60%
Large banks	4	20%	-	-	-	-	-	-	1	20%
Development associations	-	-	3	75%	-	-	-	-		
Microfinance	-	-	-	-	2	33%	-	-		
Municipality	-	-	-	-		-	1	20%		
Total	20	100%	4	100%	6	100%	5	100%	5	100%

Table 3: Sources of capital for private companies and MSEs.

Variables	Mean	Standard deviation	Minimum	Maximum
Dependent Variable				
Waste collected per day	74	135.27	8	720
Independent Variables				
Number of vehicles	2.2	2.296	1	12
Capacity of vehicles (in cubic metres)	8.5	2.998	4	20
Distance to disposal site (in kilometres)	9.48	1.927	4	13

Note: Descriptive statistics, analysis by author from the dataset.

Table 4: Descriptive statistics.

Route plan prepared and followed	Frequency	Percent	Cumulative
No	18	47	47
Yes	21	53	100
Total	39	100	

Note: Source: Field survey result, 2015.

Table 5: Availability of route plan.

first made the private enterprises be organised as MSE associations and later allowed them to become private companies. These changes also cause private companies to lose confidence and to refrain from more investment.

Factors determining the amount of solid waste collected

The amount of SWC in each city was analysed by using the following multiple regression model.

$$Y_i = \beta_0 + \sum_{K=1}^{K} \beta_k X_{ik} + \delta_j + \varepsilon_i$$

Where i =1,… n, I is the number of firms, K is the number of independent variables and j identifies the city's fixed effects. The data on the amount of solid waste collected, the number of cars, crew, and load capacity are found to be very asymmetric (skewed). Hence, the log transformation is made to reduce the skewedness of the distribution. The dependent variable is (the logarithm of) waste collected per day. The independent variables are (the logarithm of) the number of cars involved in operation, (the logarithm of) the number of crew members, the (logarithm of) the capacity per car (cubic metres), the number of supervisors, the distance from the disposal site (kilometres), the service experience of companies and (unobserved) city characteristics. We also add dummy variables for the use of computers in the office, the use of route plans and regulation (i.e., scope and duration of the contract).

The hypothesis of the study is that scale of operation, technology, operational management capability and regulation each has a statistically significant influence on the amount of waste handled. Scale of operation includes the number of vehicles of each private company, the waste carrying capacity of cars, number of crew members and technology, i.e., use of computers. The operational management capability of private companies includes route planning, operations supervision capability and service experience of companies. Regulation is proxied using scope and duration of the contract. The scope of the contract is measured as a composite indicator taking the zoning and the service arrangement into account. The scope is considered as 'unlimited' if the nature of the contract is on the basis of unlimited zoning and the service arrangement is for both house to house and communal collection. Other variables that could explain the amount of waste to be handled are the distance from the customer's service zone to the disposal site and fixed effects of

the city in which the company is located.

The effect of scale of operation (linked to investment) on SWC: The survey shows a variation in the amount of waste collected per day (M=74, SD=135.27). The variation in the five cities shows a minimum of 8 and a maximum of 720 m^3. It was noticed that out of 39 companies, 30 companies (82% of the sample) collected less per day than the average of 74 m^3/vehicles (Table 6). The difference in the amount of waste collected per day by companies seems to be related to the differences in the scale of operation of the companies and their operational management capabilities.

To test these hypotheses, a regression model was developed. In the tested model, most of the capacity and capability variables are statistically significant, model 1. The table below shows the result of the regression analysis. To see the partial effect of zoning and service arrangements on waste collected per day, we developed model 2. Moreover, the effect of the population and density of each city in waste collection is included in model 3. In order to observe how the explanatory variables vary without violating the predicted waste collected, we have developed model 4. The minimum number for the explanatory variable in model 4 is 6.

It is clear that more vehicles will lead to more SWC. The theory suggests that higher expenditure by a private sector is a sufficient condition for improving SWC. Because it results in a higher quantity of SWC services, provided that the resources are effectively managed in order to deliver the maximum potential benefits [13].

As shown in Table 7 above, controlling for other factors which can affect the dependent variable, the number of vehicles in operation for each company has a statistically significant effect (p=0.000) on the amount of solid waste collected per day. An increase in the number of vehicles from 1 to 2 increases waste collection by exp (0.8*0.7)-1 = 75%.

Two reasons could explain the results above. First, private companies with more cars can serve a larger service area. These companies can serve more customers per day and collect more waste per day. Second, the survey results show that private companies with more cars had the capability to avoid service stoppage due to vehicle breakdowns by utilizing one of the vehicles in the place of a non-functioning vehicle in the service area. This could increase the amount of waste collected per day.

Scope of contract	Frequency	Percent	Cumulative
Limited	26	66.67	66.67
Unlimited	13	33.33	100
Total	39	100	

Table 6: Scope of contract.

Geographical Area	Total Population Size (2013)	Urban Residents	Main City of the Region
Oromia region	32,220,000	283,000	Adama
Addis Ababa city Administration	3104000	3,103,700	Addis Ababa
Amhara region	19212000	198,900	Bahir Dar
S.N.N. People region	17887000	225,700	Awasa
Tigray region	5062000	286,600	Mekelle
Somali region	5318000	152,700	Gigiga
Dire Dawa city Administration	359000	269100	Dire Dawa
Afar region	1650000	185,135	Semera
Benishangul Gumuz region	1028000	105,926	Asosa
Harari region	215000	99,368	Harar
Gambella region	406000	77,925	Gambella

Table 7: Population size and urban residents of ethiopian regions.

It is worth mentioning that increasing the number of vehicles from one to two increases waste collection by 75%, not 100%. The estimate suggests decreasing returns to scale. Companies can serve a larger area, but not an area twice as large. This might be due to the lack of proportional increase in operational management capacity with respect to an increase in the number of vehicles. Specifically, an interview with some company mangers revealed that they themselves supervise the operation of their vehicles. When the number of vehicles is low, the owners can efficiently handle and control operation of all the vehicles; however, with an increase in the number of vehicles, controlling becomes difficult, which might lead to a decrease in waste collected.

Moreover, the survey shows a variation in the number of vehicles each private company owns (M=2.2, SD=2.296). The variation in the five cities shows a minimum of 1 and a maximum of 12 cars. It was noticed that the majority (74%) of the companies have two vehicles for waste collection (Table 3). Most of the companies had less than three cars (the average number of cars). This shows that the majority of the private companies in the five Ethiopian cities are small. Some of the major problems for most of the waste collection companies include a lack of vehicles, constant breakdowns due to bad roads and poor vehicle maintenance.

The effect of load capacity of vehicles on SWC: As shown in Table 1 above, controlling for other factors that affect the dependent variable, the waste carrying capacity of vehicles has a statistically significant effect (p=0.044) on the amount of solid waste collected per day. When the capacity of the vehicles increases by 10%, the amount of solid waste that can be handled increases by 5% in m^3.

The survey shows a variation in the capacity of vehicles for each private company (M=8.5, SD=2.998). In the five cities, it shows a minimum of 4 and a maximum of 20 tons, which suggests a wide variation in the capacity of vehicles owned by private companies in the five cities (Table 3). Most of the companies (89% of the sample) had an average number of vehicles with a capacity of 8 m^3, which was far below the maximum loading capacity.

Private companies with a high load capacity can serve more customers per visit in the service zone. Ccompact garbage collection trucks with reduced body weight in order to increase load capacity means less frequent collection. When customers bring out more waste for each collection, the frequency of vehicles' trips decreases and this makes SWC more productive and cost efficient. Moreover, achieving cost efficiency on the part of private companies could decrease the charges to customers; a decrease in vehicles' trip reduces fuel emissions (contributing to the prevention of global warming), shrinks traffic flows and helps to ensure safe operations by reducing opportunities for accidents and avoiding peak hours.

The impact of private companies' operational management capability on SWC: Private companies differ in the amount of solid waste collected per day as a result of their operational management capability. Literature suggests that operational and strategic process management in private companies is related to the performance of the companies. Management variables include both strategic variables (strategy processes and content, leadership styles and human resource management) and operational/tactical variables (capacity planning, operations supervision, operations improvements, and service design and maintenance management). Thus, the impact of operations planning, supervision and maintenance on SWC is considered in this study.

Solomon [29] and Kim et al. [30] remark that vehicle route planning consists of routing vehicles to collect customers' waste with a minimal

number of vehicles and total travelling time and distances that could be flexible with respect to changes in service users and conditions of the city. Planning the departure of a vehicle, its stops and its return is vital in order to increase the amount of waste collected. As noticed from the interview, some private companies start transporting waste from the compounds of the households to the disposal site at 5:30 in the morning in order to avoid traffic jams and peak hours. This strategy is practical and safer compared to later start times.

Controlling for all the other factors, the regression result (Table 1) indicates that preparing vehicle route plans and ensuring their use by drivers has a statistically significant positive effect (p=0.01) on the amount of solid waste collected per day. For companies with a route plans prepared and implemented by drivers, the increase in the mean of waste collected per day is 27%.

The survey results show that 21 (53%) of the 39 companies have practical vehicle route plans prepared, whereas the remaining 18 (47%) of the companies do not (Table 4). Relatively big companies with more than three vehicles and with more customers have route planning. They also have lists of addresses in various formats that they give to their drivers. They have planned the departure of vehicles to serve users in a set sequence and minimise the travelling time. Currently, because of the newly built railways and cobblestone roads in Addis Ababa, private companies choose the shortest routes with less traffic jams. In Mekelle city, the route plan is prepared by the municipal experts and kebele officials (the lowest level in the hierarchy of the district administration) together with the private companies. The companies are obliged to stick to the route plan.

Private companies that have vehicle route plans in the five cities appoint supervisors to ensure that the drivers follow the planned routes. It is assumed that this may prevent some drivers from misusing resources, wasting time and doing any extra business of their own without the companies' knowledge.

The current route planning practice for SWC by some companies is not well-organised and is inefficient in terms of fuel consumption and time. Interviews with nine private company managers in Addis Ababa revealed inefficient SWC practices. When transporting waste, company vehicles start from their station and go to a hotel or an institution to pick up the containers and dump the contents at the disposal site. These sites were known locally in Addis Ababa as 'Koshy' in Bahir Dar city as 'Sebatabit,' in Mekelle city as 'Adi Kolem' and in Hawasa as 'Diaspora.' Then the vehicles return the empty containers to the hotel or institution. This is because they do not have an empty container to serve a neighbourhood with a single vehicle, minimizing travelling time and distance. Also, forming a cluster of clients would have allowed each cluster to be served by a single trip.

The private companies in the five cities do not have modern tools for route planning and vehicles tracking. Recently, the municipality in Addis Ababa started the monitoring and follow-up of vehicles through satellites using a real-time tracking system. Such systems could avoid unwanted manipulation of the vehicle by the drivers. They could also facilitate fast maintenance of vehicles as well as preventing wasted time and fuel. The private companies need to learn from this useful practice and make use of it to improve their own performance.

Well-known remedies such as Solomon's [29] insertion algorithm model for vehicle route planning could help rectify the planning lapses of those private companies and improve their performance. What Kim et al. [30] suggest for more efficient vehicle route plan operation could also be considered. According to them, 'Companies may first deliver an additional empty container at the customer location, pick up the full container, travel to a disposal facility and then dispose of the contents. At this point, the vehicle may serve another customer with the same size container'.

Concerning maintenance, the interviews with company managers in each city show that private companies do not have maintenance schedules for their vehicles but rather carry out unplanned repairs for the vehicles. However, planned maintenance of assets is paramount to overall operational efficiency. Howell [31] points out that maintenance integrates equipment into the manufacturing process through a system designed to ensure that machinery and equipment are always available to provide service (uptime) by minimizing rework and maximizing cycle time and resource usage. The bottom line is providing the maximum value for the customer at the minimum cost.

The effect of distance from the disposal sites on SWC: The regression results (Table 1) indicate that the distance between the disposal site and customer service zone also has a statistically significant effect (p=0.05) on the amount of solid waste collected per day. We can say that for every 1 km increase from the disposal site, there is about a 5.6% decrease in the mean of waste collected per day. There was a statistically significant difference in the score of the distance in km from the disposal site to the customer service zone in each city (M=9.48 SD =1.927). The results in the five cities show a minimum of 4 km and maximum of 13 km. This suggests wide variation in each city (Table 3). This might mean that companies operating in the service zone near to the disposal site could make more trips with less fuel consumption, labour, and quick maintenance as well as lower depreciation costs per trip than those companies whose customers are far from the disposal site. Tselios et al. [32] confirm that the greater the proximity to the service area the lower the transportation costs. One way to increase the number of trips is by establishing different disposal sites in various directions in the cities. Another way is by creating transferring stations so that waste could later be transferred to the main landfill of the cities, integrating waste segregation and recycling activities in the transfer station. The disposal site could contribute as a source of income by using waste as a resource. It could also enable the landfill to serve a longer time as it reduces the amount of waste that reaches the landfill.

The impact of regulation on SWC: Regulation is defined by van Dijk [33] as sustained and focused control exercised by a public agency over activities of the private sector that are valued by a community. There is a range of regulatory instruments that include audit, inspection, financial control, performance indicators, plans and annual reports. Such regulation is usually justified on the grounds of accountability for the public.

The relationship between regulation and service performance is less obvious. Boyne et al. [27] state that if regulators know better than private providers how to improve services, the impact of regulation is likely to be positive. Otherwise, the regulation is likely to be counterproductive. Gidman et al. [34] also mention that such regulatory arrangements will ideally have legislative powers of control built into their constitution. In SWC, regulations remedy market failures such as monopoly power, externalities and information asymmetries or deficiencies.

Literature shows that regulation of private sector involvement may be regulation 'by contract', where the regulatory rules are enforceable in a contract [28,35]. The Ethiopian Solid Waste Management Proclamation (SWMP) states: 'Urban administrations shall create enabling conditions to promote investment in the provision of SWM services' (SWMP, number 513/2007). Accordingly, the city administrations of the five cities develop their own regulation and contract for PSI. Hence,

the impact of the existing regulation on SWC in Ethiopian cities is investigated by focusing on the scope of the contract through which each private company is engaged in SWC service. The contract is measured as a composite indicator taking the zoning and the service arrangement.

Controlling for all the other factors, the regression result (Table 1) indicates that contracts with an unlimited scope have a statistically significant positive effect (p=0.01) on the amount of solid waste collected per day. For companies benefiting from such contracts, the increase in the mean of waste collected per day is 24%.

Two reasons could explain the results above. First, private companies operating with such a contract that has no restrictions on the zones in which they can operate could normally serve a larger service area. These companies could serve more customers per day and collect more waste per day. Second, the arrangement for these companies is both at the house to house and at the communal collection level. This kind of contract allows companies to provide SWC services for all the city residents, institutions and hotels based on the waste collection preferences of customers.

When it comes to peculiarity between firms that have zone limits and that have not. There is a difference in the practice of zoning in each city. It is primary based on the size in Addis Ababa that the big companies with many cars have no restrictions as waste collection is concerned. From the interview there is flexibly for large firms in Addis Ababa to allow them unlimited zoning. Intimacy with some municipal officials is mentioned by some company mangers as a means for receiving unrestricted service zone. In Hawasa and Adama, existing firms are not restricted, but incumbent firms are zone restricted. Old company in Bahir has favored than the others for having unrestricted zoning. This would caution the reader that it is experience, rather than scope that determines the collected waste. For that reason, we include experience and find it insignificant. Moreover, to observe the partial effect of zoning and service arrangements explicitly, we have run a new model that keeps the other explanatory variables constant. The result in model 2 shows that zoning still has a statistically significant impact on waste collection with (p=0.04).

The effect of the location of the private companies on SWC: According to Tselios et al. [32], firms depend on their surrounding geographical environment for qualified labour, information and knowledge of spillover. Identifying such regional determinants is essential, since regional characteristics influence the performance of SWC by private companies. The growing body of literature on the determinants of performance at the firm level typically adds regional (or city) dummies, since location may account for part of the differences between high and low performers. Population density, population location and composition are important in explaining why regions with similar geography may end up with different levels of challenges and opportunities [36].

The regression result indicates that the city in which the private companies are located has a statistically significant effect (p=0.01) on the amount of solid waste collected per day. For companies located in Mekelle, a 34% decrease of SWC per day was exhibited compared to the city of Addis Ababa.

Two reasons could explain the situation above. First, from the interview with all the private companies in Mekelle, it was found that the open hours for the disposal site are limited – it is only functional for eight hours per day - which restricts the number of vehicle trips and the amount of waste collected. The interviewees added that they could have worked day and night and left no heaps of waste uncollected were it not for the CAD's unwillingness to pay the private companies the amount they expect when working full time. Second, there are more and larger private companies in Addis Ababa than Mekelle city which results more waste collection.

In many parts of the world, the privatisation of urban services is being promoted on the basis of the supposed advantages of the private operators. Private sector involvement is consistent with economic rationality, resulting in efficiency, vitality and innovation. The research upheld the theoretical base of sustainable SWM. As shown in the literature, a waste management system needs to be tuned to the local conditions and feasible from a technical, environmental, social, economic, financial, institutional and political perspective [7]. It should be able to maintain itself over time without exhausting the resources upon which it depends. In this study, examining the practice and factors that explain the service performance of private companies in SWC, the scale of their operation (investment) and operational management capability (route planning) and their regulation (type of contract) in the five Ethiopian cities were identified as determinants.

A higher number of vehicles used and good operational management capability lead to a high amount of solid waste collected. This is consistent with our hypothesis that private companies' scales of operation and operational management capabilities influence the amount of SWC handled. Also, it coincides with the theoretical implication that adequate private sector capacity and effective operational management ensures the more productive use of resources. This entails a competitive advantage to collect more waste and to achieve service improvement. Technically, however, the practice of collection in each city is characterised by waste jumbling (collection without sorting of wastes) and thus it hinders environmental sustainability. It fails to apply waste prevention and reduction principles; it disregards considering the composition and the suitability of the waste for certain types of treatments. Consequently, in assessing the findings from the perspective of the popular sustainability concept of people, planet, and profit (described in the conceptual framework), the waste transferred to the disposal site in each city forms a large pile posing health risks to the society (threatening the people sustainability aspect) that ultimately could affect the air and water supply (which brings about negative impact on planet sustainability). Besides, the existing SWC is not financially sustainable (profit sustainability) for several reasons including overlooking the potential prevention of pollution by reduction of waste [37]; poorly committed to prolong the lifespan of landfills [38]; and nor does it succeed at bringing down the cost of waste collection, transporting, recycling and disposal [39].

The route planning practice of some private companies is based on the address lists of customers and the supervisors' ability to monitor the SWC service. Such effective route planning coupled with a high load capacity of vehicles has a direct impact on vehicle productivity. It increases the total number of customers served and the amount of waste transported through minimizing the distance, time and vehicles required to visit the customers. This has a positive impact on cost recovery and financial sustainability, which could lead to more investment in SWC. However, in most of the private companies interviewed, there existed inadequate capacity and ineffective operational management capability in SWC practices in the five cities. Logically, this phenomenon has hampered the private companies from generating sufficient and sustainable revenue for the SWC business that could then be scaled up to the other part of the value chain of SWM in the long run, i.e., recycling and re-use [40-42].

Regulation in terms of the scope of the contract which was used by the cities to involve private companies in SWC affected SWC. Cities with unlimited contract scopes, i.e., unrestricted zoning and service arrangements, enabled some private companies to collect more waste, which allows them to provide SWC service to more customers. However, the zoning and service practice is still not based on an analysis of the quantity and type of waste in different locations in the cities. This has had a negative effect on the technical, social, economic and environmental sustainability of SWC. First, hazardous waste that poses health risks is not collected separately. Second, the zoning and service arrangement fails to achieve equity. What is evident is the practice of some private companies to provide service only in rich neighbourhoods. These companies do not reach out to the poor neighbourhoods and hillsides. Ultimately, this has a negative effect on the society, as polluted areas lead to poor conditions and affect even the richer neighbourhoods [43-46].

The prevalence of large heaps of solid waste left uncollected in Ethiopian cities is still a serious problem. Thus, SWC as part of a chain of sustainable SWM is not yet perfect. Treating waste as a resource seems far from reach. Therefore, the way forward is to uplift PSI practically through providing enlightened opportunities for the market and strengthening the regulatory role of the government. Moreover, with the limited financial access both from large banks and microfinance institutions, private companies and municipalities need to make a paradigm shift to improve technology and innovation for SWC, such as the application of a shortest route indicator device and electronic chip in every waste container (to notify when the containers are full).

We also recommend that the municipalities in Ethiopia provide private companies with maps showing roads and building densities suitable for route planning. Studies that could contribute to the development of handling realistic complications and generalisations of the basic routing model in developing countries need to be conducted as well.

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