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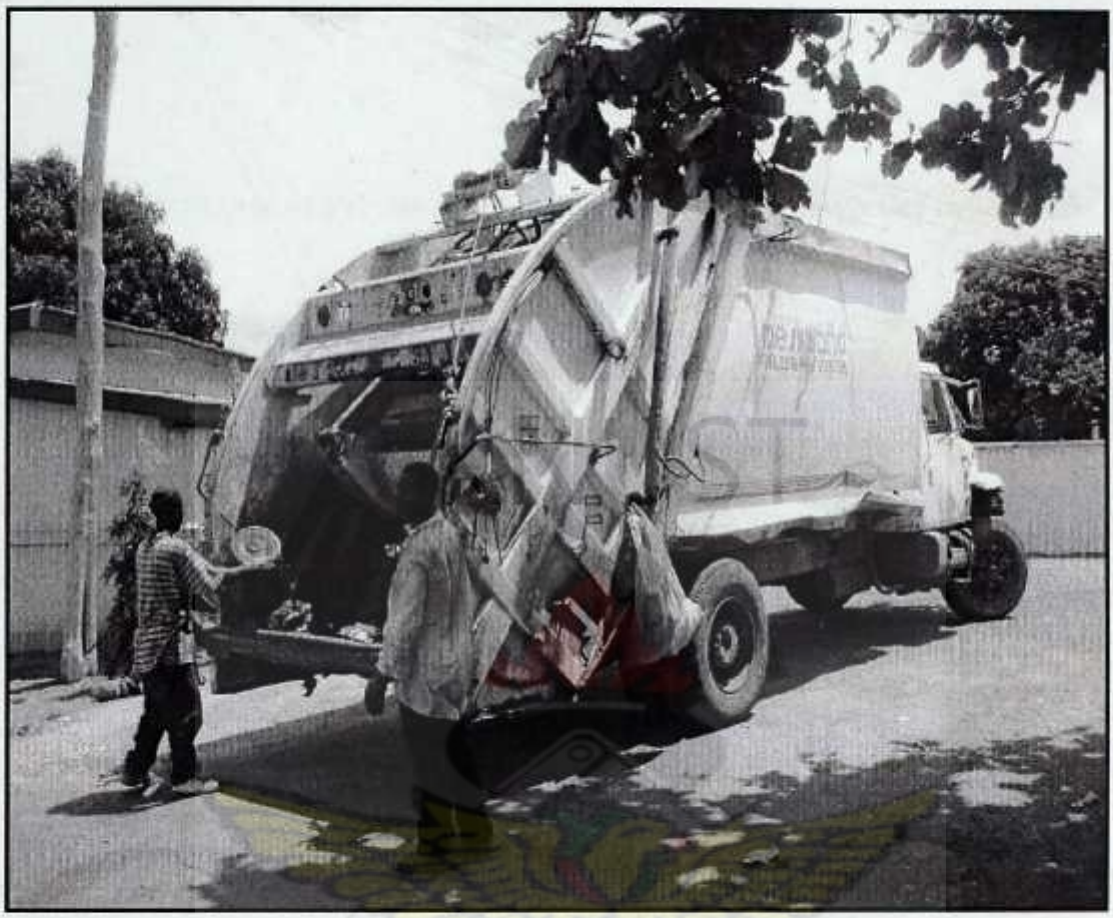

Performance of Private Solid Waste Collection Companies in Kumasi

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Water Resources and Environmental Sanitation Project – KNUST

Faculty of Civil and Geomatic Engineering

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Master of Science Thesis
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CERTIFICATION

I hereby declare that this submission is my own work towards the M.Sc. and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

I dedicate this work to my family especially Jennifer Yaayin, the last born of my mother.

ABSTRACT

The study focused on the performance of private solid waste collection companies in Kumasi. The study objectives were to assess the performance of private solid waste collection companies and the factors influencing the performance and also to assess the contribution of private solid waste collection companies in terms of percentage of waste the companies collect. The data used for the study were from questionnaires and landfill records on the performance indicators and the factors influencing the performance. Primary data were collected from six private solid waste collection companies in Kumasi and secondary data from nineteen private solid waste collection companies in four other cities in Ghana. The data were analysed and the performance of the companies in Kumasi was compared with the performance of the companies in the four other cities. The results of the study revealed that the average performance in terms of vehicle productivity (ton/day/vehicle) for the six companies in Kumasi was 17.2 and only two companies out of the six were above average. The average vehicle utilisation was 62% and two out of the six companies were above average. This implies the majority of the companies in Kumasi were under utilising their waste collection vehicles. Across the cities, the average vehicle productivity (tonnes/day/vehicle) was 16.02 and the average performance of companies in three cities (Tema, Accra and Kumasi) was above this value. Also the average vehicle utilisation of companies across the cities was 60% and the performance of companies in three out of the five cities was above average. The proportion of waste collected by the private companies across the selected cities in Ghana was comparatively higher than that of the metropolitan assemblies. The study also revealed that there was a correlation between market share and vehicle productivity of private solid waste collection companies. This means that market share influences vehicle productivity. There was also a correlation between vehicles supervision and vehicle productivity. It implies vehicles supervision affects vehicle productivity.

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LIST OF ABBREVIATIONS AND ACRONYMS

ABC	Aryeetey Brothers Company
AMA	Accra Metropolitan Assembly
CBD	Central Business District
CBO_S	Community Base Organisations
GMT	Greenwich Meridian Time
JSO	J- Stanley Owusu
KMA	Kumasi Metropolitan Assembly
KNUST	Kwame Nkrumah University of Science and Technology
KWML	Kumasi Waste Management Limited
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NGO_S	Non-Governmental Organisations
SWM	Solid Waste Management
UNCHS	United Nations Centre for Human Settlements

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First of all I owe a great gratitude to the Almighty God for sustaining me to accomplish this task. Without him this work would not have been realized. I equally acknowledge the assistance of my fellow Christian brothers and sisters of Deeper Life Campus Fellowship KNUST chapter for their numerous supports in the area of prayer and encouragement.

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1. INTRODUCTION

1.1 Background

According to Schubeler *et al.*, (1996), Municipal Solid Waste Management (MSWM) is major responsibility of local government. It is a complex task which requires appropriate organizational capacity and cooperation between numerous stakeholders in the private and public sectors. Although it is essential to public health and environmental protection, solid waste management in most cities of developing countries like Ghana is highly unsatisfactory. In Ghana, most areas where solid waste is generated have been left uncollected and this creates odour nuisance and potential ground for the transmission of waste related diseases. Aesthetically, many cities of Ghana are not very attractive due to the mess of uncollected solid waste in places where it is generated.

The provision of municipal waste services is a costly and vexing problem for local authorities everywhere. In developing country cities, service coverage is low, resources are insufficient, and uncontrolled dumping is widespread, with resulting environmental problems. Moreover, substantial inefficiencies are typically observed. One solution commonly proposed is to contract service provision with the private sector with the belief that service efficiency and coverage can be improved and environmental protection enhanced (Cointreau-Levine and Coad, 2000). Ghana as one of the developing countries is equally faced with the problem of low service coverage and insufficient resources pertaining to solid waste collection.

The involvement of the private sector in solid waste collection services in recent times is widespread. In Ghana, there are increasing numbers of private solid waste collection companies, but the cleanliness of most cities in the country is still unsatisfactory. It is against this background that the study seeks to assess the performance of private solid waste collection companies in Kumasi.

1.2 Problem Statement

Many municipal and metropolitan authorities in Ghana have not been able to cope with the rapid escalation of the solid waste problems. They have consequently left densely settled areas with little or no service, polluted precious air by the open burning of waste, and damaged land and water resources by careless dumping of solid waste. The most recent approach has been to involve private enterprise in the task, to increase coverage, improve efficiency and reduce the pollution of natural resources due to the rapid escalation of the solid waste problems.

Previous studies also revealed that numerous private firms are engaged in solid waste collection in Ghana, yet a significant portion of the population does not have access to a waste collection service and only a fraction of the generated waste is actually collected. There are still problems of uncollected waste in some areas of the cities in the nation. Therefore, the poor or inadequate solid waste collection in Ghana has necessitated the researcher to assess the performance of private solid waste collection companies in Kumasi.

1.3 Objectives of Study

The main objective is to assess the performance of private solid waste collection companies in Kumasi and compare with the performance of private companies in four other cities in Ghana.

The specific objectives include:

1. To assess the performance (vehicle productivity and vehicle utilisation) of private solid waste collection companies in Kumasi and compare with the performance of private companies in four other cities in Ghana
2. To assess the contribution of private solid waste collection companies in Kumasi and compare with the contribution of private companies in four other cities in Ghana
3. To assess the factors (internal management capacity and external factors), that influence the performance of private solid waste collection companies in the selected cities in Ghana.

1.4 Research Hypotheses

The main hypothesis to be tested in this study is that performance of private solid waste collection companies is influenced by factors such as internal management capacity and external factors such as road and traffic conditions.

The sub hypotheses to be tested are:

Hypothesis 1: Vehicles route planning and operation scheduling influence the performance of private solid waste collection companies.

Hypothesis 2: Supervisory capacity and workers moral affect the performance of solid waste collection companies.

Hypothesis 3: Vehicles maintenance and good vehicles condition influence the performance of private solid waste collection companies.

Hypothesis 4: Traffic and road conditions influence the performance of private solid waste collection companies.

Hypothesis 5: Market share affects the performance of private solid waste collection companies.

1.5 Justification

The study outcome will be relevant for policy formulation and implementation for private solid waste collection companies in Ghana. The study outcome will also identify the factors that influence the performance of private solid waste collection companies. This will guide the companies for proper planning so as to maximize profit in the solid waste collection business. Studies have been carried out to assess the performance of private solid waste collection companies, but on individual cities in Ghana. This study is also carried out in one city, but it goes further to compare the performance with private companies in four other cities in Ghana. This will inform private companies about the level of their performance within and across cities because comparative performance monitoring of all private companies increases competition among service providers, leading to increased efficiency and improved service quality. This study will further inform the government of Ghana on how much contribution the private sector involvement has rendered to solid waste

collection in Ghana. The gaps which may exist that this study does not cover will pave the way for further research.

1.6 Operational Definitions

1.6.1 Municipal Solid Waste (MSW).

It includes non-hazardous solid waste generated in households, commercial and business establishments and institutions, and non-hazardous industrial process waste, agricultural waste and sewage sludge (Schubeler *et al.*, 1996)

1.6.2 Private Company

According to the Oxford Dictionary definition, it is a company with restricted membership and no public share issue.

1.6.3 Private Sector.

It is the part of the economy in which economy activity is carried out by private enterprise as distinct from the public sector Cointreau-Levine and Coad (2000).

1.6.4 Vehicle Productivity

Vehicle Productivity is defined as the actual waste collected in tonnes per day per vehicle (tonnes /day /vehicle).

1.6.5 Vehicle Utilisation

Vehicle utilisation is the ratio of actual waste collected to the expected output of the waste collection vehicle expressed as a percentage.

1.6.6 Market Share

Market share is the percentage of waste collected by each company to the total waste collected in the city.

1.6.7 Management Capacity

The management capacity of the private solid waste collection companies under this study is concerned with vehicle operations planning, vehicle operations supervision, and vehicle maintenance capacity which influence performance of the companies.

1.6.8 External Factors

These are factors such as road conditions and traffic conditions that affect the performance of private solid waste collection companies. The companies do not have direct control over such factors.

1.7 Structure of Report

The structure of the report is organised in five main chapters. Chapter one covers the introduction of the study which comprises background of the study, problem statement, objectives of the study, research hypotheses, justification and operational definition. Chapter two mainly consists of the literature review of the study. The research methodology is addressed in chapter three and the results and discussion of the study are highlighted in chapter four. Finally, conclusion and recommendations are outlined in chapter five.

2. LITERATURE REVIEW

2.1 Municipal Solid Waste Management (MSWM)

Municipal Solid waste management (MSWM) involves the collection, storage, transportation, processing, treatment, recycling and final disposal of waste. Systems need to be simple, affordable, sustainable (financially, environmentally and socially), and should be equitable, providing collection services to poor as well as wealthy households. SWM should aim at improving the environment, provide direct health benefits, support economic productivity, and provide safe, dignified and secure employment (Techobanoglous *et al.*, 2001).

According to Schubeler *et al.*, (1996), municipal solid waste management is a major responsibility of local governments, typically consuming between 20% and 50% of municipal budgets in developing countries. It is a complex task which depends as much upon organization and cooperation between households, communities, private enterprises and municipal authorities as it does upon the selection of and application of appropriate technical solutions for waste collection, transfer, recycling and disposal. Furthermore, waste management is an essential task which has important consequences for public health and well-being, the quality and sustainability of the urban environment and the efficiency and productivity of the urban economy. In most cities of developing countries, waste management is inadequate: a significant portion of the population does not have access to a waste collection service and only a fraction of the generated waste is actually collected. Systems for transfer, recycling and/or disposal of solid waste are unsatisfactory from the environmental, economic and financial points of view.

The solution to the problems of solid-waste management is the careful selection and operation of solid-waste collection equipment that is efficient and yet responsive to the physical and socio-economic conditions of the various neighbourhoods in which service is supplied. The objectives of improved solid-waste collection could, therefore, be defined as:

a. Development and use of, as far as possible, relevant, efficient, indigenous equipment that requires the least cost per ton to operate;
b. Optimisation of labour and equipment requirements, such that high productivity is ensured for labour and equipment;
c. Minimisation of vehicle round-trip and out-of-service time (UNCHS, 1992).

According to Mensah (2008), in Ghana and also in many developing countries, collection from the immediate source of waste generation is usually manual where head loads (domestic dwellings, offices, markets), handcarts (markets, lorry stations), and wheel barrows (street and drain cleansing, markets, lorry stations, offices) are employed in sending refuse to dumps or containers (communal collection). The other mode is by house-to-house collection (door-to-door, curbside and block collection). House-to-house collection is a system of collection of domestic waste where a collection crew assists the generators by bringing the collection vehicle closer to the point of generation. The generators place the bin (containing the waste) outside their house at the curbside on specific days of the week for collection. This service is rendered to residents in high and middle income areas. Generators who enjoy this less participatory type of service use standard bins (120 or 240 litres). It is considered less participatory because generators play a lesser role in the collection process as

compared to communal collection method where generators carry waste all the way to secondary collection points. In this type of collection, the crew enters the premises and collects the storage receptacle for emptying (door-to-door collection). Plate 2.1 below indicates door-to-door/curbside collection.

(Door-to-door collection) (Curbside collection)

Plate 2.1: Door-to-door and Curbside Collection of Solid Waste

Communal collection is the system where waste generators discharge their waste into communal skip containers at secondary collection points from where waste companies collect and transport the waste to the final disposal site. It is a system for waste collection in which individuals bring their municipal solid waste directly to a central point, from where it is collected (Cointreau-Levine and Coad, 2000). Plate 2.2 below indicates a type of communal collection containers that are placed at vantage points for community members to dump their solid waste.

Plate 2.2: Communal Skip Containers for Solid Waste Collection

Source: Lecture notes (Mensah, 2008).

2.2 Measurement and Monitoring of Performance

Performance monitoring establishes a basis for evaluating the efficiency, effectiveness, and cost of service delivery. It defines the "rules of the game" and measures how well the "game" is being "played". Comparative performance monitoring of all private sector and government players increases competition among service providers, leading to increased efficiency and improved service quality. By quantifying the performance measures to the maximum extent possible, accountability among service providers is increased; in addition, service, service delivery is linked with consumer satisfaction, and so actions are linked with their consequences and there is effective feedback (Cointreau-Levine and Coad, 2000). The performance indicators include vehicle utilisation and vehicle productivity

2.2 .1 Vehicle Utilization

Vehicle utilization refers to the level at which the companies are making use of their vehicles in solid waste collection services. It is the ratio of the actual waste collected to the expected output expressed as a percentage. The factors determining the level of vehicles utilization are the number of trips vehicles are able to make per day and the actual weight in tonnes of refuse disposed per trip by different types of vehicles in relation to their capacities. The capacity of the collection vehicle is the maximum quantity of waste (load) in tonnes that the vehicle collects per trip. These factors mentioned depend on the companies' ability to plan for the collection services.

2.2 .2 Vehicle Productivity

Vehicle Productivity is defined as the actual output in tonnes per day per vehicle. Productivity primarily depends on how the collection companies structure and organise their operations so as to optimally operate their vehicles in terms of the number of trips each vehicle makes in a day.

The vehicle productivity index (company's vehicle productivity) is the sum of vehicle productivities of all vehicles used for waste collection in a period of time divided by the number of vehicles for a particular company. The index is an average that represents the vehicle productivity of that company in the period of assessment.

2.2 .3 Market Share

Market share is the pereentage of waste collected by each company to the total waste collected in the city. Market share is used by businesses to determine their competitive strength in a sector as compared to other companies in the same sector. It

also allows you to accurately assess your performance from year to year. If you only use sales to measure your performance, then you don't take into account the market conditions that may have improved or decreased your sales. Your sales may have gone up because of increased popularity of your type of widget, or they may have gone down because of a drought or recession. Since those factors are beyond your control, they don't give you meaningful information about how you are actually doing as a company in terms of improving your business. By measuring market share, you can see if you are doing better or worse compared to other companies that are facing the same challenges and opportunities that you are (Wise, 2008).

2.3 Collection and Transportation of Municipal Solid Waste

According to Schubeler *et al.*, (1996), collection systems comprise household and neighbourhood (primary) waste containers, primary and secondary collection vehicles and equipment, and the organization and equipping of collection workers, including the provision of protective clothing. Selection of collection equipment should be based on area-specific, data on waste composition and volumes, local waste handling patterns and local costs for equipment procurement and operation and maintenance (labour, fuel, lubricants, tires etc.). Collection and transportation is one of the main elements of waste management system. It is capital intensive and most expensive part of the system. Organisation of operation of collection is the most difficult part. The solid waste collection is expensive and cost recovery is essential to ensure sustainable waste collection services. Although a variety of collection service is used worldwide, the house-to-house collection has gained popularity because labour cost for collection

can be minimized. Also large containers, which can be emptied mechanically is the common method used for collection of municipal solid waste.

As explained in lecture notes according to Mensah (2008), the mode of transport of MSW for final disposal can be described as:

1. **Direct Haul:** collection /transportation equipment which collect refuse and also directly hauls to the disposal point. This describes the house-to-house service (using side loaders and compaction trucks) where distances are less than 20km and it is economic to haul directly to the disposal facility.
2. **Waste Transfer:** transportation via the collection from containers sites (and transfer stations) for haulage to the final disposal facility. In Ghana, skip loaders, roll-on-off and arm- roll container trucks are the predominant mode of transfer from communal container sites.

2.3.1 Access to Waste for Collection

Many sources of waste might only be reached by roads or alleys which may be inaccessible to certain methods of transport because of their width, slope, congestion or surface. This is especially critical in unplanned settlements such as slums or low-income areas and thus largely affects the selection of equipment (Zurbrugg, 2003).

2.3.2 Collection Frequency

Municipal solid waste should be collected at least twice a week. Waste may be collected weekly in residential areas and daily in business areas. Laxity in the collection of MSW leads to unhygienic conditions. The main factors that have a direct bearing on the optimal frequency of collection are: characteristics of the waste,

climate, system of storage, type of container provided and unit collection cost. Other factors which affect MSW collection include: proper location of containers, number of persons employed, density of population and vehicular traffic density.

2.3.3 Collection Rate/Coverage

Solid waste collection rate is the percentage of the waste generated in a community which is collected for disposal in a period of time. The term collection rate can be interchanged with collection coverage which is defined as the ratio of the population served in an area to the total population in the area.

2.3.4 Efficiency and Effectiveness of MSW collection

According to United Nations Centre for Human Settlements (UNCHS, 1992), efficiency and effectiveness of a solid waste collection system are primarily determined by the equipment used for waste transport, they are nonetheless intimately related to the methods of waste storage and collection adopted. The nature of waste collection equipment to be used for a specific location will be a function of the method of waste collection which, in turn, will determine the appropriate method of storage. Compatibility between each of the three stages of storage, collection and transport is essential to ensure efficient operation.

As highlighted by Obirih-Opareh (2002), given its high visibility and importance, waste collection should receive a high degree of attention, scrutiny and supervision, monitoring and evaluation to ensure effective and efficient public or private operation. However, in developing countries, the opposite is the case.

2.3.5 Collection Equipment and Vehicles

Transportation poses some of the major problems for most of the garbage collection companies. Problems range from inadequacy, high costs of hiring, low payload of vehicles, unsuitability, and constant breakdowns due to poor roads (Karanja, 2005).

A variety of system and equipment have been developed for used in solid waste collection. These equipment may be classified based on the mode of operations, driving force used (animal or fuel powered) and the kind of interaction with storage facilities. Some of the equipment and vehicles are human handcart, animal cart, human pedal cart, tractor and trailer, conventional truck, roll top truck, high-side open-top truck, real loading hydraulic compactor.

Plate 2.1 below indicates different types of waste collection vehicles appropriate for various haulage distances.

According to Cointreau-Levine and Coad (2000), the following definitions are put forward for the various vehicle types.

a. **Compactor Truck:** this is a vehicle that is specially designed for collecting low density solid wastes. There are several different types, but they are all designed to lift and compress waste so that the body of the truck is filled with the full weight of the waste that the truck is designed to carry.

b. **Arm-roll Truck (roll-on-roll-off):** this is a type of mechanism used on a truck to enable it to pick up, empty and put down a large container that can be used to carry solid waste or other materials. The containers may be described as roll-on containers and they typically have capacities between $6m^3$ and $30m^3$.

c. **Open Tipper Truck:** it is a common type of truck that can be used for carrying a wide variety of loads. It has no roof or cover over the body that carries the load (open) and it unloads by inclining the body (tipper).

d. **Side Loading Truck:** this is a truck designed for carrying dense waste in an enclosed body, so that if the openings are closed, the waste is not blown out of the body when the truck is moving fast. The openings are closed by shutters which slide up and down. The body tips to unload.

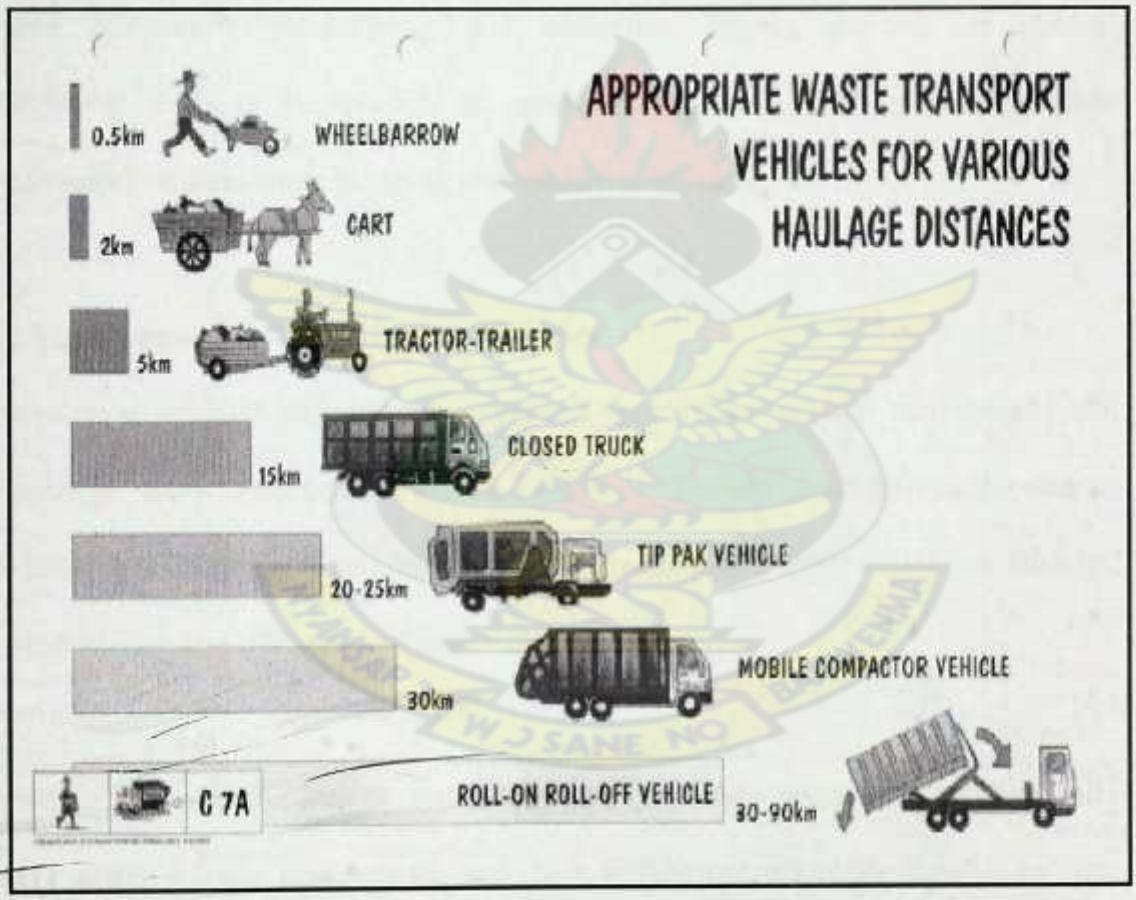

Plate 2.3: Appropriate waste transport vehicles for various haulage distances
Source: Lecture notes (Mensah, 2008).

2.4 Factors Affecting Performance of Private Companies

The factors affecting performance of private solid waste collection companies are identified as internal and external factors. Internal factors in this case are the factors that relate to the internal management and operations of the company. External factors on the other hand are those factors that the companies do not have direct control. Examples are road and traffic conditions that influence the performance of private solid waste collection companies. The internal management and operations appear to be a crucial factor in attaining a reasonable high productivity and utilisation. This is because company's productivity and utilisation largely depend on internal management such as supervision of operations, motivation of workers, vehicle maintenance, rational route planning and vehicle scheduling.

2.4.1 Maintenance and Condition of Vehicles

Utilisation of vehicles depends on operations supervision, regular maintenance and response to faults and breakdown of vehicles. For efficient operation, vehicle maintenance is required. When there is delay in maintaining waste collection vehicles, the productivity and utilisation of such vehicles will be low.

According to Cointreau-Levine and Coad (2000), private companies can generally achieve better vehicle maintenance and their workforces are more flexible to cope with the unforeseen circumstances, but well-written agreements and good enforcement are important in ensuring good operational performance. Discussion regarding vehicle productivity has so far concentrated on increasing the total quantity of waste transported each day when the vehicle is in operation.

Over a long term, however, the overall productivity of a vehicle will depend on the total amount of time the vehicle remains operationally productive during its life. Implicit in this relationship is the need to minimize the total out-of-service or down-time of a vehicle. Specific schedules of preventive maintenance and proper garaging facilities to undertake both routine maintenance and repair work can contribute substantially to increasing long-term vehicle productivity (UNCHS, 1992).

2.4.2 Rational Route Planning and Vehicle Scheduling

Routing is the detailed assignment of MSW collection vehicles and labour to collection routes such that collection efficiency is maximized. Routing often includes the actual route that a vehicle should take to minimize either the distance that it covers or the time that is taken to complete the collection assignment (Cointreau-Levine and Coad, 2000).

As discussed in UNCHS (1992), a further way of increasing vehicle productivity is to select and plan routes so that the quantity of waste collected daily is maximized. Often, the task of choosing vehicle routes is assigned to the supervisor or left to the discretion of vehicle operators. Districts to be served and priority areas within each district are often established on the basis of political boundaries, such as constituency areas, and provide little opportunity for overall co-ordinate planning. Even so, conformity to some guiding principles on route definition can contribute substantially to improving productivity. In urban centres, where a uniform waste-generation process is in place and disposal sites limited, the problem of route selection simply amounts to the identification of transport routes involving the least distance.

To maximise productivity the companies have to plan their collection routes for the drivers and do not have to allow the drivers to use their discretions as to which route to take. Whether the companies have workers with ability to plan their routes requires further assessment.

2.4.3 Vehicle Operation Planning and Supervision

Overall solid waste management plans at both the national and local levels are essential for utilizing limited resources most effectively, and providing a frame of reference for potential external support (Ogawa, 1995). Planning of vehicle routes, collection scheduling and supervision of operations are important factors to consider in the optimization of vehicle utilization.

2.4.4 Motivation of Workers

Public sector waste workers and formal private sector workers are subjected to unhealthy working conditions and poor social security. Access to social and health care services should be ensured. Proper equipment and protective clothing can reduce health risks. By contributing to the "professionalism" of the waste worker's role, proper clothing and equipment may also help to alleviate the social stigmatization which is often associated with waste work (Schubeler *et al.*, 1996).

As part of making people aware of the value of solid waste management and the efforts of the service providers, workers in the solid waste system should have clean and brightly coloured uniforms to upgrade their status and to make their presence (and work) more noticeable and easily monitored (Bernstein, 2004).

2.4.5 Road and Traffic Conditions

Road conditions, traffic density and overall haul distance will have a determining influence on vehicle choice. Condition at collection and disposal sites must also be evaluated. There is little point in using high-speed vehicles in situations where haul distances are short and traffic speeds are slow. The density of traffic in any city or town will determine the speed of road traffic which in turn will govern the type of vehicle most appropriate for the conditions. Alternatively, collection could be conducted at night in areas experiencing high diurnal traffic densities (UNCHS, 1992).

3. RESEARCH METHODOLOGY

3.1 Description of Study Area

Kumasi metropolis is the regional capital of Ashanti region in the central part of the republic of Ghana. The city is the second largest in the country, comprising ten (10) sub-metros, but only six (6) sub-metros are currently administered due to the unavailability of well structured offices as well as administrators and certain key leaders of assemblies' men/women to man the affairs of the other four (4) sub-metros. The sub-metros are equivalent to districts. The northern part of the city is Manhyia Sub-metro District and the south-eastern part is Asokwa Sub-metro District. The western part is Nhyiaeso Sub-metro District, the north-west and south-west is Bantama Sub-metro District, the eastern part is Oforikrom Sub-metro District while in the central part is Subin Sub-metro which is normally referred to as the Central Business District (CBD). Therefore, the following 6 sub-metros (Manhyia, Asokwa, Nhyiaeso, Bantama, Subin and Oforikrom) are currently administered.

Table 3.1 below illustrates the number of service zones, the zonal name (sub-metro) and the solid waste collection companies in charge.

Table 3.1: List of waste collection companies operating on Sub-metro (Zonal) basis

ZONE NO.	SUB-METRO (ZONE) NAME	COMPANY IN CHARGE
1	Asawase	Osbon Enterprise
2	Asokwa	Sak-M Co. Ltd
3	Bantama	Meskworld Gh. Ltd

4	Kwadaso	Waste Group Ltd
5	Manhyia	Meskworld Gh. Ltd
6	Nhyiaeso	KWML
7	Oforikrom	ABC Ltd
8	Suame	Anthoco Waste Co. Ltd
9	Subin	Zoomlion Gh. Ltd
10	Tafo	Zoomlion Gh. Ltd

Plate 3.1 shows the map of Ghana indicating the study area (Kumasi) and the other four cities in Ghana (Accra, Tema, Sekondi-Takoradi and Tamale).

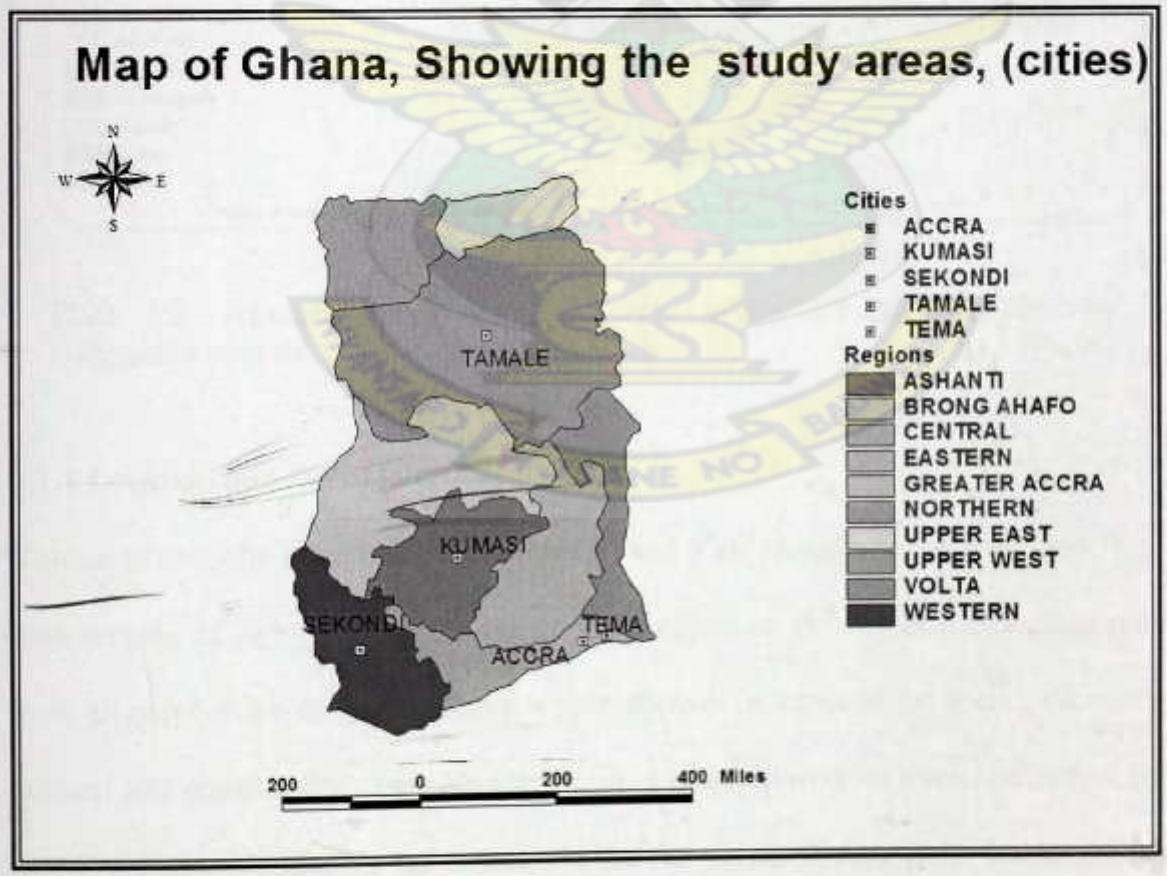

Plate 3.1 Map of Ghana, showing the study areas (cities)

Plate 3.2 below presents the map of Kumasi solely on sub-metro basis within which the waste collection companies operate. Each company is allocated to a particular sub-metro as shown in Table 3.1 above where it is only entitled to collect waste.

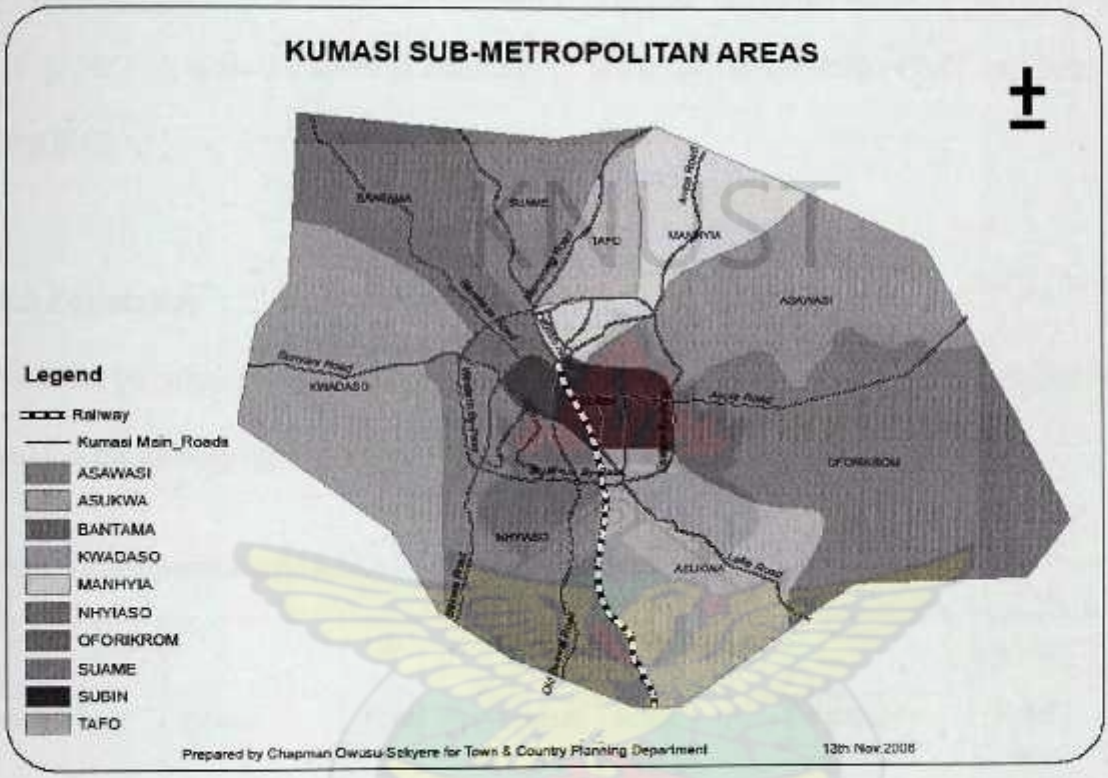

Plate 3.2: Kumasi sub-metropolitan areas where the waste collection companies operate

3.1.1 Location and Climate

Kumasi Metropolis lies within latitudes $6^0 35^1$ and $6^0 40^1$, longitudes of $1^0 30^1$ and $1^0 35^1$, with an area of 254 km^2. The unique central location of the city as a traversing point from all parts of the country makes it a special place in terms of the social, economic, cultural and political life of the country. It has a good network of roads, with the CBD in the city centre, and other infrastructures like telephones (both mobile and landlines), electricity and water facilities being present also. The topography of the city is gentle,

with four main drainage basins. There are often flooding in low-lying areas where flood plains have not been protected from illegal developers and/or due to siltation of drains or unauthorized refuse dumps along the natural courses of storm water. The climate of the city is the wet sub-equatorial type with a double maxima rainfall regime of about 214.3mm in June and 165.2mm in September. The average temperature ranges between 21.5 to 30.7^{0}C, with the average humidity of about 84.16% at 0900 GMT and 60% at 1500GMT.

3.1.2 Population

The latest population census carried out in the year 2000 by Ghana Statistical Service revealed the population figures as represented in Table 3.2 below.

Table 3.2: Population of KMA by Sub-Metros and gender

Sub-metros	Zones	Total Population in 2000	Gender		Total population in 2007 (projected)
			Male	Female	
KMA		1,170,270	587,012	583,258	1,383,212
ASOKWA	2	354,659	177,479	177,180	419,193
BANTAMA	3, 4, 6	283,584	140,375	143,209	335,185
MANHYIA	1, 5, 8, 10	405,629	205,962	199,667	479,437
SUBIN	7, 9	126,398	63,196	63202	149,397

Source: Ghana Statistical Services, 2000

Using the growth rate of 3.4% for Ashanti region, the 2000 population figures were projected for seven year period as shown in Table 3.2 above. The 2007 population figures were estimated by the use of a geometric growth model approach, in which the present population was obtained by the use of the following equation, $p_1 = p_0 (1+ r)^n$ where r=0.034, p_0=2000 population, p_1=2007 population projected and n=7 (seven year period)

3.1.3 Housing

The housing in Kumasi has been classified in the following four classes for the purposes of planning. These are: Tenement Housing; Indigenous Housing; New Government Housing and High-Cost Housing.

3.1.4 Department of Waste Management

The Kumasi Waste Management Department was founded to maintain the urban sanitation in 1999 with the support from United Nations Development Programme (Kumasi Sanitation Project) and has since then, as required by the policy that established it, been responsible for the collection, transportation and safe disposal of all solid waste generated in the metropolis along with the liquid waste. Its mission as stated in the mission statement is "to *keep the metropolis clean and healthy, by ensuring the efficient and effective removal and safe disposal of solid and liquid wastes from all the premises and public spaces, to create an enabling environment for development and recreation.*"

3.1.5 Dompoase Sanitary Landfill

The Kumasi landfill site, located at Dompoase in the south-east of Kaase (which is the industrial area of the city) started its operation on 28th of January, 2004. This implies it has been in service now for four years since it started operation. The site has 100-acre piece of land on which the solid waste receiving cells are built alongside with nine (9) waste stabilization ponds to receive and treat both leachate coming out of the solid waste and septage from cesspit emptiers from Kumasi. The design period for the facility is 15 years, planned to be developed in three phases of five years each.

Solid waste from various communities of the Kumasi metropolis is brought to the site in truckloads of various types by different companies. The collection vehicles mostly used are skip trucks and roll-on trucks for communal collection system and compactor trucks and side loader trucks for house-to-house collection system. Where refuse is dumped on ground, wheel loaders are used to load the tipper trucks. There are also other companies and individuals who bring their own generated refuse to the site. All wastes into the site are weighed at the weigh bridge through an electronic computerized system.

Plate 3.3 shows an engineered sanitary landfill and the entrance facilities that take care of all the wastes that are brought to the site.

Plate 3.3 Dompoase Sanitary Landfill and Entrance Facilities in Kumasi, Ghana

3.2 Sample Size

Six (6) private solid waste collection companies were chosen for the study out of a total of eight (8) private solid waste collection companies operating in Kumasi. The sample size was chosen based on the availability of data for the study. The six companies were the major companies contracted by the Kumasi metropolitan assembly to participate in the waste collection services, thus data were accessible for the study. The population of the city according to the 2000 population census stood at 1,170,270 and this was projected to 1,383,212 in 2007 using a growth rate of 3.4 %.

3.3 Data Collection

Data collection to accomplish the study objectives was carried out through desk study, questionnaire administration, gathering of secondary data, and conducting structured interviews. Both qualitative and quantitative data were collected. The desk study was done through review of literature on previous studies conducted in Ghana and other

countries regarding private companies' involvement in solid waste collection. The questionnaires were administered to six private solid waste collection companies in Kumasi and the structured interviews were conducted with the operations managers of the six companies in Kumasi. Secondary data (from previous study) involving nineteen companies in four other cities in Ghana were also used for the study. The detailed of the sample size based on which the secondary data were used is shown in Appendix 6.

3.4 Framework for Data Collection and Analysis

Table 3.3 below presents the framework for data collection and analysis. Performance data were collected from the disposal sites (landfill records) based on tonnes of waste collected per day and number of trips per vehicle per day by the various companies. The data from the companies on vehicle operations planning and supervision, mode of vehicle supervision, worker motivation, vehicles maintenance and condition, roads and traffic conditions in the service areas were collected using questionnaires and structured interviews.

Table 3.3 Framework for data collection and analysis

Aspects of the study	Variables	Definitions of Variables
Performance of companies	1.Vehicle Productivity	It is the actual waste collected in tonnes per day per vehicle
	2. Vehicle Utilisation	Ratio of actual waste collected to the expected output expressed as a

		percentage
Internal Management Capacity	Size of company	Number of waste collection vehicles on road
	Mode of collection planning and supervision	Rational route plan for vehicles, Vehicles operation supervision
	Vehicles maintenance	In-house maintenance with availability of maintenance schedules
External Factors	Market share	Ratio of quantity of waste collected by a company to the total waste collected in the city
	Road and traffic conditions in the service area	Condition of road (poor, fair or good) and nature of traffic condition (low, moderate or high congestion).

The total waste collected in tonnes by each vehicle per day was calculated as the actual outputs for the various collection vehicles type for all the companies. The expected output was determined using the average maximum number of trips each type of vehicle made per day based on the landfill records and the average maximum

capacity (load) of waste that was collected and disposed by the various types of collection vehicles per day. The product of the average maximum number of trips per day and the average maximum capacity of waste in tonnes gave the expected load (ton/day) for the various types of waste collection vehicles as summarised in Table 3.4 below. The expected load was then used as a benchmark to determine the utilisation of each type of collection vehicle. As at the time of assessment, the collection vehicles type shown in Table 3.4 below were used by the companies according to the landfill records.

Table 3.4: Expected load, number of trips per day and nominal capacity for various vehicles types.

Vehicle type	Expected load (ton/day)	No. of trips per day	Nominal capacity (tonnes)
Compactor truck	20	2	10
Skip truck	28	7	4
Roll on truck	63	7	9
Side loader	10	2	5

The market share of the various companies was determined using monthly landfill records of waste collected and disposed of by the various companies. The total waste collected by a given company was divided by the total waste collected in the city and that represents the market share of that company.

3.5 Data Analysis

The data collected from the companies based in Kumasi were analysed using statistical tools such as Microsoft Excel and SPSS. The results in terms of companies' performance (vehicle productivity and vehicle utilisation) were used to compare with performance of the companies in the four other cities using secondary data. One month landfill records were used to compute the vehicle productivity, vehicle utilisation and market share of the waste collected by the companies. The Microsoft Excel tool was used to present the results in the form of charts and the SPSS tool was used to present the statistical analysis of the results. The output of the results using correlation matrix (Pearson's correlation and Spearman's rho correlation coefficient) was used to test the research hypotheses.

4. RESULTS AND DISCUSSION

This chapter presents the results and discussion of the study. The discussion was based on the Performance (Vehicle productivity and Vehicle utilisation) of private solid waste collection companies, the contribution of private companies to solid waste collection and the factors that influence the performance of private solid waste collection companies.

4.1 Performance of Companies

A survey of six private solid waste companies was conducted in Kumasi to assess the performance of the companies. The performance of the companies was assessed in terms of vehicle productivity and vehicle utilisation. The data for computing the vehicle productivity and vehicle utilisation of waste collected were obtained from the summarised landfill records (Appendix 4A to 4D). The performance of the vehicle types responsible for waste collection in the companies was assessed.

4.1.1 Vehicle Productivity

Vehicle productivity is defined as the actual output in tonnes per day per vehicle. Different types of waste collection vehicles are used by each company, thus the productivity of each vehicle type was calculated based on the landfill records (Appendix 2A). The calculation was done by taking the total waste collected in tonnes per each vehicle type divided by the number of days that the vehicle was in operation within the month. Vehicle productivity index (company's vehicle productivity) was computed for each of the six companies in the Kumasi metropolis. The vehicle productivity index is defined as the sum of all vehicles productivities engaged in

waste collection in a period of time divided by the number of vehicles in operations. The index therefore is an average that stands for the vehicle productivity of that company in the period of assessment.

4.1.1.1 Vehicle Productivity of Companies in Kumasi

Vehicle productivity of a given company is directly influenced by the number of trips that each collection vehicle makes per day, the quantity of waste collected in tonnes per trip and the quantity of waste collected in tonnes per day per vehicle. If a waste collection company is able to maximise these factors, the productivity index of that company will increase. The combined effect of the number of trips that each collection vehicle makes per day, the quantity of waste collected in tonnes per trip and the quantity of waste collected in tonnes per day per vehicle determines the level of a company's overall vehicles productivity (vehicle productivity index). A trip is a single round of waste collected by a vehicle from the collection point to the disposal point.

The vehicle productivity index (company's vehicle productivity) for each of the company is shown in Figure 4.1 below. Companies such as KWML and Meskworld with high vehicle productivities signified that there was effective management capacity put in place by the said companies. Those companies whose vehicles productivities were comparatively low and even below average revealed that there was inadequate management. The average vehicle productivity was 17.23 ton/day/vehicle and only two companies (KWML and Meskworld) performed beyond average. On the average in terms of waste collected in tonnes per day per vehicle by different collection vehicles, KWML recorded the highest value followed by

Meskworld, Zoomlion, Waste Group, ABC and Sak-M as indicated in Figure 4.1 below. The data used to present the results in Figure 4.1 are shown in Appendix 2C.

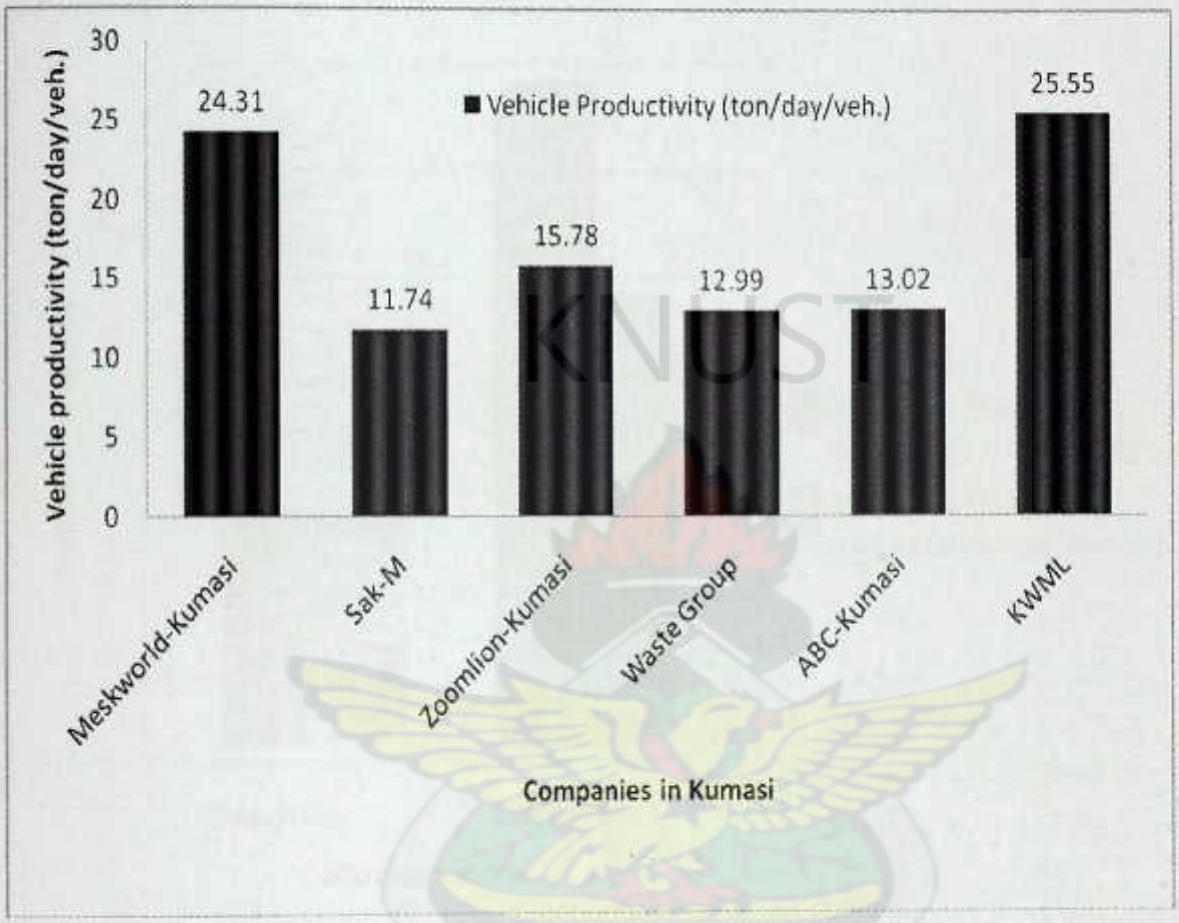

Figure 4.1: Vehicle productivity of waste collection companies in Kumasi

a. **Number of trips made per day by different collection vehicles types of companies with productivities above and below average**

In Figure 4.2, the results indicated that for compactor vehicles the average number of trips made per day was the same for companies whose productivities were above and below average. However, for skip trucks, the average number of trips made per day was higher for companies whose productivities were above average than those companies whose productivities were below average. On the whole, in terms of

number of trips made per day the skip trucks were higher than the compactor trucks. This was due to the fact that the skip trucks were mainly used for communal collection whereas the compactor trucks were used for house -to- house collection.

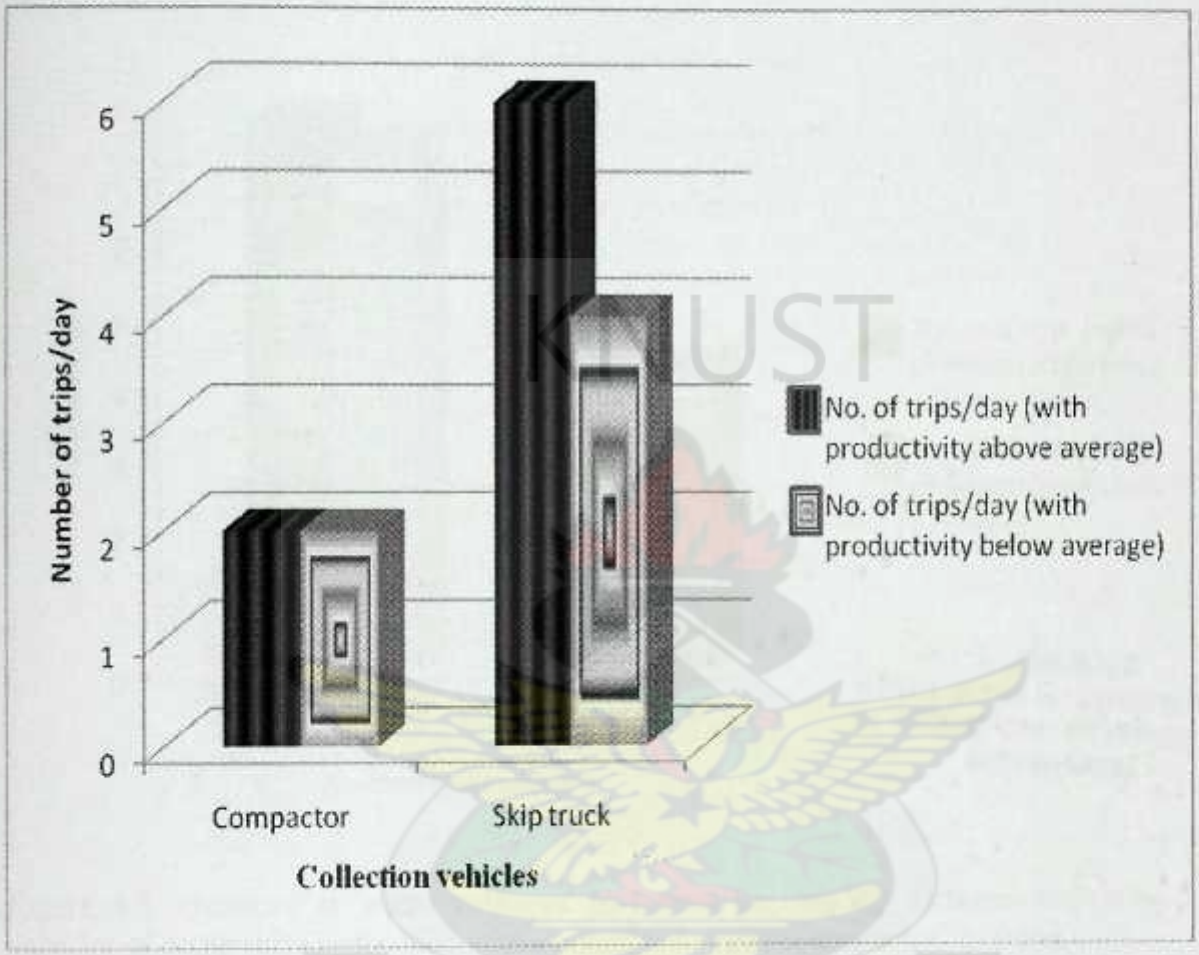

Figure 4.2: Waste collected in terms of number of trips per day by different collection vehicles of companies in Kumasi with productivities above and below average.

b. **Quantity of waste collected in tonnes per trip by different collection vehicles types of companies with productivities above and below average.**

For the average quantity of waste collected in tonnes per trip, the variation was not much for both the compactor trucks and the skip trucks for companies whose productivities were above and below average. In terms of quantity of waste collected in tonnes per trip, the compactor trucks were higher than the skip trucks (Figure 4.3).

This could be explained in line with the fact that the capacity or the volume of waste collected by the compactor trucks was higher than that of the skip trucks.

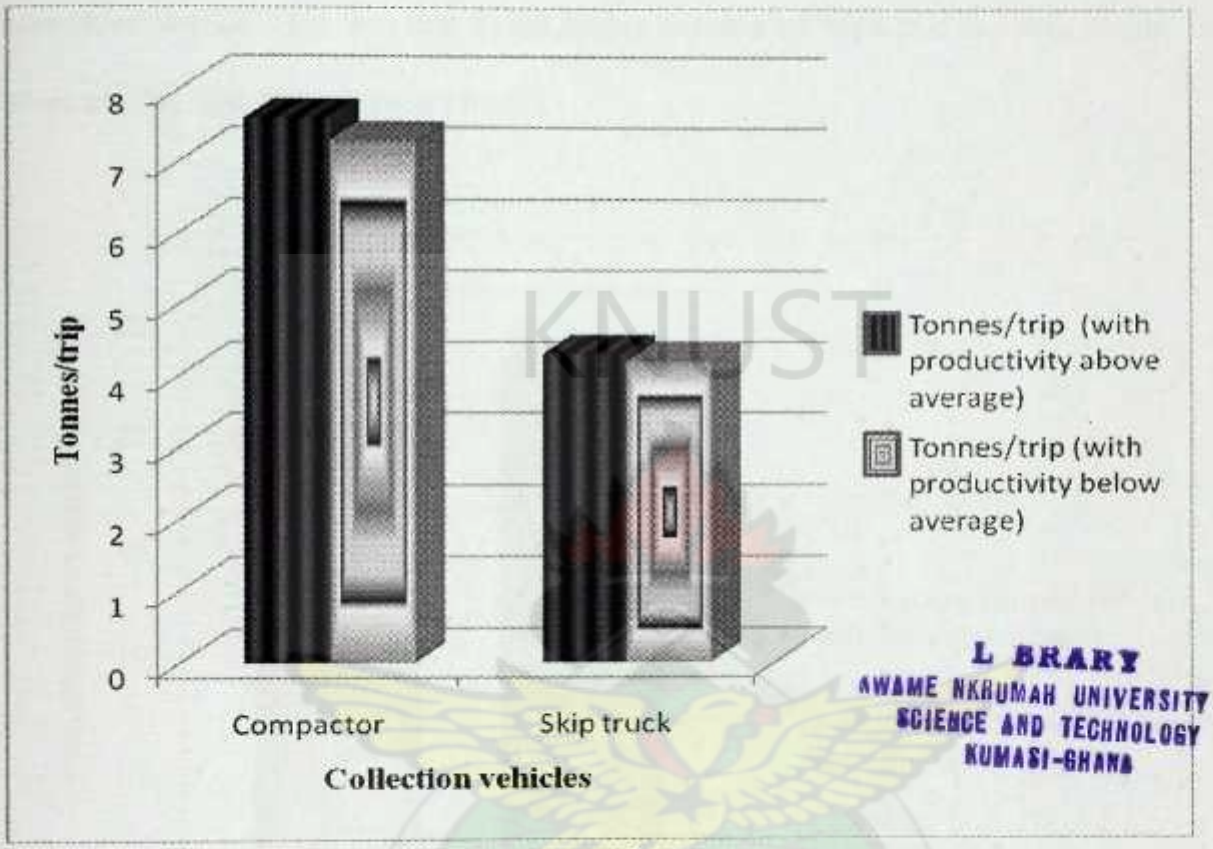

Figure 4.3: Quantity of waste collected in tonnes per trip by different collection vehicles of companies in Kumasi with productivities above and below average.

c. Quantity of waste collected in tonnes per day per vehicle by different collection vehicles types of companies with productivities above and below average.

Finally, for the average quantity of waste collected in tonnes per day per vehicle, companies with vehicle productivities above average recorded quite higher values than those companies with productivities below average for both compactor and skip trucks as shown in Figure 4.4. In terms of vehicle productivity in tonnes per day per

vehicle, the skip trucks were higher than the compactor trucks. Even though the volume of waste collected by the compactor trucks was higher than the skip trucks, the productivities in tonnes per day per vehicle of the skip trucks were higher than the compactor trucks. This was due to the higher number of trips that the skip trucks made per day than the compactor trucks.

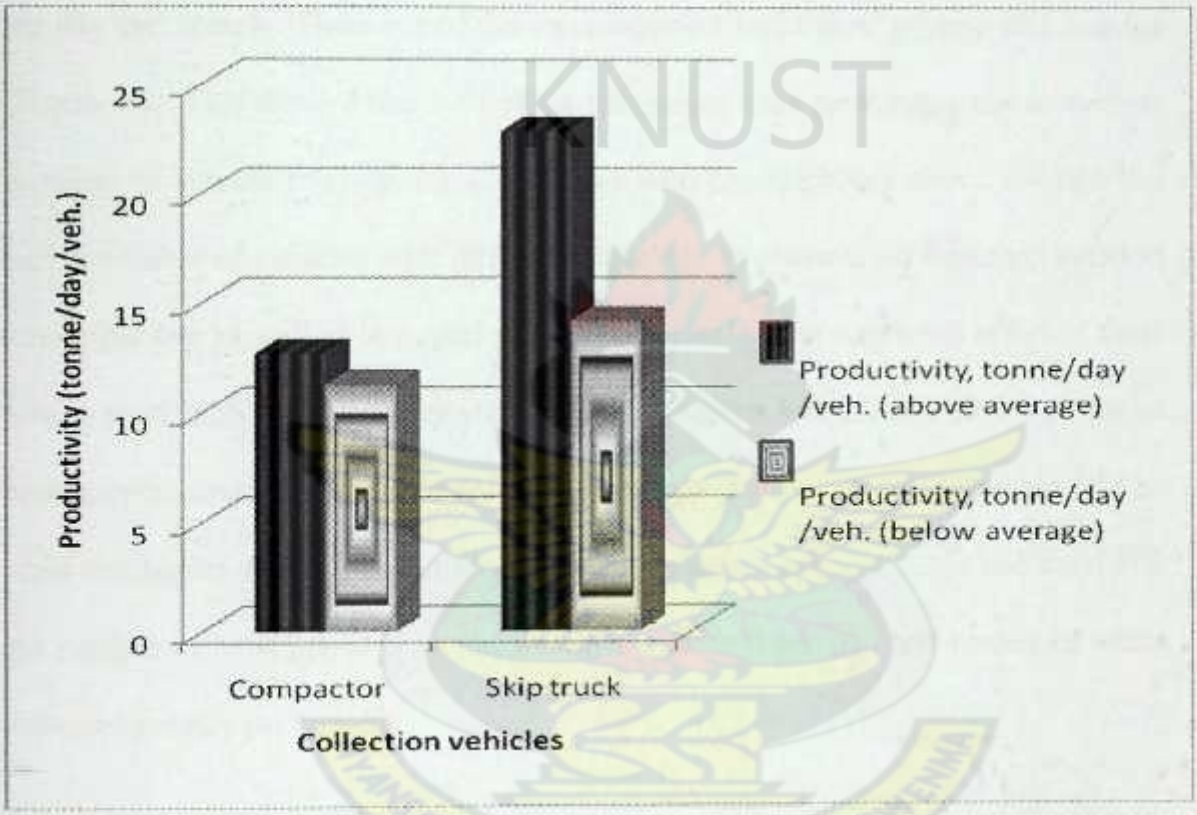

Figure 4.4: Quantity of waste collected in tonnes per day per vehicle by different collection vehicles of companies in Kumasi with productivities above and below average.

To ensure maximum output of waste collection vehicles therefore, it depends primarily on how the collection companies structure and organise their internal management capacity. Companies with the highest average values of vehicle productivity maximised the number of trips made and quantity of waste collected in tonnes by the various capacities of waste collection vehicles used.

4.1.1.2 Vehicle Productivity of Companies in Accra

A vehicle productivity index was calculated for each of the six companies used in the analysis in this city. A summary of the vehicle productivity indices for the 6 companies in Accra using the landfill records from the secondary data is shown in Appendix 2F.

The average vehicle productivity index for the companies in Accra was 19.4 tonnes per day per vehicle. Three out of the six companies had values beyond this average (Figure 4.5). This showed that 50% of the companies were performing above average in terms of vehicle productivity. Companies with productivities above average had varied number of vehicles with different capacities of quantity of waste collected in tonnes per trip as well as in tonnes per day per vehicle. The combined effect of these factors were high for companies such as Daben, Mohas and Liberty which produced productivity values of 33.9, 24.4 and 20.8 tonnes per day per vehicle respectively. The other companies whose productivity values were below average could not maximise the number of trips per day, tonnes of waste collected per trip and tonnes of waste collected per day per vehicle.

4.1.1.3 Vehicle Productivity of Companies in Tema

A vehicle productivity index was equally calculated for each of the four companies used in the analysis. The index is an average that represents the vehicle productivity of a company in the period of assessment.

The performance of the private companies in Tema revealed that vehicle productivity for a given vehicle type varied within and across companies. For instance vehicle

productivities for skips were generally higher than the compactor trucks across the companies .The average vehicle productivity index for the companies in Tema was 25.5 tonnes per day per vehicle and only one company (JSO) performed above average as indicated in Figure 4.5. The remaining three companies were performing below average due to the sort of management practices that were put in place to supervise the vehicles operations. Productivity depends on how the companies organise their operations to make optimum use of the vehicles in terms of the number of trips made in a day, tonnes of waste collected per trip and the quantity of waste collected in tonnes per day per vehicle.

4.1.1.4 Vehicle Productivity of Companies in Sekondi-Takoradi

The vehicle productivity index was as well calculated for the three companies in Sekondi-Takoradi. The factors that influence vehicle productivity already explained for companies in other cities were reflected in this city.

The average vehicle productivity index for the companies in this city was 12.4 tonnes per day per vehicle and two companies (ABC and Rusaben) were performing above average. The low productivity values recorded by the companies in this city were mainly due to the management capacity put in place. The management was not efficient enough to ensure high productivity of the vehicles at the time of assessment.

4.1.1.5 Vehicle Productivity of Companies in Tamale

The average vehicle productivity index for the six companies in this city was 5.6 tonnes per day per vehicle and only one company that is about 17% of the companies had productivity values above average. The 83% of the companies were averagely underperforming. Even though the average performance in terms of vehicle productivity was as low as 5.6 tonnes per day per vehicle compared to the performance of companies in the other cities, the majority of the companies could not achieve this average. Only one company (Zoomlion) recorded a vehicle productivity index of 18 tonnes per day per vehicle which was significantly higher than the average value (Figure 4.5).

One would wonder what was accounting for this low performance of the companies in Tamale in terms of vehicle productivity. The size of the company (number of collection vehicles on road) to some extent, the type of vehicles and the capacities (volume of waste collected) of vehicles used in waste collection were factors that accounted for the low performance. Apart from Zoomlion which had four collection vehicles, the rest of the companies had one collection vehicle each at the time of assessment (Appendix 2D). As regards the type of collection vehicles used, a number of companies used tractors and tipper trucks for the waste collections. These were vehicles that were quite old with frequent breakdowns thereby affecting the productivity of such vehicles and the companies for that matter.

4.1.1.6 Relationship between Vehicles Productivities and Size of Company

The vehicles productivities for companies in Accra increased with increasing number of collection vehicles from 1, 2 and 3 for Gee Waste, Golden Falcon and Daben respectively and then began to decrease with further increased in number of collection vehicles from 4, 5 and 15 for Mohas, Liberty and Zoomlion respectively as shown in Figure 4.5. On the other hand, the vehicles productivities for companies in Tema increased with increasing number of collection vehicles from 3, 3, 5 and 7 for Teriwhite, Asibod Co., Zoomlion and JSO respectively.

Regarding the relationship between vehicles productivities and size of company, for companies in Tamale, Sekondi-Takoradi and Kumasi there were fluctuations as indicated in Figure 4.5. The implication therefore is if a given company has a greater number of collection vehicles, it does not necessarily mean that the vehicles productivities of that company will be greater and the vice versa. In this regard, it suffices to say that the productivity of collection vehicles and how effectively such vehicles are operated largely depend on how the individual companies structure and organise their internal management capacity.

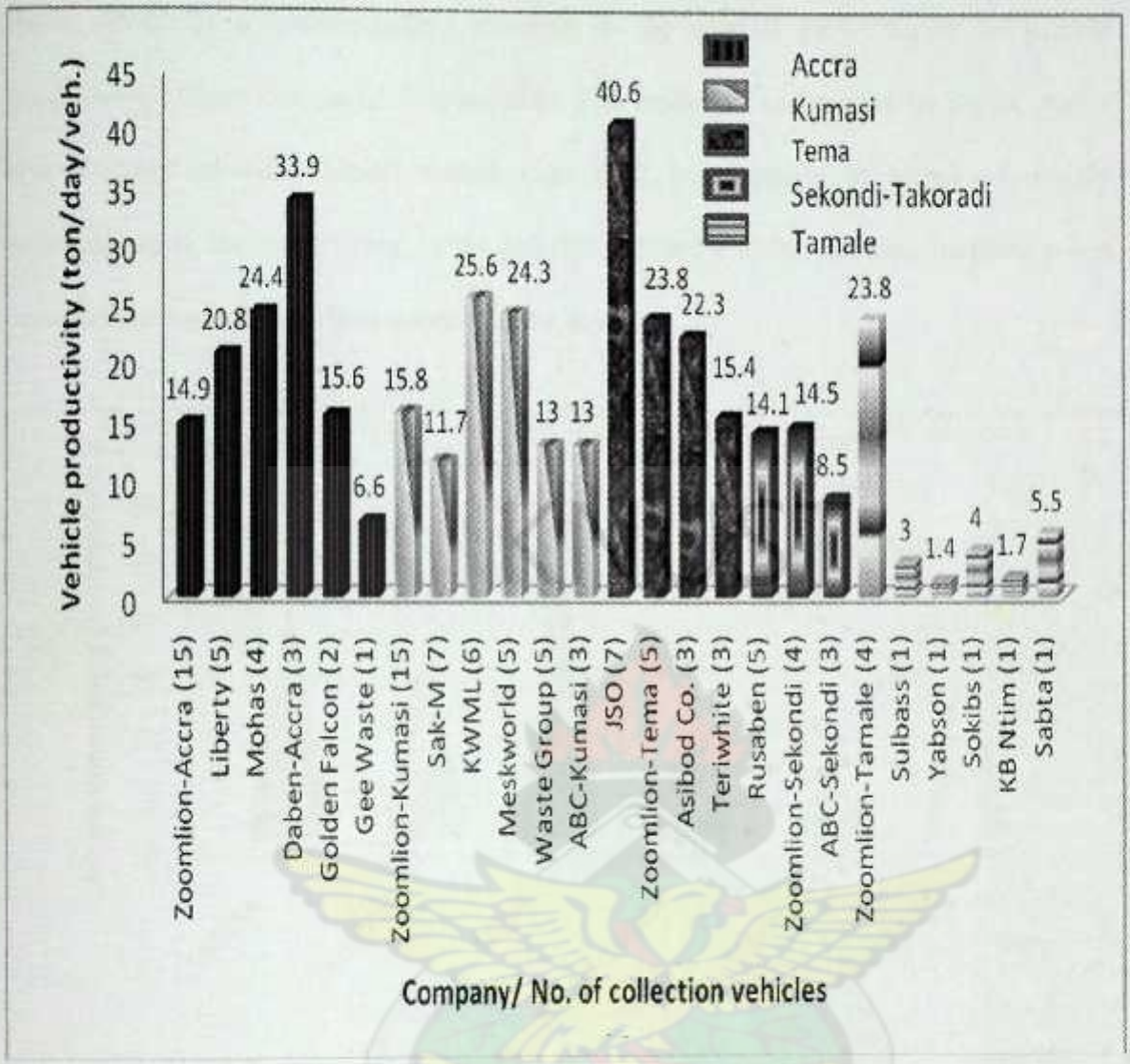

Figure 4.5: Vehicle productivity of companies in Kumasi compared with companies in 4 other cities in Ghana

4.1.1.7 Vehicles Productivities across Five Cities.

Generally, the average vehicle productivity of the companies in the 5 cities in Ghana considered for the study was 16.02 tonnes per day per vehicle (Figure 4.6). The average vehicles productivities in 3 cities (Tema, Accra and Kumasi) were above average. Companies in Sekondi-Takoradi and Tamale in this regard were performing below average. The results indicated that in a particular city if the average performance of the individual companies in terms of vehicle productivity was high,

there would be a corresponding increase in the overall performance in vehicle productivity when compared across cities. For instance, companies in Tema, Accra and Kumasi recorded higher values than their counterparts in terms of vehicle productivity in their individual cities and that yielded a corresponding increase when comparison was made across cities (Figure 4.6).

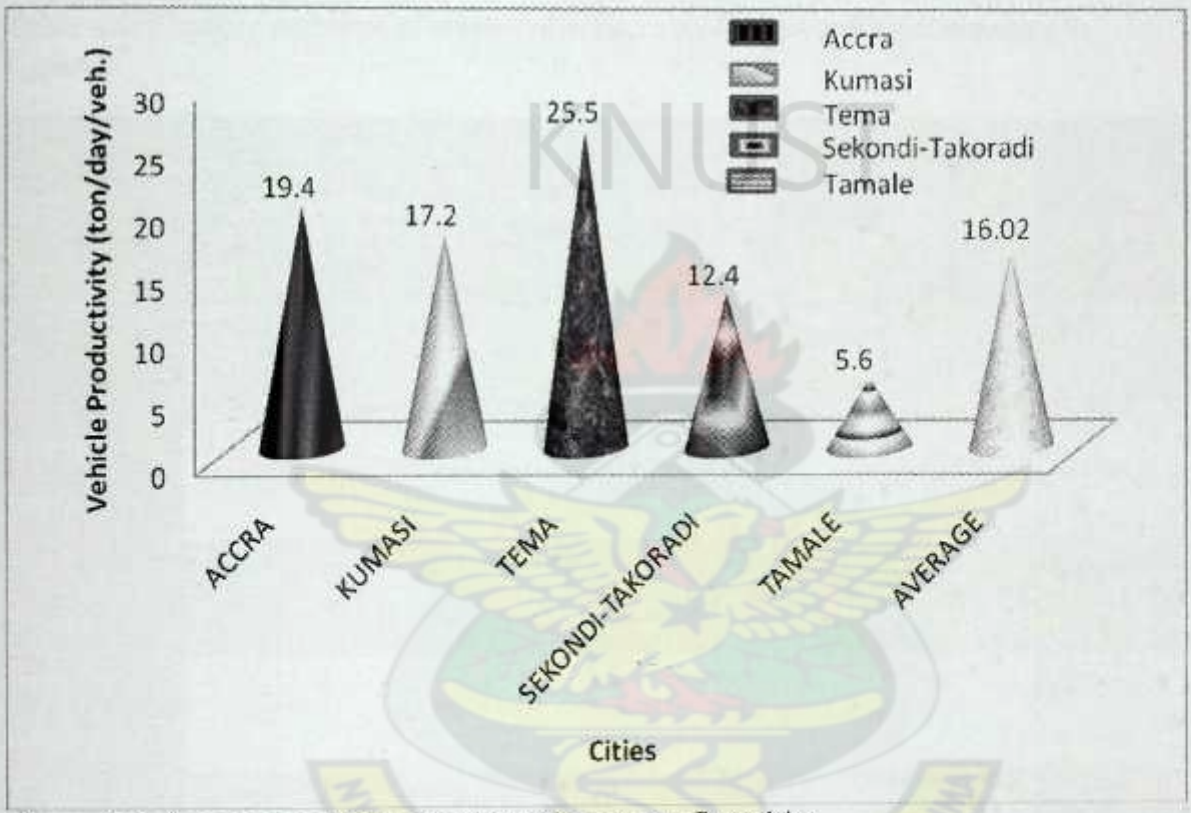

Figure 4.6: Average vehicles productivities across five cities.

4.1.2 Vehicle Utilisation

Vehicle utilisation is the ratio of the actual waste collected by each vehicle to the expected output of the vehicle expressed as a percentage. It measures the actual output of vehicles as against the expected output for a period of time. It is a measure of how the various companies are utilising their waste collection vehicles. The essence is to determine whether a given company is under utilising or over utilising its collection vehicles.

4.1.2.1 Vehicle Utilisation of Companies in Kumasi

Table 4.1 below illustrates the number and type of solid waste collection vehicles owned by the companies as at the time of assessment (using monthly landfill records) based on which the utilisation of such vehicles was computed and compared among the companies.

Table 4.1: Number and type of waste collection vehicles owned by companies in Kumasi

Vehicle type	Number owned by companies involved					
	Meskworld	Sak-M	Zoomlion	Waste Group	ABC	KWML
Compactor trucks	3	5	3		1	3
Skip trucks	4	4	10	2	2	2
Roll-on trucks	-	-	-	-	-	2
Total	5	7	15	5	3	7

Figure 4.7 below presents the vehicles utilisation of six waste collection companies in Kumasi. The average vehicle utilisation for the six companies was 62% and only two companies (Meskworld and KWML) utilized their vehicles above the average. Zoomlion was average in terms of its vehicles utilisation whereas companies such as Waste Group, ABC and Sak-M were utilizing their vehicles below average. This showed that the actual output of vehicles owned by Waste Group, ABC and Sak-M

was far below expectation hence the under utilisation of vehicles owned by such companies. The company (Meskworld) with the highest vehicle utilisation of 92% had collection vehicles which were well maintained with strict supervision thus the vehicles were able to achieve their maximum capacities in terms of waste disposal. Other factors which explained the difference in vehicles utilisation by the individual companies (Figure 4.7) were the number of trips made per day, the tonnes of waste collected per trip, the availability of vehicles on road and strict adherence to the internal management capacity.

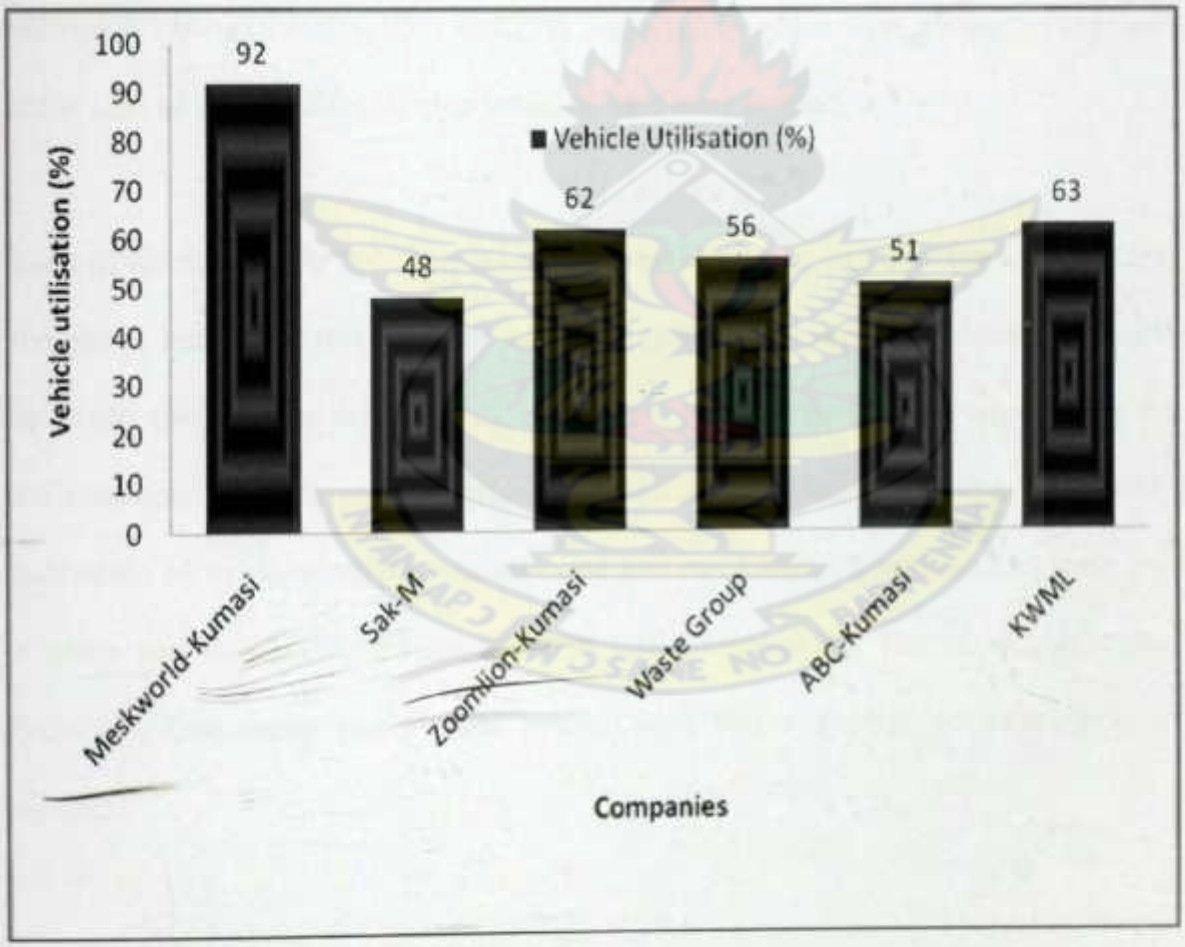

Figure 4.7: Vehicle utilisation of waste collection companies in Kumasi

4.1.2.2 Vehicle Utilisation of Companies in Accra

Figure 4.8 presents the vehicle utilisation values of companies in Accra together with the other companies comprising 25 companies operating within 5 cities in Ghana. An average vehicle utilisation value was computed for each of the companies in Accra. Vehicle utilisation normally gives an indication of the level at which the companies make use of their vehicles in the waste collection services. The average vehicle utilisation value of the companies was 68.8% and 50% of the companies (3 companies out of 6) performed above this average. The following three companies; Daben, Mohas and Liberty were outstanding in the utilisation of their vehicles. They recorded utilisation values of 105%, 95% and 77% respectively which were above the average. In the case of Daben, its collection vehicles were over utilised.

Some of the reasons for the companies which performed above average were that the companies had newer trucks which were all in very good working conditions as such the trucks were able to achieve their maximum capacities in terms of waste collected and disposed. The internal management capacities (vehicles supervision operations, motivation of workers, vehicle maintenance and conditions of vehicles etc) were put in place and that accounted for the high utilisation values. The other companies Zoomlion, Gee waste and Golden Falcon were below average in utilising their vehicles.

4.1.2.3 Vehicle Utilisation of Companies in Tema

Generally, there was significant increased in the vehicle utilisation of the companies in Tema compared to companies in the other cities as indicated in Figure 4.8 below.

The average vehicles utilisation value for the 4 companies in Tema was 89.5% and 3 companies (JSO, Asibod Co. and Zoomlion) could achieve this. The performance indicated that the daily output of the vehicles in terms of waste collected in tonnes was high and the daily number of trips expected of each vehicle type was met thus the high values of vehicles utilisation. This task was achieved as a result of effective management. The required management capacity was put in place. One of the companies (JSO) in Tema was over utilising its vehicles because the average vehicle utilisation was 110 %. This was very good, but could easily lead to breakdown of such vehicles.

4.1.2.4 Vehicle Utilisation of Companies in Sekondi-Takoradi

Three companies were assessed in this city and the average vehicles utilisation was 45% and only one company (ABC) could achieve this. This gave a clear indication that the companies in this city were underperforming with respect to vehicles utilisation. The average vehicles utilisation was below 50% that is the required management capacity was not put in place hence collection vehicles were not able to meet the daily demand of waste collected in tonnes and the number of trips.

At the time of assessment the number of collection vehicles owned by the companies was ~~3, 4~~ and 5 for ABC, Zoomlion and Rusaben respectively (Appendix 2D). Even though ABC had the least number of vehicles, its vehicles utilisation was 64% (Figure 4.8) which was far above the average. This indicated that the main problem accounting for the low values of utilisation for the other companies was not the number of collection vehicles on road, but management.

4.1.2.5 Vehicle Utilisation of Companies in Tamale

There were a number of factors that determined the utilisation of vehicles in this city. These included the number of trips each vehicle made per day, the actual waste in tonnes disposed per trip, the capacity of the vehicles, company's ability to plan, and organise route schedules and the motivation of the workers. At the time of assessment, apart from Zoomlion which had 4 collection vehicles on road the rest of the companies each had one collection vehicle (Appendix 2D). The results presented in Figure 4.8 showed that the average vehicles utilisation was 33.7% and companies such as Zoomlion, Sokibs and Sabta could perform above the average. The rest of the companies were below average. On the whole, the vehicles utilisation of the companies in this city was quite low compare to companies in the other four cities.

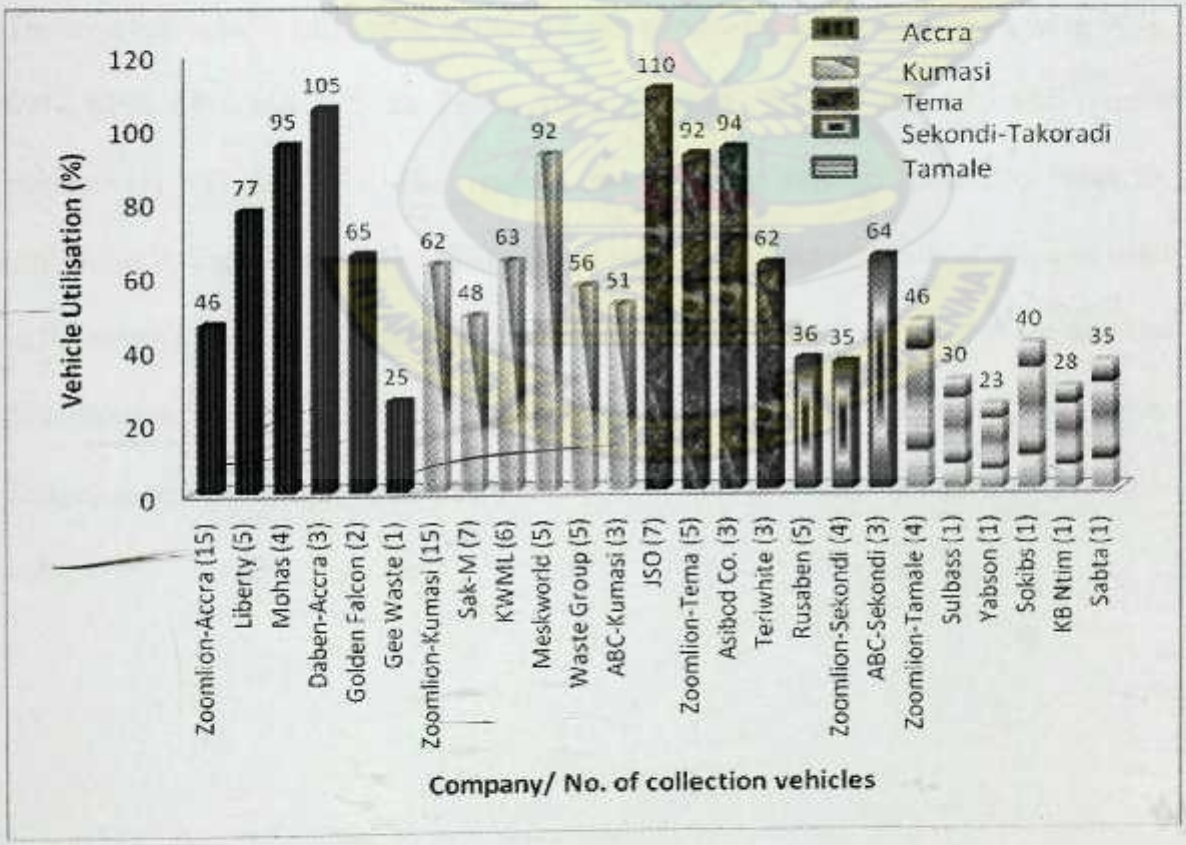

Figure 4.8: Vehicle utilisation of companies in Kumasi compared with companies in 4 selected cities in Ghana

4.1.2.6 Vehicles Utilisation across Five Cities

Generally, the average vehicles utilisation of the 5 cities in Ghana was 60% (Figure 4.9). The average vehicles utilisation in 3 cities (Tema, Accra and Kumasi) out of the 5 was above the average. Companies in Sekondi-Takoradi and Tamale in this regard were performing below average.

The results indicated that in a particular city if the average performance of the individual companies in terms of vehicles utilisation was high, there would be a corresponding increase in the overall performance in vehicles utilisation when compared across cities. For instance, companies in Tema, Accra and Kumasi recorded higher values than their counterparts in their individual cities and that yielded a corresponding increase when comparison was made across cities (Figure 4.9).

The average vehicle utilisation values for the companies in the five cities were 90%, 69%, 62%, 45% and 34% for Tema, Accra, Kumasi, Sekondi-Takoradi and Tamale respectively (Figure 4.9). The reasons for the low average values of vehicles utilisation in Tamale and Sekondi-Takoradi were due to the capacity of vehicles used in the waste collection, the maintenance capacity of the vehicles as well as the number of collection vehicles on road. Some of the companies had just one tractor as the only collection vehicle which could easily breakdown thus affecting the utilisation of such vehicle.

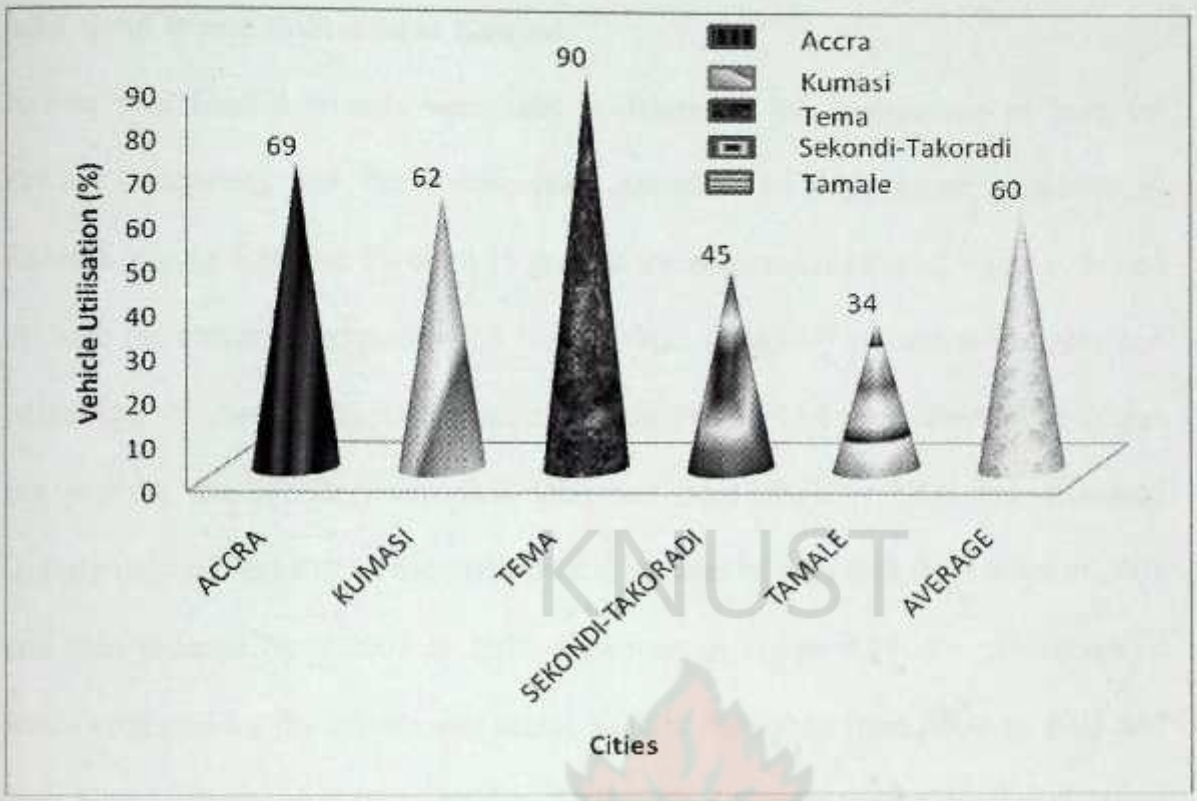

Figure 4.9: Average vehicles utilisation across five cities.

4.2 Contribution of Private Companies to Solid Waste Collection

The contribution of private companies to solid waste collection cannot be over-emphasised. Private companies have contributed tremendously to solid waste collection in Ghana such that their participation in solid waste collection is far more than the collection carried out by the Municipal and Metropolitan Assemblies. The waste collection previously carried out by the Municipal and Metropolitan Assemblies was inadequate hence the need to involve the private sector in the waste collection services.

4.2.1 Solid Waste Collection in Kumasi

A four year landfill records were used to determine the contribution of both the Private Companies and the Metropolitan Assembly to solid waste collection in Kumasi. Figure 4.10 and Figure 4.11 present the proportion of solid waste collected by both the Private Companies and Metropolitan Assembly in tonnes per year and percentage of yearly collection respectively. In Figure 4.10 the collection in tonnes per year by the private companies, increased from 2004 to 2006 and decreased slightly in 2007 and that of the Metropolitan Assembly increased from 2004 to 2005 and then reduced from 2005 to 2007. However, in Figure 4.11, the percentage of waste collected by the private companies slightly decreased from 2004 to 2005 and then kept on increasing from 2005 to 2007 with a corresponding decreased in the percentage collected by the Metropolitan Assembly.

On the average, as illustrated in Figure 4.11, the private companies in Kumasi contributed to 95% solid waste collection within four year period as against 5% collection by the Kumasi Metropolitan Assembly within the same time interval. This analysis showed that the impact being made by the private companies regarding solid waste collection in Kumasi as at the time of assessment was great. Following the contribution made by the private companies, it meant that many areas in the Kumasi Metropolis would have been left in a mess of uncollected waste if the collection was solely carried out by the Metropolitan Assembly.

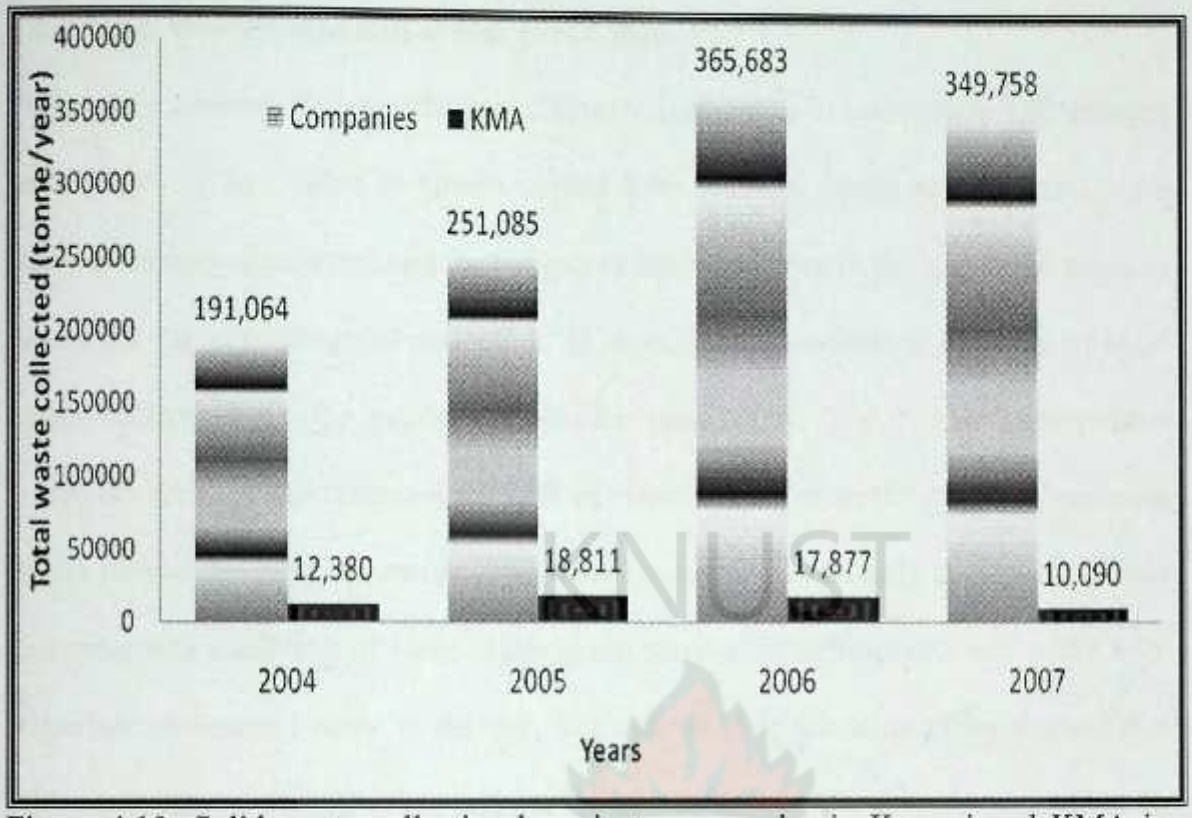

Figure 4.10: Solid waste collection by private companies in Kumasi and KMA in tonnes per year for four year period

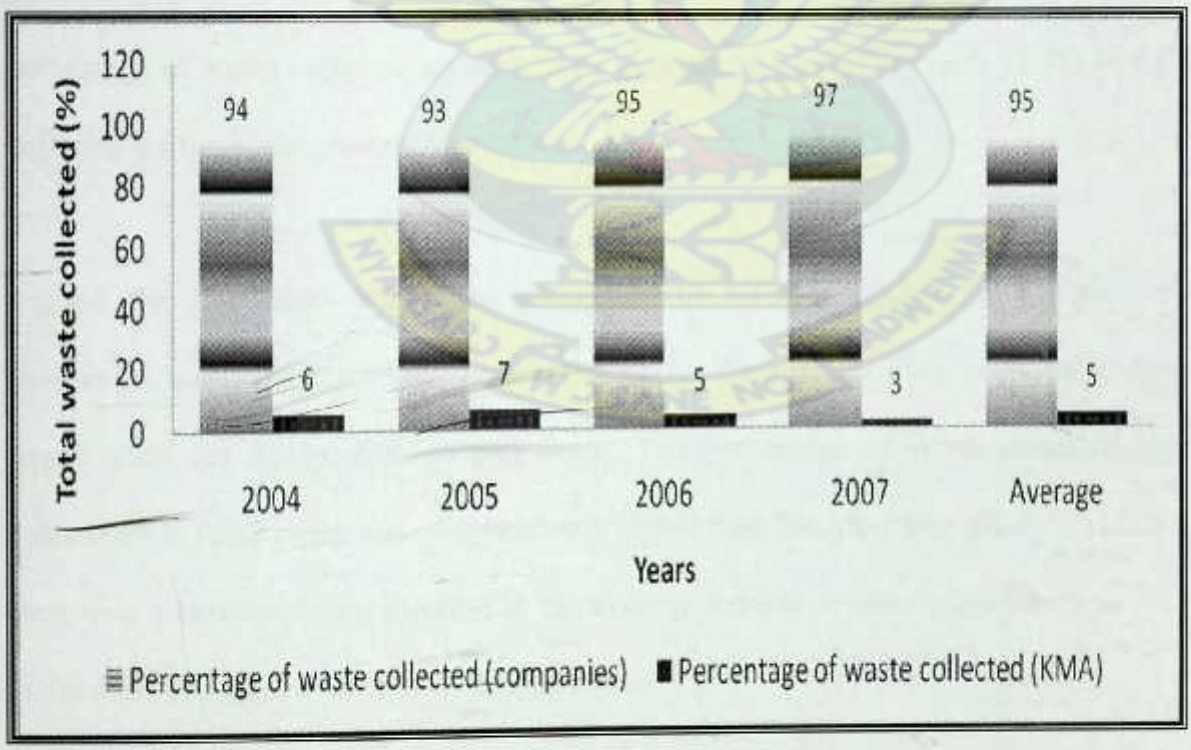

Figure 4.11: Solid waste collection by private companies in Kumasi and KMA in percentage for four year period

4.2.2 Solid Waste Collection across Five Cities

Figure 4.12 presents the contribution of private companies to solid waste collection in percentages in five cities in Ghana. Apart from Kumasi where primary data were used, secondary data were used for the rest of the companies in the four other cities to determine the percentage of collection. In Accra, the contribution in terms of solid waste collection by the private companies was 100%. The Accra Metropolitan Assembly (AMA) had relegated the bulk of waste collection to the private companies whilst it oversees their operations. The AMA however, is currently engaged in drains cleansing and sweeping of some major governmental establishments and some very important ceremonial roads in the city. The collection in the other cities showed that with time, the waste collection will purely be handled by the private companies. In Kumasi, the private companies have just 5% to cover so as to take sole responsibility of municipal solid waste collection. Generally, in the five cities in Ghana, the average percentage of waste collected by the private companies was 82.7% with 17.8% being collected by the Metropolitan Assemblies.

Among the five cities where the proportion of waste collected by the private companies was compared with that collected by the metropolitan assemblies, the larger cities are Accra, Kumasi and Tema. The percentage of waste collected by companies in these cities was comparatively higher than the other two cities. In effect, there was a corresponding increase in the average vehicle productivity of companies in the three mentioned cities than the other two.

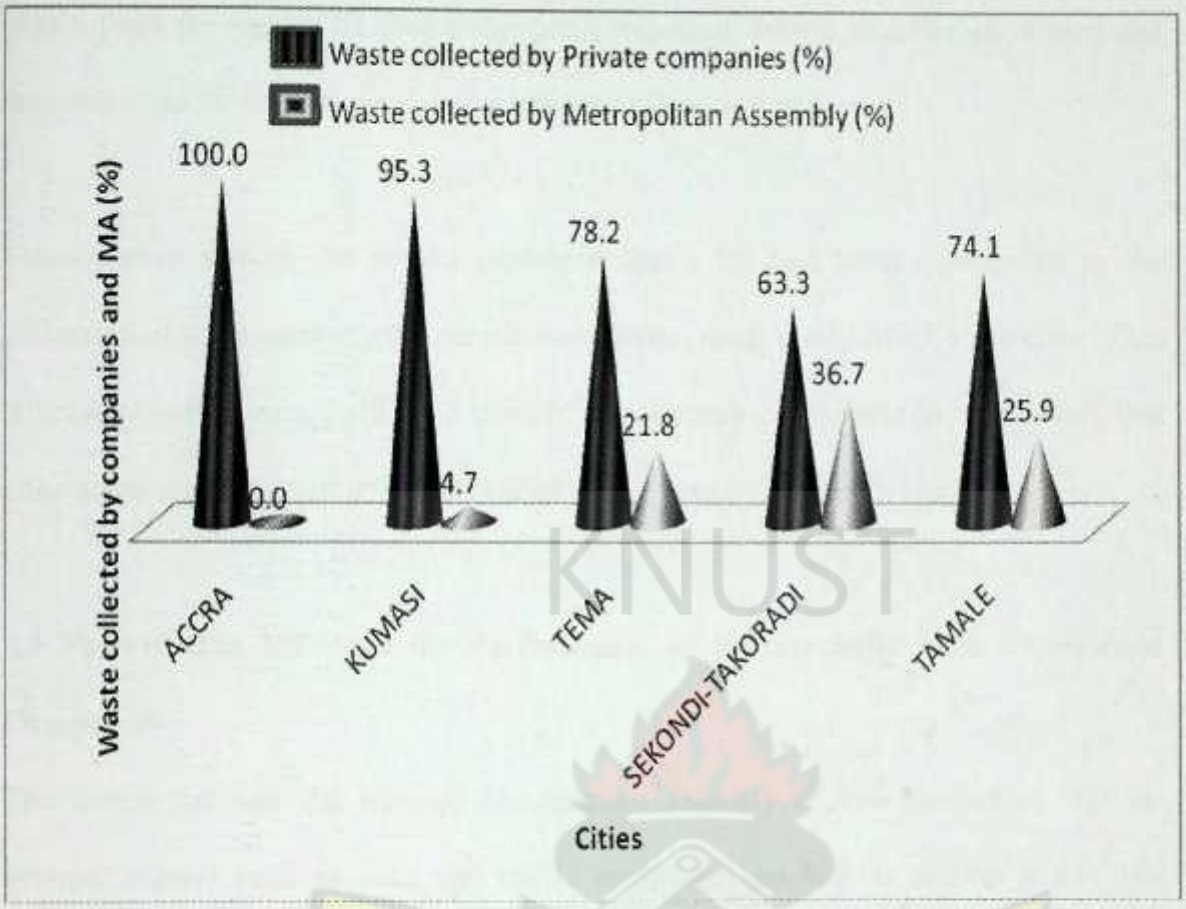

Figure 4.12: Solid waste collection in percentage by Private Companies and Metropolitan Assemblies in five selected cities in Ghana

Some of the reasons that accounted for the enormous contribution of the private companies to solid waste collection at the time of assessment were the competition among private companies for solid waste collection services. Thus the solid waste collection by the private companies was effective due to the competitive nature of the business. Unlike the public sector, private companies are assessed base on clear performance measures. This objective drives many private enterprises to effective performance. Another area was that private companies had management flexibility which mandated them to hire the optimum staff, paid according to performance, and adjusted work hours whenever there was the need. Also, unlike the public sector where bureaucracy is the order of the day, private companies had the freedom to

obtain parts for repairs of their collection equipment, leased vehicles as needed and subcontracted to meet demand peaks whenever there was the need.

Finally, even though the results explained that a lot had been contributed to the collection of solid waste by the private companies, there is still much to be done. This is because our cities are still in a mess of uncollected solid waste in many areas that pose odour nuisance and potential risk of waste related diseases in our cities.

4.3 Factors that Influence the Performance of Private Solid Waste Collection Companies

The factors include the internal management capacity of the companies and the external factors such as road and traffic conditions as well as market share. The management capacity of the private companies under this study highlights the following aspects: vehicle operations capacity, operations supervision capacity and vehicle maintenance capacity which directly influence performance of the companies.

4.3.1 Vehicle Operations Capacity

Vehicle operations capacity comprises vehicles route planning and operation scheduling. Routing is the detailed assignment of MSW collection vehicles and labour to collection routes such that collection efficiency is maximized. Routing often includes the actual route that a vehicle should take to minimize either the distance that it covers or the time that is taken to complete the collection assignment. Table 4.2 below indicates the assessment of the solid waste collection companies on vehicle operations capacity. Out of twenty-five (25) companies comprising the six companies

in Kumasi where primary data were used and the nineteen companies in the other cities where secondary data were used, twenty-three (23) companies agreed that vehicles route plans were prepared for drivers to follow and that vehicles followed specific routes for solid waste collection and disposal. Two (2) companies disagreed on the basis that vehicle routes were not prepared for drivers to follow. Vehicles route planning is necessary because it avoids waste in terms of fuel consumption. It also maximizes the use of time that contributes to an increase in the daily output of the vehicles. Drivers were daily assessed to ensure that routes planned for them were strictly followed and that the assessment was done based on their daily output in terms of vehicles utilisation. On vehicles route planning, ten (10) companies relied on external experts being hired on part-time to plan their vehicles operations whereas fourteen (14) companies did not rely on external experts to plan their vehicles operations. It meant that those 14 companies had the required internal capacity to manage their vehicles operations. Effective management is said to be the heart of every organization thus effective management of vehicles operations influences vehicles productivity and utilisation.

On operation scheduling as shown in Table 4.2 below, 23 companies out of the 25 companies agreed that waste pick-up schedules were prepared and strictly followed whilst 2 companies disagreed that waste pick-up schedules were prepared and strictly followed. Waste pick-up schedule means certain days and times are planned for pick-up of containers or empting of bins. Waste pick-up schedules are necessary to ensure that waste generated by the communities is picked-up as scheduled to avoid inconveniences such as spill over and odour nuisance at the collection points. It also

determines the performance of the companies. Waste pick-up schedules if strictly followed will contribute to how much waste is collected in tonnes per day per vehicle by each company.

Another aspect of the operation scheduling was to find out whether drivers use their own discretion about scheduling and which route to take for waste collection and the final disposal at the landfill site. A further way of increasing vehicle productivity is to select and plan routes so that the quantity of waste collected daily is maximized. Often, the task of choosing vehicle routes is assigned to the supervisor or left to the discretion of vehicle operators. As indicated in the results presented in Table 4.2 below, 13 companies agreed that drivers did not use their own discretion about scheduling and which route to take. On the other hand, 9 companies disagreed that drivers did not use their own discretion about scheduling and which route to take for waste collection. This means that some drivers do use their own discretion about scheduling and which route to take.

The management of the solid waste collection companies has it as one of their responsibilities to design arterial roads for waste collection drivers to follow so that they can maximize the daily output of waste collection and final disposal at the landfill site. It therefore means that if drivers fail to go by the designed arterial roads their daily output may go down and fuel may be wasted thereby affecting the performance of the companies. Conversely, some drivers do not follow the arterial roads designed for them; rather they use their own discretion about scheduling and which route to take. The decision of the drivers in this regard is sometime due to

odour nuisance when the waste is not covered especially when there is high traffic congestion along the arterial road. To maximize daily output of waste collection depending on the prevailing conditions, drivers normally opt to go by their own discretion about scheduling and which route to take.

Table 4.2: Vehicle operations capacity

Variable	Item No.	Items measurement scale	Disagree	Agree	Cannot tell	Total
Route Planning	OP1	Vehicles route plans are prepared for drivers	2	23	0	25
	OP2	Vehicles follow specific routes for solid waste collection	2	23	0	25
	OP3	External experts are hired on part-time to plan vehicle operations	14	10	1	25
Operation Scheduling	OS1	Waste pick-up schedules are prepared and strictly followed	2	23	0	25
	OS2	Drivers do not use their own discretion about scheduling and which route to take	9	13	3	25

4.3.2 Operations Supervision Capacity

Another area of the companies' management capacity is on operations supervision capacity which includes supervisory capacity and workers moral as illustrated in Table 4.3 below. The results showed that all the companies considered for the study agreed that technical personnel had the ability to supervise vehicles operations. Technical personnel are those personnel who have the technical know-how to supervise vehicles operations of the waste collection companies. This component of management is required because the productivity and utilisation of the waste collection vehicles depend on the extent to which operations are supervised.

Alongside the supervision of vehicles operations by the technical personnel is the role played by the top management of the companies. Top management in this context means directors or top managers of the company who see to the day-to-day operations of the solid waste collection business. The study was to find out whether the top management was capable of managing the vehicle operations. As illustrated in Table 4.3 below, all the companies agreed that the top management was capable of managing the vehicle operations. Management plays a critical role in the growth of every organization. In this regard, the quality of service, the productivity and utilisation of vehicles of the companies involved in solid waste collection are greatly influenced by management. The degree of management therefore, clearly indicates the difference in performance of various companies.

Another equally important aspect that determines the performance of the companies is on the moral of the workers. In this domain, the study sought to find out if the moral of the employees was high due to fair labour practices and as to whether drivers and

collection crew put on protective clothing during waste collection. Fair labour practices in this context means whether employees are paid wages above minimum wage; receive medical benefits, social security and other benefits. Twenty one (21) companies agreed that the moral of the employees was high due to fair labour practices, one (1) company disagreed whilst three (3) companies could not tell whether the moral of the employees was high due to fair labour practices (Table 4.3). According to the results indicated in Table 4.3, it was explained that the driver and the crew members wore protective clothing during waste collection and that the dress code was meant to identify the driver and the crew members for each waste collection company.

As part of making people aware of the value of solid waste management and the efforts of the service providers, workers in the solid waste system should have clean and brightly coloured uniforms to upgrade their status and to make their presence and work more noticeable and easily monitored. On the issue of the moral of the employees being high due to fair labour practices, it was noticed that employees in some companies were paid wages above minimum wage; receive medical benefits, social security and soft loans. Generally, public sector waste workers and formal private sector workers are subjected to unhealthy working conditions and poor social security. Access to social and health care services is necessary to boost the morale of waste workers. Proper equipment and protective clothing can reduce health risks. By contributing to the "professionalism" of the waste worker's role, proper clothing and equipment may also help to alleviate the social stigmatization which is often associated with waste work.

Table 4.3: Operations supervision capacity

Variable	Item No.	Items measurement scale	Disagree	Agree	Cannot tell	Total
Supervisory Capacity	SC1	Technical personnel has ability to supervise operation	0	25	0	25
	SC2	Top management is capable of managing the vehicle operations	0	25	0	25
Workers Moral	SM1	High moral of the employees due to fair labour practices	1	21	3	25
	SM2	Driver and collection crew put on protective clothing	1	24	0	25

4.3.3 Vehicle Maintenance Capacity

The maintenance capacity is one of the factors influencing performance of private solid waste collection companies. Vehicles maintenance under this study was assessed in terms of whether vehicle maintenance schedules were prepared and followed and vehicles condition was assessed in terms of whether breakdowns of vehicles depended

on the 'make' and 'age' of the vehicles and whether the higher the age of a vehicle the more breakdowns would occur (Table 4.4). The results showed that 23 companies did agree that vehicles maintenance schedules were prepared and followed. Maintenance of vehicles includes schedules and facilities owned for maintenance and repairing of collection vehicles. This is necessary because it leads to reduction of vehicles breakdown and increase service life for vehicles. Utilisation of vehicles depends on regular maintenance and response to faults and breakdowns of vehicles. For efficient operation, vehicle maintenance is required. Specific schedules of preventive maintenance and proper garaging facilities to undertake both routine maintenance and repair work can contribute substantially to increasing long-term vehicle productivity.

Again, from the results indicated in Table 4.4 it was pointed out that some companies had mechanics with varied specialization and technical know-how to take care of vehicles maintenance depending on the fault that occurs. Others also resorted to external mechanics as and when there was the need for vehicles maintenance.

Also, with reference to the view of the companies on vehicles condition, fifteen (15) companies agreed that breakdowns of vehicles depended on the 'make' and 'age' of the vehicles , five (5) disagreed and 5 companies were undecided. They could not tell whether breakdowns of vehicles depend on the 'make' and 'age' of the vehicles (Table 4.4). The 'age' refers to how old a particular vehicle has been in service and the 'make' refers to the manufacturer of the collection vehicle for example, M-benz and Renault. On vehicles condition, 15 companies agreed that the higher the age of a vehicle the more breakdowns occur; eight (8) companies disagreed whilst two (2) companies could not tell whether the higher the age of a vehicle the more breakdowns

occur (Table 4.4). From the results it was explained that breakdowns of vehicles influenced the number of trips expected in a day and that would ultimately affect the productivity of such vehicles in terms of waste collected in tonnes per day per vehicle. A breakdown that needed spare parts for replacement would greatly reduced vehicles productivity if the spare parts were not immediately available.

Table 4.4: Vehicle maintenance capacity

Variable	Item No.	Items measurement scale	Disagree	Agree	Cannot tell	Total
Vehicles maintenance	MC2	Vehicle maintenance schedules are prepared and followed	1	23	1	25
Vehicles Condition	VC1	Breakdowns of vehicles depend on the 'make' and 'age'	5	15	5	25
	VC2	The higher the age of a vehicle the more breakdowns occur	8	15	2	25

Plate 4.1 below indicates the breakdown situation of waste collection vehicles. In situation of this kind, if the repair of such vehicles is not immediate, their productivity and utilisation in terms of waste collection will be highly affected. In addressing

situations of the kind the waste collection companies have established workshops where collection vehicles that are broken down are brought in for repair as indicated in plate 4.2 below.

Plate 4.1 Breakdowns of waste collection vehicles in Kumasi

Plate 4.2 Maintenance workshop for waste collection vehicles in Kumasi

4.3.4 Road and Traffic Conditions of Collection Vehicles

Road condition and traffic condition are likely external factors that influence the productivity and utilisation of collection vehicles. The results presented in Table 4.5 below indicated that ten (10) companies assessed the condition of roads used for

waste collection as poor; nine (9) companies placed it on the level of fair whilst six (6) companies rated the condition of roads used for waste collection as good. As regards traffic condition, twelve (12) companies reported that the nature of traffic conditions along collection routes was low congestion, 10 companies rated it as moderate congestion and 3 companies rated it as high congestion.

In the case of road condition, it was indicated that some access routes were bad and that breakdowns of collection vehicles were frequent for vehicles that were not designed for such routes and that posed an adverse effect on the performance of such vehicles in waste collection. Road conditions limit the maximum capacity of waste to be carried by each vehicle type. On the issue of traffic, to manage the situation, it was explained that management of companies ensured that drivers report to work early enough to avoid high traffic congestion. Drivers were also abreast with traffic conditions at different times of the day and so planned their movement to avoid the situation.

Table 4.5: Road and traffic conditions of collection vehicles

Variable	Item No.	Items measurement scale	Poor	Fair	Good	Total
Road Condition	RC	Condition of road used for waste collection	10	9	6	25
			Low congestion	Moderate congestion	High congestion	Total
Traffic Condition	TC	The nature of traffic conditions along collection routes	12	10	3	25

Plate 4.3 indicates the traffic condition of waste collection vehicles and that can affect the productivity and utilisation of such vehicles. An interview with one of the drivers of the waste collection vehicles revealed that several hours are normally wasted as a result of high traffic congestion along some of the roads used by the collection vehicles. Collection vehicles usually do not meet the number of trips they expect in a day due to traffic condition in most cases, hence low vehicle productivity and utilisation.

Plate 4.3: A typical traffic condition of a compactor truck (waste collection vehicle) in one of the major roads in Kumasi

4.3.5 Hypotheses testing using Dependent and Independent Variables

Questionnaires were administered to the various waste collection companies and the responses were tested statistically to address the research hypotheses. The dependent variables in this study consist of vehicle productivity and vehicle utilisation. The independent variables include vehicle route planning, operation scheduling,

supervisory capacity, workers moral, vehicles condition, size of company, market share and road condition and traffic condition. These independent variables serve as factors that influence the performance (vehicle productivity and vehicle utilisation) of the solid waste collection companies. The hypotheses testing in this study aims at finding out if there are statistically significant correlations between the dependent variables and the independent variables that form the basis for assessing the performance of the solid waste collection companies.

Tables 4.6 and 4.7 present the Pearson's correlation between the dependent variables and the independent variables. Supervisory capacity which measures as to whether technical personnel has the ability to supervise operation and whether top management is capable of managing the vehicle operations indicated positive and statistically significant correlation with vehicle productivity (Pearson's correlation .398* sig. $p<0.05$) as shown in Table 4.6. This means that when supervisory capacity is rationalised vehicle productivity will increase. Depending on how vehicles operations are supervised, productivity may be increased or reduced. Market share also showed positive and statistically significant correlation with vehicle productivity (Pearson's correlation .423* sig. $p<0.05$). This shows that when the market share is large, vehicles productivity may increase or otherwise. However, vehicle route planning, workers moral, vehicle condition and road condition indicated positive correlation but not statistically significant with vehicle productivity (Tables 4.6 and 4.7). Vehicles operation scheduling and maintenance capacity also showed both negative and statistically insignificant correlation with vehicle productivity (Tables 4.6 and 4.7).

Table 4.6: Correlation matrix (Pearson's correlation) and descriptive statistics

Variables		1	2	3	4	5	6	7	8
1.Vehicle productivity	Pc	1.00							
2.Vehicle utilisation	Pc	.916**	1.00						
3. Market Share	Pc	.423*	.200	1.00					
4. Size of company	Pc	.331	.214	.488*	1.00				
5. Route planning	Pc	.251	.310	.022	.103	1.00			
6.Operation scheduling	Pc	-.064	-.097	.155	.248	.049	1.00		
7. Supervisory capacity	Pc	.398*	.240	.400*	.514**	.205	.303	1.00	
8.Workers moral	Pc	.042	-.081	-.081	.098	.036	.050	.353	1.00

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 4.7 Correlation matrix (Pearson's correlation) and descriptive statistics

Variables	1	2	3	4	5	6	7
1. Vehicle productivity	1.00						
2. Vehicle utilisation	.916**	1.00					
3. Market share	.423*	.200	1.00				
4. Maintenance capacity	-.132	-.166	-.018	1.00			
5. Vehicles condition	.319	.226	.314	-.118	1.00		
6. Road condition	.283	.319	-.033	.079	-.209	1.00	
7. Traffic condition	.364	.388	-.005	-.200	.248	.012	1.00

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Tables 4.8 and 4.9 present the Spearman's rho correlation coefficient between the dependent variables and the independent variables. The size of company (number of collection vehicles on road) indicated a positive and statistically significant correlation with vehicle productivity (Spearman's rho correlation coefficient .586** sig. $p<0.01$) as shown in Table 4.8 below. Also, traffic condition showed positive and statistically significant correlation with vehicle productivity (Spearman's rho correlation coefficient .452* sig. $p<0.05$) as shown in Table 4.9 below. This means that both the size of company and traffic condition influence vehicle productivity. Thus improper management of the number of vehicles on road and high congestion traffic condition will affect vehicle productivity.

Table 4.8 Correlation matrix (Spearman's rho correlation coefficient) and descriptive statistics

Variables	1	2	3	4	5	6	7	8
1. Vehicle productivity	1.00							
2. Vehicle utilisation	.905**	1.00						
3. Market share	.541**	.361	1.00					
4. Size of company	.586**	.457*	.683**	1.00				
5. Route planning	.262	.268	.167	.072	1.00			
6. Operation scheduling	-.070	-.085	.196	.181	.030	1.00		
7. Supervisory capacity	.382	.232	.428*	.495*	.223	.281	1.00	
8.Workers moral	.004	-.176	-.029	-.004	.303	.269	.504*	1.00

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 4.9 Correlation matrix (Spearman's rho correlation coefficient) and descriptive statistics

Variables	1	2	3	4	5	6	7
1. Vehicle productivity	1.00						
2. Vehicle utilisation	.905**	1.00					
3. Market share	.541**	.361	1.00				
4.Maintenance capacity	.021	-.132	-072	1.00			
5. Vehicles condition	.320	.235	.313	-.085	1.00		
6. Road condition	.246	.321	.122	.113	-.238	1.00	
7. Traffic condition	.452*	.437*	.055	-.222	.224	-.010	1.00

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The size of company indicated positive and statistically significant correlation with vehicle utilisation (Spearman's rho correlation coefficient .457* sig. $p<0.05$) as shown in Tables 4.8. Traffic condition also showed positive and statistically significant correlation with vehicle utilisation (Spearman's rho correlation coefficient .437* sig. $p<0.05$) as shown in 4.9. It therefore goes to explain that both the size of the company and traffic condition determine vehicle utilisation. That is if the traffic condition is not effectively planned and the collection vehicles on road are not effectively managed, the utilisation of such collection vehicles will be influenced. Vehicles route planning, supervisory capacity, vehicles condition and road condition, though the correlations were positive, they were not statistically significant with vehicle utilisation (Tables 4.6 and 4.7). On the other hand, vehicles operation scheduling, workers moral and maintenance capacity indicated a negative and not statistically significant correlation with vehicle utilisation (Tables 4.6 and 4.7).

The analysed results under this section showed that there was positive and statistically significant correlation between some dependent variables. For example, vehicle utilisation indicated positive and statistically significant correlation with vehicle productivity (Tables 4.6 and 4.7). On the other hand, it was observed that there was positive and statistically significant correlation between some independent variables as well. For instance, supervisory capacity showed positive and statistically significant correlation with the size of company as indicated in Tables 4.6

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The study revealed that the average performance in terms of vehicle productivity (tonnes/day/vehicle) of the six private solid waste collection companies in Kumasi was 17.2 and only two out of the six companies performed above average due to how effectively the two companies planned and operate their collection vehicles. Comparing the average vehicle productivity (tonnes/day/vehicle) of companies in Kumasi with the companies in the other four cities in Ghana, the values were 25.5, 19.4, 17.2, 12.4 and 5.6 for companies in Tema, Accra, Kumasi, Sekondi-Takoradi and Tamale respectively. Across the cities, the average vehicle productivity (tonnes/day/vehicle) was 16.02 and the average performance of companies in three cities (Tema, Accra and Kumasi) was above this value.

The average performance in terms of vehicle utilisation of the six private solid waste collection companies in Kumasi was 62 % and only two companies performed above average due to how effectively the two companies utilised their collection vehicles. Comparing the average vehicle utilisation of companies in Kumasi with the companies in the other four cities in Ghana, the values were 89.5%, 68.8%, 62%, 45% and 33.7% for companies in Tema, Accra, Kumasi, Sekondi-Takoradi and Tamale respectively. Across the cities, the average vehicle utilisation was 60% and the average performance of companies in three cities (Tema, Accra and Kumasi) was above this value. The average performance of companies in Tema, Accra and Kumasi in both vehicle productivity and utilisation was generally higher than those companies in Sekondi-Takoradi and Tamale. Companies with higher average values of vehicles

productivity and utilisation maximised the number of trips made and quantity of waste collected in tonnes by the various capacities of waste collection vehicles used.

The study also indicated that private companies contribute to an average solid waste collection of 95% in Kumasi. Comparison with other cities indicated that the collection by the private companies was 100%, 95%, 78%, 74% and 63% in Accra, Kumasi, Tema, Tamale and Sekondi-Takoradi respectively. The percentages of waste collected are in increasing order of population for the various cities except for Tamale and Sekondi-Takoradi. This shows that with time the collection in the other cities will be purely by the private companies as the population increases. The rest of the percentages in the various cities were those collected by the Metropolitan Assemblies. Generally, in the five cities in Ghana, the average percentage of waste collected by the private companies was 82.7% with 17.8% being collected by the Metropolitan Assemblies as at the time of assessment.

The study suggests that factors such as vehicles operations planning and supervision, the size of the company (number of collection vehicles on road), market share and traffic conditions influence the performance (vehicle productivity and vehicle utilisation) of private solid waste collection companies. If these factors are rationalised, the performance will increase. There is a correlation between market share and vehicle productivity. There is also a correlation between vehicles operations planning and supervision and vehicle productivity.

5.2 RECOMMENDATIONS

The following recommendations are put forward for improved performance of private companies and policy formulation.

Regular assessment should be carried out on vehicle productivity and vehicle utilisation to provide data for monitoring the performance of private solid waste collection companies.

Regular training of technical personnel on management capacity such as maintenance and conditions of collection vehicles, vehicle route planning and supervision of services should be put in place so as to maximise the performance of private solid waste collection companies.

The government should set up a kind of yearly award for the top leading company in terms of waste collection which will serve as a motivation for effective and efficient waste collection.

Companies that recorded low values for both vehicles productivity and utilisation could be attributed to certain policies governing the operations of vehicles in such companies. It is therefore recommended that further study be carried out to assess the effect of policies on performance of waste collection vehicles.

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APPENDICES

Appendix 1: Private companies Questionnaire

Private Companies' Questionnaire

Coding of Data

1.0 solid waste service characteristics and Performance

Variable name (label)	Values (values to be entered)	measure
1.1 Company name		*(nominal)*
1.2 City		*(nominal)*
1.3 Type of collection service	*1 Only house-to-house* *2 Only communal collection* *3 Both house-to-house and communal collection*	*nominal*
1.4 Provision of standard bins for house-to-house	*1 Company 2 Assembly* *3 residents*	*(nominal)*
1.5 HtH Collection frequency per week		*(scale)*
1.6 No. of communal containers		
1.7 No. of company owned communal containers		
1.8 No. of company owned collection vehicles		
1.9 No of collection vehicles on road		
1.10 Total number of vehicles		
1.11 Number of Compactor		
1.12 Number of Skip truck		
1.13 Number of Roll-on-truck		

1.14 Number of Side loader 1.15 Number of Tipper truck 1.16 Number of Tractor 1.17 Other type of vehicles		
1.18 Number of collection crew including driver for Compactor vehicle 1.19 Number of collection crew including driver for Skip vehicle, Roll-on Vehicle, Side loader, Tractor, Tipper truck		*(scale)*
1.20 Vehicle productivity 1.21 Worker productivity 1.22 Overall productivity 1.23 Vehicle utilization 1.24 Actual output (ton/day)		
1.25 Resident satisfaction about the quality of service	1Yes ...0 no.....	*nominal*

1.26 Appreciation of effectiveness and quality of waste collection service.

How will you rate the effectiveness and quality of waste collection service in the city?

Use these Scales (1) very poor (2) poor (3) fair (4) good (5) very good

(a). Frequency of waste collection and reliability of waste collection 1 2 3 4 5

(b). Sanitary conditions at bin/container site and spill-over of waste 1 2 3 4 5

(c). cleanliness of surroundings (rating of 5 for no littering) 1 2 3 4 5

(d). Neatness of waste collection crew, wearing of protective clothing 1 2 3 4 5

(e).	Neatness of waste collection vehicles	1	2	3	4	5
(f).	Quick response to residents' complaints	1	2	3	4	5
(g).	Behaviour/attitude of collection crew towards residents	1	2	3	4	5
(h).	Sanitary conditions of drains in the area	1	2	3	4	5

Total score

.....

2 Company's capacity, technical operations and resources management

Vehicle operations planning

2.1 Vehicle operations planning (*(scale)*

Rated using scales of (1) strongly disagree (2) disagree (3) cannot tell (4) agree (5) strongly agree

a) Supervisor has prepared vehicle route plan for drivers 1 2 3 4 5

b) Waste pick-up schedules are prepared and strictly followed 1 2 3 4 5

c) Drives use their own discretion about which route to take 5 4 3 2 1

d) Vehicles follow specific routes for solid waste collection 1 2 3 4 5

e) External experts are hire on part-time to plan vehicle operations 5 4 3 2 1

Total score for vehicle operations planning:

.....

Vehicle operations Supervision

2.2 Number of operations supervisors...

(Scale).....

2.3 Number of vehicles per supervisor... *(Scale)*.....

2.4 Vehicle operations supervision

Rated using scales of (1) strongly disagree (2) disagree (3) cannot tell (4) agree (5) strongly agree

f) Technical personnel has ability to supervise operation 1 2 3 4 5

g) Top Management is capable of managing the vehicle operations 1 2 3 4 5

Total score for vehicle supervision:

.....

2.5 Mode of vehicle supervision

How is vehicle operations supervised? (Nominal)

1. Field monitoring 2.

2.6 Worker motivation

Rated using scales of (1) strongly disagree (2) disagree (3) cannot tell (4) agree (5) strongly agree

h) The moral of the employees is high due to fair labour practices 1 2 3 4 5

i) The drivers and collection crew put on protective clothing 1 2 3 4 5

Total score for worker motivation:

.....

2.7 Waste spill over at CC locations *(nominal)*

Reasons for waste spill over at communal container (CC) locations (nominal)

1 Inadequate container 2. Delays in pickup, 3. others

2.8 Cooperation of residents served by HtH

How would you judge the cooperation of residents served by house-to-house service?

1 Very poor 2 poor 3 fair 4 good 5 very good

2.9 Residents complaints *(Nominal)*

What complaints are often received from service beneficiaries or collection crew? (Nominal)

1 spill over of waste 2. Non collection of waste 3. Others……..

Vehicles Maintenance and Condition

2.10 In-house repairs

Where are vehicles repaired? 1. In-house vehicle workshop 0. Workshop elsewhere

2.11 Number of mechanics for in-house repairs.....

2.12 Number of vehicles per mechanic.....

2.13 Vehicle maintenance schedules available

Rated using scales of (1) strongly disagree (2) disagree (3) cannot tell (4) agree (5) strongly agree

j) Vehicle maintenance schedules are prepared and followed 1 2 3 4 5

Total score for vehicle maintenance: ……

2.14 Vehicle conditions

Rated using scales of (1) strongly disagree (2) disagree (3) cannot tell (4) agree (5) strongly agree

k) The breakdowns of vehicles depend on the 'make' and 'age' 1 2 3 4 5

l) The higher the age of a vehicle the more breakdowns occur 1 2 3 4 5

Total score for conditions of vehicles: ……

Road and traffic conditions in the service areas

2.15 Approximate distance between the service area and the disposal site (scale).....

2.16 Condition of road *(ordinal)*

Rating of the condition of road used for waste collection (ordinal)

1 Very poor 2 poor 3 fair 4 good 5 very good

2.17 Nature of traffic conditions *(ordinal)*

Rating of the nature of traffic conditions along collection routes (ordinal)

1. Low congestion 2. Moderate congestion 3 high congestion

Appendix 2 A: Data on Average Vehicle Productivity (Companies in Kumasi)

Companies	Types of vehicles	Average total waste disposed (ton/trip)	Average total number of trips	Average number of trips/day	Average total number of working days	Average vehicle productivity (ton/day/veh.)
Meskworld	Compactor	8.11	27.0	2	18	12.16
	Skip truck	4.0	152.0	6	24	27.35
Sak-M	Compactor	5.9	18.0	2	11	10.91
	Skip truck	4.0	36	3	14	12.36
Zoomlion	Compactor	7.01	46	2	28	11.64
	Skip truck	4.0	93	4	22	17.90
Waste Group	Compactor	8.01	32	2	17	14.40
	Skip truck	4.0	54	3	22	10.86
ABC	Compactor	8.2	24	1	24	8.20
	Skip truck	4.0	111	4	31	15.40
KWML	Compactor	7.0	39	2	22	13.2
	Skip truck	4.0	49	5	11	18.3
	Roll-on truck	9.0	28	5	7	38.5

Appendix 2 B: Data on Average Vehicle Utilisation (Companies in Kumasi)

Companies	Types of vehicles	Average Vehicle Utilisation (%)	Crew members including driver
Meskworld	Compactor	60.8	3
	Skip truck	97.6	2
Sak-M	Compactor	54.5	5
	Skip truck	44.1	2
Zoomlion	Compactor	58.2	3
	Skip truck	63.8	2
Waste	Compactor	72.1	6
Group	Skip truck	38.8	2
ABC	Compactor	41.0	7
	Skip truck	55.1	2
KWML	Compactor	66.07	5
	Skip truck	65.37	2
	Roll-on truck	61.15	2

Appendix 2 C: Data on Vehicle Productivity Index and Utilisation

Company's Name	Vehicle productivity index (ton/day/veh.)	Vehicle utilisation (%)	Number of Vehicles	Total number of crew members including drivers
Meskworld	24.31	92.08	5	11
Sak-M	11.74	47.77	7	23
Zoomlion	15.78	62.29	15	35
Waste				

Group	12.99	56.00	5	22
ABC	13.02	51.41	3	11
KWML	25.55	63.30	6	23
Average	**17.23**	**62.14**		

Appendix 2 D: Companies performance Data in five selected cities in Ghana (Accra, Tema, Tamale, Sekondi-Takoradi and Kumasi)

Company's Name	Vehicle Productivity (ton/day/veh.)	Vehicle Utilisation (%)	Number of Vehicle on road	Market Share (%)
Daben-Accra	33.9	105	3	6.4
Mohas	24.4	95	4	3.3
Zoomlion-Accra	14.9	46	15	21.0
Gee Waste	6.6	25	1	0.1
Liberty	20.8	77	5	5.5
Golden Falcon	15.6	65	2	0.1
JSO-Tema	40.6	110	7	34.0
Asibod Co	22.3	94	3	2.6
Teriwhite	15.4	62	3	10.4
Zoomlion-Tema	23.8	92	5	13.5
Zoomlion-Tamale	18.0	46	4	37.3
Sulbass	3.0	30	1	2.5
Yabson	1.4	23	1	1.1
Sokibs	4.0	40	1	2.2
KB Ntim	1.7	28	1	2.0
Sabta	5.5	35	1	5.1
Zoomlion-Sekondi	8.5	35	4	5.0
ABC-Sekondi	14.5	64	3	21.0
Rusaben	14.1	36	5	28.0

Meskworld-Kumasi	24.3	92	5	10.6
Sak-M	11.7	48	7	3.5
Zoomlion-Kumasi	15.8	62	15	21.1
Waste Group	13	56	5	4.4
ABC-Kumasi	13	51	3	4.2
KWML	25.6	63	6	6.5
TOTAL	392.4	1480		
AVERAGE	15.7	59		

Appendix 3: Percentages of Waste Collected by Private Companies and Metropolitan Assemblies

CITY	Waste collected by Private Companies (%)	Waste collected by Metropolitan Assembly (%)
ACCRA	100.0	0.0
TEMA	78.2	21.8
SEKONDI-TAKORADI	63.3	36.7
KUMASI	95.3	4.7
TAMALE	74.1	25.9

Appendix 4 A: Landfill Records for Waste Collection in 2004 (Weights in Tonnes) in Kumasi

Landfill Records for Waste Collection in **2004** (Weights in Tonnes)												
Company	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Sak-M	140	170	150	130	130	140	170	200	170	170	190	**1760**
Meskworld	880	1300	1300	1400	1100	1000	1200	1000	99	900	1300	**11479**
Waste Group	1500	2400	2000	2000	1900	1800	2000	2000	2000	2300	2300	**22200**
KWML	9800	12000	13000	11000	12500	11000	10000	9000	14000	18600	20780	**141680**
ABC Ltd	210	210	240	260	260	270	260	240	200	200	270	**2620**
KMA	-	600	1300	1600	1400	1200	1200	780	1000	1000	2300	**12380**
Total	**12530**	**16680**	**17990**	**16390**	**17290**	**15410**	**14830**	**13220**	**17469**	**23170**	**27140**	**192119**

Appendix 4 B: Landfill Records for Waste Collection in 2005 (Weights in Tonnes) in Kumasi

Landfill Records for Waste Collection in **2005** (Weights in Tonnes)													
Company	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Sak-M	234	164	184	171	180	187	167	151	139	147	49	84	**1857**
Meskworld	1819	1038	2150	2100	2522	2505	2614	3617	2514	1775	1724	1664	**26042**
Waste Group	2081	2022	2222	2117	2386	2383	2211	2695	3454	2552	2295	2441	**28859**
KWML	9979	9224	12230	12733	10846	14917	12342	16058	20422	14873	12955	10840	**157419**
ABC Ltd	244	240	295	247	286	291	259	286	289	7507	10958	10316	**31218**
KMA	1278	1148	1290	1458	1894	1642	1727	1672	1718	1842	1477	1665	**18811**
Total	**15635**	**13836**	**18371**	**18826**	**18114**	**21925**	**19320**	**24479**	**28536**	**28696**	**29458**	**27010**	**264206**

Appendix 4 C: Landfill Records for Waste Collection in 2006 (Weights in Tonnes) in Kumasi

Landfill Records for Waste Collection in **2006** (Weights in Tonnes)													
Company	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Zoomlion	-	-	-	-	5022.8	1813.2	1813.2	1363.2	91.1	1154.3	14096.3	10333.1	**35687.2**
Sak-M	93	84.7	86.5	98.6	111	180	207.2	112.5	163.7	154.7	215.5	178	**1685.4**
Meskworld	1576	1494	1764.4	3187.5	2299.2	14175.9	16336.7	11383.6	8731	7778.8	12913.1	9220.9	**90861.1**
Waste Group	2383	2238.2	2774.1	2373.3	7372	2027.1	2612.2	2509.8	2168	2347.1	2598.6	2863.5	**34266.9**
KWML	11362	12926.2	15230	9683.5	14196.6	11302.7	10172.8	11945.2	8806.2	6551.5	5860.7	7657.7	**125695.1**
ABC Ltd	2320	1243.6	1273.9	3341.9	5264.5	3626.7	10172.8	10576.8	9092.1	2377.9	12726.4	8748.6	**70765.2**
KMA	1767	1513	3219.3	1674.3	1221.7	1115.8	1020.3	1032.1	1154.3	817.1	1258.1	2083.9	**17876.9**
Total	**19501**	**19499.7**	**24348.2**	**20359.1**	**35487.8**	**34241.4**	**42335.2**	**38923.2**	**30206.4**	**21181.4**	**49668.7**	**41085.7**	**376837.8**

Appendix 4 D: Landfill Records for Waste Collection in 2007 (Weights in Tonnes) in Kumasi

Landfill Records for Waste Collection in **2007** (Weights in Tonnes)													
Company	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Zoomlion	6894.82	10328.42	12060.16	9721.52	7847.84	11844.5	6579.84	7993.32	12368.4	7456.96	4865.38	11942	**109903.2**
Sak-M	148.76	145.3	160.78	78.24	46.84	96.66	39.72	74.28	0	116.48	86.66	108.96	**1102.68**
Meskworld	18327.56	13425.04	13569.78	7049.38	4605.54	6177.86	7651.02	8306.52	8230.2	9661.44	16051.1	14839.3	**127894.8**
Waste Group	3047.68	2569.76	2492.54	1699.16	1835.9	2068.74	1949.26	2022.54	1467.54	2127.98	1551.28	2048.24	**24880.62**
KWML	8044.06	4576.96	4953.82	3245.04	4254.62	3367.82	2877.56	3982.1	3404.34	4766.4	3243.55	4582.96	**51299.23**
ABC Ltd	1798.26	1207.46	1302.46	6002.92	1060.06	903.88	943.14	862.94	3717.68	5611.08	1035.4	1081.96	**25527.24**
KMA	2125.56	1259.48	1192.48	698.78	786.2	699.42	1056.48	1498.42	1005.64	1162.54	1009.72	1233.58	**13728.3**
Total	**40386.7**	**33512.42**	**35732.02**	**28495.04**	**20437**	**25158.9**	**21097**	**24740.1**	**30193.8**	**30902.9**	**27843.1**	**35837**	**354336**

Appendix 5: Data on vehicles performance measurement (Companies in Kumasi)

Companies	**KWML and Meskworld**	**Zoomlion, Waste Group, Sak-M and ABC Ltd.**
Vehicle Type	No. of trips/day (with productivity above average)	No. of trips/day (with productivity below average)
Compactor	2	2
Skip truck	6	4
Companies	**KWML and Meskworld**	**Zoomlion, Waste Group, Sak-M and ABC Ltd.**
Vehicle Type	Tonnes/trip (with productivity above average)	Tonnes/trip (with productivity below average)
Compactor	7.6	7.3
Skip truck	4.3	4.2
Companies	**KWML and Meskworld**	**Zoomlion, Waste Group, Sak-M and ABC Ltd.**
Vehicle Type	Productivity, tonnes/day/veh. (above average)	Productivity, tonnes/day/veh. (below average)
Compactor	12.7	11.3
Skip truck	22.9	14.2

Appendix 6: Sample size for secondary data in four cities.

Number of companies in four cities and sample size chosen			
City	Population (2000 census)	Number of companies	Sample size
Accra	1,658,937	18	6
Tema	506,400	11	4
Sekondi-Takoradi	369,166	3	3
Tamale	293,881	6	6
Total		38	18

Appendix 7: Waste collected by service providers and metropolitan assemblies

	Year, 2006			Percentage of collection	
City	Waste collected by service providers (SP) (ton/year)	Waste collected by Metropolitan Assemblies (MA) (ton/year)	Total	SP	MA
ACCRA	464921.6	0.0		100.0	0.0
TEMA	172805	48269.5	221074.5	78.2	21.8
SEKONDI-TAKORADI	24076	13928.8	38004.8	63.3	36.7
KUMASI	365682.5	17876.9	383559.4	95.3	4.7
TAMALE	8736.0	3060.1	11796.1	74.1	25.9