UNIVERSITY FOR DEVELOPMENT STUDIES

ASSESSMENT OF MUNICIPAL SOLID WASTE MANAGEMENT SYSTEMS IN SELECTED MUNICIPALITIES AND METROPOLIS IN NORTHERN GHANA

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FACULTY OF NATURAL RESOURCES AND ENVIRONMENT

DEPARTMENT OF ENVIRONMENT AND SUSTAINABILITY SCIENCES

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BY

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(MPHIL. IN AGROENVIRONMENTAL ENGINEERING)

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[THESIS SUBMITTED TO THE DEPARTMENT OF ENVIRONMENT AND SUSTAINABILITY SCIENCES, FACULTY OF NATURAL RESOURCES AND ENVIRONMENT, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE IN ENVIRONMENTAL MANAGEMENT AND SUSTAINABILITY]

JANUARY, 2024

DECLARATION

Student

I, Emmanuel Volsuuri, declare that this thesis is my own work and a result of my own investigation. All the sources that I have used or quoted have been indicated and duly acknowledged by means of complete references. To the best of my knowledge, this work has not been submitted before for any degree at any university.

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I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of dissertation/thesis laid down by the University for Development Studies.

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ABSTRACT

The narrative on poor municipal solid waste management in Ghana is far from complete. The literature points to a sector that has gone through trial-and-error policies over the years but without an end in sight. One of such policies is private sector participation as a gold standard in service delivery. Despite the participation, challenges in service quality and efficiency remain unresolved. The study sought to assess how private sector participation contributed to service quality, efficiency and equity in the study areas. Such an assessment can contribute to addressing the waste management challenges besetting the municipalities as they expand. The study sought to assess the performance of private sector participation on service quality and efficiency in the study areas (Wa, Tamale, Bolgatanga and Sagnarigu). The concurrent triangulation mixed method design was employed to gather data. Quantitative data was gathered through structured questionnaires administered to 400 respondents, and geographic coordinates of waste collection points were taken GPS device. Qualitative data was collected through interviews of purposively selected respondents from relevant agencies/departments/units. Focused Group Discussions and personal observations was also employed to collect data. The study applied Wasteaware Integrated Solid Waste Management (ISWM) Benchmark Indicator Framework, Gap Score analysis, Data Envelopment Analysis, and the Nearness Neighbour Index to analyse the data. The results show that the average score for service quality dimensions was -0.31, indicating poor service quality even though there were variations in the levels of services quality across the municipalities. The indicates a state-sponsored monopoly that result in weak compliance to the principles of competitiveness, accountability,

transparency, and value for money. Furthermore, the distribution of waste collection sites was skewed to commercial areas and high-class residential areas, limiting access to low-class residential neighbourhoods. The study recommends the de-monopolization of the sector and the decentralization of the signing and execution of waste management contracts from the ministerial sector level to the Municipal Assemblies. Considering the important role played by the informal sector, it is recommended that the Municipal Assemblies regulate the activities of the activities of the informal sector and strongly position it as a main player in the delivery of solid waste management services. As the municipalities make progress in service delivery, the study recommends that the Municipalities develop and enforce waste management operational and services standards.

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DEDICATION

This work is dedicated to my wife, Mrs. Emilia Volsuuri, and children, Viola Kanyiri, Valencia Erasung, Valerian Mwininumbu, and Victor Mwinimaalu.

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ACARP	Accra Compost and Recycling Plant
AIs	Aggregate Indicators
ANOVA	Analysis of Variance
BAT	Best Available Technology
BBO	Buy-Build-Operate
BDO	Build-Develop-Operate
BLOT	Build-Lease-Operate-Transfer
BOO	Build-Operate-Own
BOOT	Build –Operate- Own-Transfer
BOT	Build-Own-Transfer
BROT	Build-Rent-Own-Transfer
BTO	Build- Transfer-Operate
CBDs	Central Business Districts
CCC	Communal Container Collection
CCR	Charne Cooper and Rhodes
CONIWAS	Coalition of Non-governmental Organizations in Water and Sanitation
CRS	Constant Returns to Scale
DACF	District Assembly Common Fund
DBFO	Design-Build-Finance-Operate
DCMF	Design-Construct-Manage-Finance
DDWC	Door to Door Waste Collection
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Programme

DESSAPs	District Environmental Sanitation Strategies and Action Plans
DMUs	Decision Making Units
EPA	Environmental Protection Agency
ESPA	Environmental Service Providers Association
FDH	Free Disposal Hull
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
GoG	Government of Ghana
GPS	Global Positioning System
GSS	Ghana Statistical Service
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GWMO	Global Waste Management Outlook
HCW	Health Care Waste
HWBs	Household Waste Bins
IMF	International Monetary Fund
IRECOPs	Integrated Recycling and Compost Plants
ISWA	International Solid Waste Association
ISWM	Integrated Solid Waste Management
JGCs	Jospong Group of Companies
KCARP	Kumasi Compost and Recycling Plant
KPIs	Key Performance Indicators
LDO	Lease-Develop-Operate
LFM	Landfill Management
LI	Legislative Instrument
LP	Linear Programming

MEHU	Municipal Environmental Health Unit
MESTI	Ministry of Environment Science Technology and Innovation
MLGRD	Ministry of Local Government and Rural Development
MMDAs	Metropolitan Municipal and District Assemblies
MoFP	Ministry of Finance and Economic Planning
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MSWR	Ministry of Sanitation and Water Resources
MWRWH	Ministry of Water Resources Works and Housing
NESP	National Environmental Sanitation Policy
NESSAP	National Environmental Sanitation Strategic Action Plans
NNI	Nearness Neighbour Index
NPM	New Public Management
NSWMS	National Solid Waste Management Strategy
PPEs	Personal Protective Equipment
PPP	Public-Private Partnership
PPPs	Public-Private Partnerships
RCCs	Regional Coordinating Councils
RDF	Refuse Derived Fuel
REHOs	Regional Environmental Health Officers
RI	Relative Importance
SD	Standard Deviation
SDGs	Sustainable Development Goals
SERVQUAL	Service Quality
SFA	Stochastic Frontier Analysis

SG	Service Gap
SIP	Sanitation Improvement Package
SQ	Service Quality
SWM	Solid Waste Management
TaMA	Tamale Metropolitan Assembly
TFP	Total Factor Productivity
UDS	University for Development Studies
UESP	Urban Environmental Sanitation Programme
UN DESA	United Nations Department of Economic and Social Affairs
UNCED	United Nations Conference on Environment and Development
UNCG/CSOs	United Nations Communications Groups/Civil Society Organizations
UNCHS	United Nations Commission on Human Settlements
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Education Fund
UPPR	Universal Plastic Products Recycling
US EPA	United States Environmental Protection Agency
VRS	Variable Returns to Scale
WMDs	Waste Management Departments
WSM	Waste and Sanitation Module
WSP	Water and Sanitation Programme

CHAPTER ONE

INTRODUCTION

1.1 Background

The past twenty years has seen a drastic growth in the world's population, especially in urban areas. The literature indicates that the rate of urbanization combined with the overall growth of the world population could increase the world urban population by 2.5 billion people in 2050 (UN, 2019, World Bank, 2018). Overwhelming volume of waste comes as a consequence of population growth and urbanization. The global waste generation is estimated to growth from 2.01 billion tons in 2016 to 3.40 billion tonnes by 2025 (World Bank, 2018). Usually, urbanization creates opportunities and enhances the quality of life. For instance, the World Bank estimated in 2019 that globally, the average Gross Domestic Product (GDP) per capita grew by almost 56% between 2010 and 2018, with an average annual growth above 6% (World Bank, 2019). Much progress was made in improving most human development indicators within the same period. In Sub-Sahara Africa, the Human Development Index (HDI) improved by 34.9% (UNDP, 2018), while the figure for countries in the Organisation for Economic Co-operation and Development (OECD) grew by 14% in the same period (UNDP, 2018). This trend is not a novelty, and projections are that the rate of global urban growth will increase remarkably over many decades (ADB, 2019; Brenner, 2018).

Rapid economic growth and urbanization have also triggered a deluge of waste. Solid waste is now ubiquitous on the land, rivers, and coasts (UNEP, 2018; Owusu-Sekyere, 2019). Open and uncontrolled dumping and burning of waste

cause horrendous air pollution (UNEP, 2018). The generation of solid waste in Africa is estimated at 244 million tonnes annually by 2025. Collecting and disposing off waste in an environmentally sustainable manner has thus become one of the major challenges for city managers. As opined by Volsuuri et al. (2022a), poor solid waste management is the biggest vote-loser in the developing countries. Waste collection and disposal are fundamental steps toward effective waste management and form a major cost component of solid waste management (Antwi, 2019; Bello et al., 2016). It is estimated that, of the total expenditure on solid waste management, 70-80% is spent on collection, transportation, and disposal (UN-Habitat, 2010). Considering the tight budget state authorities operate under, efficient distribution of collection containers is important to enhance accessibility and effective collection and disposal of waste.

However, collection and disposal have remained a major problem for municipal and metropolitan areas in African (Volsuuri et al., 2022b). The global waste management outlook shows that the rate of solid waste collection in Africa varies between 25-70%, with an average collection of about 55% (UNEP, 2015). About 37.5% of the collection is through the communal container system (UNEP, 2018). Collection services can summarily be described as unreliable, irregular, and inefficient. Waste collection strategies vary greatly between countries, cities, and even between areas of the same city (Mpofu, 2013; World Bank, 2012). Depending on the spatial plan and area income level, collection can be done by different methods: wheelbarrows, manual tricycles, motor tricycles, bola taxis, mini-compact trucks, and large compact or dump trucks to

long trailers (van Niekerk & Weghmann, 2019). While the standard collection rate should be 100%, global collection rates vary from 39% for low-income countries to 96% for high-income countries (World Bank, 2012; UNEP, 2015). Generally, collection for low-income and middle-income countries is estimated at 54% and 82%, respectively (World Bank, 2012). Collection in urban areas in Sub-Saharan Africa (SSA) remains low at 44% and almost non-existent in rural areas (UN-Habitat, 2010).

In Ghana, effective solid waste collection and disposal remains an illusion. Collection coverage varies greatly among cities, ranging from 28% in Wa to 80% in Accra (Oteng-Ababio et al., 2017; MSWR, 2020; Volsuuri et al., 2022b). Solid waste collection in the country is carried out by both formal and informal sectors (Owusu-Sekyere, 2019). In addition to inadequate collection containers, container distribution is influenced by local politics and community pressures. The absence of an adequate and efficient collection system results in indiscriminate dumping in drains and open spaces in many cities and towns nationwide. Various stakeholders have introduced new waste collection fleets or treatment plants to nib the problem in the bud. Still, the success rate has not been the utmost due to the lack of local capacity to adequately maintain equipment. Distribution imbalances of collection and disposal infrastructure create proximity and accessibility challenges leading to illegal dumping (van Niekerk & Weghmann, 2019). Meanwhile, Leblanc (2017) argued that efficient placement and collection of waste containers in cities is an important waste management phase.

Over the years, waste management planners have tried several innovative ways to sustainably manage solid Waste in several Ghanaian cities (Millington & Lawhon, 2019). This is evidenced by the speed, scale, scope, and complexity of partnerships and policies that have been developed. The problem has been translating the nice policies on paper to practices on the ground. State authorities have agreed to the World Bank's suggestion of cost-sharing since the 1990s, and have welcomed the private sector into the waste management space by delegating government waste management obligations to private companies (UN-Habitat, 2010; World Bank, 2018a; Oteng-Ababio et al., 2017). Ghana's version of privatization is in three main forms (UN Habitat, 2010; World Bank, 2018a). The first is contracting where the government hires private companies to operate disposal sites, conduct street sweeping, waste collection and other solid waste management services among others for a set period. Such contracts are usually awarded after a competitive procurement process (Alhassan et al., 2017). The government reimburses the private enterprise for service performance according to the contract terms. The second type is a concession, whereby the government gives a private business permission to construct a facility using assets that belong to the government. This concession might enable a private corporation to transfer or dispose of garbage as well as recycle waste-derived products (paper, plastic, metal, and glass) and resources (compost, heat, and power). A private entity builds the facility under a long-term contract that serves as a concession (Dinye, 2006). The third form, which is franchising, allows the government to grant a private company a finite-term zone monopoly (a franchise) to provide solid waste collection services (Kyere et al., 2019). An extensive qualification process is followed before the franchise

award is given. The private company pays a license fee to cover the costs of government oversight and deposits a performance bond with the government. The private company charges direct fees to the homes and companies it services in order to recover its costs and profits. The final kind of privatization in Ghana is open competition, where qualified private businesses freely compete for waste disposal, recycling, and collection contracts. For garbage collection and/or recycling in a free market, specific homeowners and institutions sign private contracts with various businesses. No company has a zonal monopoly inside a certain zone, and any number of companies can engage in competition (Owusu-Sekyere, 2020). The problem is that all these forms of contractual arrangements are bedevilled with some level corruption, resulting in monopoly.

According to the World Bank (2010), the private sector has the operational capacity to organize long-term waste management service efficiently. The data from the literature indicates that the introduction of the private sector has seen a substantial advancement in collection, transportation and final disposal of solid waste (Post et al., 2003; UN Habitat, 2010). Oteng-Ababio (2011) indicated door-to-door collection service, in particular, has improved since the emergence of the private sector and that the general rate of waste collection, which stood at 40% of total waste generation, has increased to over 67% as of the year 2008. According to other research, the private sector has introduced and is continuing to implement integrated waste management strategies throughout the waste management stream, from collection to haulage, transfer, sorting, and recycling (Oteng-Ababio et al., 2017). In the last 14 years, private

waste management have constructed waste compost and recycle plants and have generated over one million jobs directly (Alhassan et al., 2020).

The private sector participation policy has nine key principles that stakeholders must operationalize and comply. The many studies on solid waste management (SWM) in Ghana in the context of private sector participation have often focused on capital injection, collection, disposal and logistics issues (see, for example, UN-Habitat, 2011; Oteng-Ababio et al., 2017; Owusu-Sekyere, 2020). The issues of how key stakeholders comply with the governance principles spelt out in Ghana's SWM policy are rarely articulated, thus creating some research gaps. The main issue however is that sustainable waste management in Ghana is complex, necessitating complicated structures and processes involving a wide range of stakeholders (UN-Habitat, 2010; Owusu-Sekyere, 2019). The geographical and conceptual diversity of waste in Ghana is even more ubiquitous than it has ever been due to the complex dynamics of population increase and economic development, which are regarded as function of garbage generation (Kyere et al., 2019; Alhassan et al., 2020). In Ghanaian cities, improper waste management has persistently been an increasing concern for citizens and city authorities (Kapepula et al., 2007). The problem has piqued academic and policy interest throughout the years, not because city governments are actively modifying their management strategies and policies (Oteng-Ababio, 2010; Owusu-Sekyere & Nkuah, 2012), but because the various systems in place appear insufficient. Uncollected solid waste finds its way into drains, limiting the free flow of water. The stagnant water becomes good breeding sites for mosquitoes and other insects. The operational inefficiencies

in emerging cities like Tamale, Wa and Bolgatanga include but not limited to the weak capacities of city authorities, lack of adequate financing, and weak policy enforcement (World Bank, 2021). This thesis therefore sought to assess private sector performance in solid waste management and how it influences service quality and efficiency in selected municipal areas in Northern Ghana.

1.2 Problem statement

Rapid population growth and urbanization in Northern Ghana have led to rapid surge in the generation of municipal solid waste. Therefore, the delivery of solid waste management services in Northern Ghana is fraught with problems including the lack of performance benchmarks for inter-municipality and intra-municipality waste management performance analogies. The Municipal Authorities have taken major measures to address the problem of waste collection and disposal in their respective areas. These interventions range from expenditure increases to policy changes and restructuring. The Local Government Act, 2016 (Act 936), which mandates Municipal, Metropolitan District Assemblies (MMDAs) to deal with sanitation issues, the revised National Environmental Sanitation Policy (NESP) of 2010, which emphasizes 80% of the delivery of waste management services by the private sector, and the 2018 Plastic Waste Management Policy, which emphasizes circularity economy, innovation and behavioural changes to combat the threat of plastic waste, are all aimed at improving the situation of waste management in cities.

Private sector participation has been adopted as a new gold-standard solution to performance-related issues in the waste management sector (Oteng-Ababio, 2010). In addition to the involvement of the private sector, resource allocations for waste management have been increased by both the central government and donor organizations to address the solid waste management problem the study areas. MMDAs spend between 20% and 50% of their budget allocations on solving sanitation and waste management issues. Despite all these interventions, there are still performance-related gaps in MSWM service delivery in the Tamale, Sagnarigu, Wa and Bolgatanga local government areas of Northern Ghana. Under-coverage and inefficient collection are still a problem in these areas. Poor service levels (SLs) are reflected in the form of limited bins and bin spillage due to non-compliance with lifting frequencies (Antwi, 2019). The failure to address poor MSW management has economic, health and social consequences. WSP (2012) estimates that Ghana loses 420 million Ghana Cedis annually due to poor sanitation and waste management, which is about 1.6% of the national gross domestic product (GDP).

Poor waste management can result to nuisance and public health risks. It leads to clogged drains, flooding and pollution of water sources, and disease outbreaks. Poorly managed municipal solid waste also causes the breeding of mosquitoes, houseflies and cockroaches, which are vectors of some diseases such as malaria, dysentery and cholera, which affect human health. In Ghana, out of the top 10 most common diseases in 2016, six (cholera, dysentery, upper respiratory infection, diarrhoea, malaria and skin diseases) are associated with unsanitary conditions (Ghana Health Service, 2017). Diarrheal diseases are

responsible for 25% deaths in children under the age of five (WHO, 2018). Poor disposal and treatment of waste in landfills and dumpsites lead to the release of pollutants including carcinogenic particles from incineration and unpleasant odours from the decomposition of organic waste. Poor waste management can also reduce tourism potential of cities and lead to the loss of valuable resources that could be recovered from waste.

The adoption of private sector participation in Wa, Tamale, Bolgatanga and Sagnarigu Municipalities is believed to contribute to the improvement of waste management services. Despite this claim, there is a paucity of empirical information on how the existing private sector participation model contributes to the improvement of quality and efficiency of solid waste management services in the municipalities. Secondly, there is limited information on empirical evidence to support the general view that private sector participation improves the quality and efficiency of municipal solid waste management services. This study therefore seeks to fill this literature gap by assessing the performance of private sector participation system and its contribution to quality and efficiency of solid waste management services in the four selected local government areas (Wa, Tamale, Bolgatanga and Sagnarigu) in Northern Ghana.

1.3 Main research question

The main research questions this study seeks to answer is how private sector participation in municipal solid waste management has enhanced sustainable service delivery in the selected localities in Northern Ghana?

1.3.1 Sub-research questions

The study would seek to answer the following sub-research questions:

i. How has private sector participation in solid waste management influenced service quality in the selected localities in Northern Ghana?

ii. How has private sector participation in the existing solid waste management enhanced efficiency of resource use in the service delivery processes in the selected localities in Northern Ghana?

iii. What is the level of stakeholder participation in the existing solid waste management governance principles in the selected localities in Northern Ghana?

iv. What is the geospatial distribution pattern of waste collection points in the selected localities in Northern Ghana?

v. Are there challenges in the management of solid waste in the selected localities in Northern Ghana?

1.4 Main objective

The main objective of the study is to assess the performance of private sector participation in solid waste management system in the selected municipalities in Northern Ghana.

1.4.1 Specific objectives

Specifically, the study seeks to assess:

i. The quality of solid waste management services delivered by the private sector in the selected localities in Northern Ghana

ii. The efficiency of solid collection services delivered by the private sector in the selected municipalities in Northern Ghana.

iii. The extent of stakeholder participation in the existing solid waste governance in selected municipalities in Northern Ghana

iv. The geospatial distribution of solid waste collection containers in the selected municipalities in Northern Ghana.

v. The challenges of solid waste management in the selected localities in Northern Ghana

1.5 Significance of the study

The results of the study would be useful to selected sector ministries such as MSWR, MLGRD, and MESTI, MDAs MMDAs and advocacy organizations such as civil society groups (Environmental Service Providers Association, Coalition of NGOs in Water and Sanitation) in their planning and decision making to improve waste management; and would help fill the literature gap on the contribution of private sector in solid waste management services in selected municipalities in Northern Ghana. Finally, assessing the performance of MSW management systems will provide an overview of MSW management performance, allowing for benchmarking of municipalities and the proffering of solutions for improvement.

1.6 Scope of the study

Geographically, the study was conducted in the savannah ecological zone of Ghana; specifically, in four selected municipalities and a metropolitan area (Tamale Metropolis, Sagnarigu, Wa and Bolgatanga Municipalities). These municipalities and metropolis were purposively selected due to their high population growth and rate of urbanization in Northern Ghana. The study was carried out in sixty (60) communities in the four municipalities and metropolis.

Contextually, the study assessed the performance of the existing solid waste management system and its contribution to the quality of solid waste management services in four municipalities and metropolis in Northern Ghana. The study assessed perception and expectations of waste service subscribers, analysed the service gaps and established the relationship between perceptions and expectations. The study also covered resource use efficiency and estimated optimal combination of resource quantities for improving efficiency in solid waste collection. The study also assessed the solid waste governance regime in terms of stakeholder participation and adequacy of policy, institutional and financial arrangements.

The targeted population for the study was household members above 18 years for quality assessment and officers in relevant institutions (Municipal Environmental Health Unit, Regional Environmental Health Directorate, Waste Management Departments, Environmental Protection Agency and Waste Management Companies) in the selected municipalities and metropolis. Assembly members, traditional authorities, informal waste collectors including scavengers and plastic waste aggregators were also part of the population.

1.7 Limitations of the study

The researcher and his team faced some challenges during the study. Among the key ones were data availability issues and unclear community demarcation boundaries. In some cases, data were either not available or was available but in forms that needed consolidations. In cases of data voids, well informed estimates were arrived at with the help of technical officers in charge.

Secondly, difficulties in identifying community boundaries were encountered in the field at Tamale Metropolis. It was difficult for the researcher to identify clear boundaries of each sampled community. Assistance of Electoral Commissioner at the Tamale Metropolis and the Assembly Members of communities were sought to address the limitation.

Moreover, collecting data from all the 60 sampled communities required some financial commitments in terms cost of transportation, feeding, allowances for field assistants, printing and photocopying of documents as well as data entry and software for data analysis. This was addressed by seeking financial help from family members.

1.8 Operationalization of concepts

For better understanding of this study, relevant terms have been defined in this section.

1.8.1 Waste system

It is a collection of elements within a complex urban management system composed of physical (hard) subsystems made up of equipment and infrastructure and a governance (soft) subsystem made up of policies and institutions that work together to deliver waste management service required by citizens (Wilson et al., 2015)

1.8.2 Waste governance

It connotes the policies, rules and regulations, both formal and informal institutional arrangements for decisions and control in delivering waste

management services in the context of accountability, transparency, value for money, and competitiveness (Wilson et al., 2015). The key indicators of governance include stakeholder participation; meetings, consultations and decisions. Good waste governance reflects in compliance with principles of accountability, transparency, value for money and competitiveness.

1.8.3 Wasteaware indicator framework

It is a comprehensive performance measurement framework universally accepted by the International Solid Waste Association (ISWA) for assessing municipal solid waste management performance (Wilson et al., 2015). It assesses waste management performance from a multidimensional perspective of governance, service quality, customer satisfaction and service efficiency.

1.8.4 Quality

It is defined as the set of characteristics and properties of a service that enable it to meet customer needs (Kotler et al., 2002; Zeithaml et al., 1990).

1.8.5 Service quality

It is the extent to which service meets customer requirements (Zeithaml et al., 1990). In this study, service quality is defined as the extent and direction of the difference between customer expectation and perception of waste management service (Parasuraman et al., 1988).

1.8.6 SERVQUAL Model (Gap Model)

It is a method used to measure service quality based on five dimensions; reliability, responsiveness, empathy, assurance and tangibility (Zeithaml, et al.,

1990). Reliability indicates how waste service providers honour their promises; responsiveness indicates how timely waste service providers respond to customers concerns and requests; empathy connotes how customers are treated with care and attention; assurance means how waste service providers convey trust and confidence in the eyes of customers; and tangibility indicates appearance of physical facilities and trucks of waste service providers.

1.8.7 Data Envelopment Analysis (DEA)

It is a non-parametric method for evaluating relative efficiencies of a set of decision-making units (DMUs) that perform similar tasks under varying conditions and for which inputs and outputs measurements are available (Goksen et al., 2015). DEA produces relative efficiencies as a ratio ranging from 0 to 1. A ratio of 1indicates a DMU is efficient and a value less than one indicates inefficiency of DMU.

1.8.8 Decision Making Unit (DMU)

It is homogeneous entity responsible for the conversion of inputs into outputs (Goksen et al., 2015). In this study, the private waste companies operating in the selected municipalities and metropolis are the DMUs.

1.8.9 Nearness Neighbour Analysis (NNA) tool

It is a key tool in ArcGIS used for analysing distribution patterns of points. NNA produces Nearness Neighbour Ratio or Index, which ranges from 0 to 1. It is the ratio of the observed mean distance to the expected mean distance of containers and ranges from 0 to 1 (Fuseini et al., 2020): 0 indicates exclusively clustered pattern, 1 indicates random pattern and above 1 indicates dispersed pattern.

1.9 Organization of the study

This study was organized into five chapters. Chapter one contains the introduction, which consist of the background of the study, problem statement, objectives of the study, research questions and hypotheses. It also contains significance, scope, limitations, philosophical underpinnings and operationalization of concepts and organization of the study. Chapter two entails a critical review of literature. It also contains review of key concepts such as public-private partnerships, solid waste management, stakeholder participation, service quality, and Data Envelopment Analysis (DEA). The conceptual issues and theories guiding the study are included in this chapter. Chapter three constitutes the research methodology/approach which consists of the research design, sources of data, study population, sampling frame and sample design, data collection instruments, sampling techniques and methods of data analysis. Chapter four consists of results and discussion. The last chapter, which is Chapter five, contains the summary, conclusions and recommendations for policy and further research. Contribution to knowledge of the study is also included in this chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviewed the key concepts and theories relevant to the objectives of the study. Concepts and theories such as wasteaware indicator framework, service Gap Model, service quality, Data Envelopment Analysis, service efficiency and waste management challenges were reviewed. Policies, governance, institutional frameworks that guide solid waste management and private sector models including the principles that guide private sector participation for solid waste management were also reviewed. The chapter concluded with a summary of lessons from the literature reviewed and established the literature gap within which the study is situated.

2.2 Historical development of waste governance in Ghana

It was imperative to situate this study by first reviewing the past trajectory of waste governance in Ghana. This study contextualized waste governance as decisions influencing the waste management systems over the past century and the trajectory of evolution of policies, processes and practices until present. Waste governance dates back to pre-independence times where the state-established agencies to manage solid waste as a public good. According to Salifu (2011), solid waste management services were organized in line with how the governance of towns and cities was run. Cities in Ghana at the time were governed according to the Municipal Ordinance Act of 1859. The same Act established municipalities in the towns along the Coast. Another Municipal Ordinance was promulgated in 1943 to expand the concept of town councils to

include Kumasi with elected members. The 1943 Municipal Ordinance also guided the establishment of Public Health Boards (PHBs) in Accra, Cape Coast and Kumasi. The PHBs had the main responsibility of ensuring that communities observed the best hygienic principles as prescribed. According to Owusu-Sekyere et al. (2017), the PHBs were mandated to enforce all the sanitation regulations in the 1943 Municipal Ordinance and apply the requisite sanctions for non-compliance.

Shortly after independence in 1961, the passage of Local Government Act 54 further entrenched the State's role in solid waste management (World Bank 2010). The Act, even though expanded the responsibilities of the national government, the responsibility of providing waste collection, sanitation services and other social amenities at the local communities was retained at the local government level (Salifu 2011). According to Awortwi (2004), the reason behind the decision was to maintain social services as public goods under state responsibility and delivery to ensure the protection of the welfare of citizens at all times. In the 1970s, the stagnation of economic growth including the dwindling of tax revenues could hardly sustain social services including waste collection and sanitation. The economic nosedive was characterized by downward agricultural productivity; increased inflation and high levels of unemployment (Odutayo, 2015). The cessation of flow of funds from the national government to local government institutions led to the bankruptcy of these institutions, severely hampering the delivery of social services including waste management (Owusu-Sekyere & Oteng-Ababio, 2014).

The period of Ghana's economic stagnation between 1970 and 1980 however witnessed rapid population growth and urbanization across cities (Odier-Bio, 2014), further aggravating the reductions in the provison of urban services. For instance, it was estimated that the rate of urban population growth increased from 23.1% in the 1960s to 32.0% by 1984 (Owusu & Oteng-Ababio, 2014). The influx of people into the cities to search for greener pastures led to rapid increase in the quantity of solid waste generation in major cities such as Accra and Kumasi. Consequently, the few waste collection and disposal facilities available were overstretched beyond their capacity. By the end of the 1980s, waste management services had virtually collapsed and needed complete revamping and restructuring to bring them back to life. This marked the dawn of the new paradigm of the privatization of social services.

The New Public Management (NPM) approach, which was already in practice in Europe and United States, was seen as a timely solution to social service delivery crises of developing countries including Ghana. Spearheaded by the Bretton Woods Institutions, Ghana's Structural Adjustment Programme (SAP) was implemented in 1983 to promote economic growth through public sector and institutional reforms, resource mobilization and market liberalization. During this period, short and medium term policies including privatization of waste management services were implemented. The involvement of the private sector, although injected some level of momentum and pace into the waste management industry, it did not meet the expectations of citizens in terms of quality of waste management services. The problem continues to be how to develop a waste management system (including a model of private sector

participation) in the local context that delivers effective and efficient waste management services to the citizens.

2.3 Policy, institutional and regulatory framework for SWM

In the broader context of forging sustainable development pathways, agenda 21 of the United Nations (UN) enjoins all countries to develop national and local policies, legislations and standards to protect the environment (UNCED, 1992). Consequently, as shown in Table 2.1, Ghana has a number of legislations, policies and regulatory frameworks that protect the environment. Generally, Ghana's SWM policies are progressive and aligned with modern trends of resource recovery. While the Draft Plastic Waste Management Policy (2018) recommended extended polluter responsibility, Strategic National Energy Plan (2006) recommended the establishment of a tariff regime in favour of renewable energy. The National Environmental Sanitation Strategy and Action Plan (2010) promotes the recovery of materials as secondary resources. The problem is often how the national policies and the local level plans work together to produce the quality of waste management services that the citizens expect from authorities. The focus of local actors at MMDAs level is on collection and disposal, with no emphasis on resource recovery. In addition, adequate resources are either not available or not allocated for the implementation of most progressive policies (NSWMS, 2020). This resource deficit creates the need and justification for private sector participation in waste management industry.

Table 2.1: Legislations for environmental protection and waste management

Legal Instrument	Year	Role/Purpose
Local Government Act (Act 462)	1993	Defines the structure and responsibilities of local governments (MMDAs) in Ghana. Decentralizes waste management responsibilities to MMDAs. Mandates the MMDAs to have waste management departments
Environmental Protection Agency (EPA) Act 490	1994	Establishes the Environmental Protection Agency of Ghana and gives it the mandate to manage, protect and enhance the country's environment and seeks common solutions to global environmental problems
Customs and Excise (Duties and Other Taxes) Act 512	1996	Provides for the introduction of Environmental Excise Tax on plastic and plastic products (on polythene bags and other plastic packaging materials)
Hazardous and electronic waste control and management Act 917	2016	This legislation refers to Waste Electricals, Electronics and Equipment (WEEE), spent batteries as well as tyres. It establishes an eco-levy on new and used equipment
Environmental Assessment Regulations, 1999 (LI 1652).	1999	Spells out procedures for environmental permits and impact assessments of undertakings. It provides operational guidelines for the EPA

Table 2.2: Policies and guidelines for environmental protection and waste management

Guideline	Year	Role/Purpose
National Environmental Quality Guidelines	1998	Sets out the procedures for regulating and controlling noise and vibration, air emissions, and liquid discharges from various sources in order to prevent pollution for purposes of protecting human and ecosystem health
Guidelines for the Development and Management of Landfills in Ghana (Landfill guidelines)	2002	Spells out the standards and procedures to be followed for the construction and operation of landfills
Guidelines for the management of healthcare and veterinary waste in Ghana (2002)	2002	Seeks to ensure that health care and veterinary waste is managed effectively in compliance with existing laws and regulations to protect health care workers, their clients (patients, caregivers and visitors) and the environment from potentially disease-causing waste materials. The Guidelines provide standards, procedures and processes for handling health care and veterinary waste
National Environmental Sanitation Policy (NESP)	2010	Seeks to develop a clear and nationally accepted vision of environmental sanitation as an essential social service and a major determinant for improving health and quality of life

Table 2.2 Cont'd Policies and guidelines for environmental protection and waste management

Policy	Year	Role/Purpose
National Environmental Sanitation Strategy and Action Plan (NESSAP)	2010	Provides a set of strategies and action plans meant to guide implementation of environmental sanitation strategies by MMDAs
Draft Ghana Public Private Partnership Bill	2013	Sets out the legal processes and requirement for private public partnerships
Oxo-biodegradable directive for plastics by MESTI	2015	Mandates all plastic products to include an oxo-biodegradable component to allow for decomposition
Plastic Waste Management Policy	2018	Seeks to resolve the increasing volume of plastic waste stream in MSW and the challenges associated with plastic waste management
Policy framework for health care waste management	2020	A revised policy that provides direction for effective, efficient and safe management of health care waste (HCW) through the adoption of Best Available Techniques (BAT) and Best Environmental Practices to prevent injuries, infections and other hazards; protect and promote public health and the environment for sustainable development
National Solid Waste Management Strategy (NSWMS)	2020	NSWMS guides the country on a direction of continuous, high-quality, cost-effective and sustainable waste management services that deliver environmental, public health, and economic benefits to all.

Policy and legal frameworks guiding waste management include the Local Government Act (Act 462, 1993) – re-enacted (Act 936, 2016), the Environmental Protection Agency (EPA) Act, 1994 (Act 490), the Pesticides Control and Management Act, 1996 (Act 528), the Environmental Assessment Regulations, 1999 (LI 1652) and the Health Care Waste Management Policy (2020). Other important waste management guidelines and standards are the regulations for Landfill Development and Management in Ghana (2002), the Handbook for the Preparation of District Level Waste Management Plans in Ghana (2002), and the Handbook for the Preparation of District Level Environmental Sanitation Strategies and Action Plans (DESSAPs). The National Environmental Sanitation Policy of Ghana (2010) directly aligns private sector involvement in waste management with the principles of polluter pays, cost recovery (value for money), community participation and equity. Based on the policy, Metropolitan, Municipal and District Assemblies (MMDAs) have direct responsibility for solid waste management within their jurisdictions.

Under the Policy, in the face of dwindling government resources, MMDAs' Waste Management Departments (WMDs) are required to maintain an internal capacity to provide at least 20% of solid waste services directly and 80% to the private sector. As enshrined in the Ghana National PPP Policy Framework, the success of Private Sector Participation (PSP) depends on the existence of an appropriate institutional and regulatory environment and an appropriate risk sharing between the public and private sectors (MoFEP, Ghana, 2011).

According to Oduro-Kwarteng (2009), without strong institutions, regulations and oversight, it is difficult to accomplish the full efficiency and cost-effectiveness that private sector involvement brings. Given the increasing share of plastics in the MSW stream, a new plastic waste disposal policy was developed in 2018 to address growing concerns about environmental pollution from plastic waste (MESTI, 2018). The policy, which comprises 17 strategic actions, is based on five focus areas: behaviour change, strategic planning and cross-sectoral collaboration, innovation and transition to the circular economy, resource mobilization, and good governance and shared accountability (MESTI, 2018). To strengthen sanitation and waste management, the Ministry of Sanitation and Water Resources (MSWR) was established in 2017 to facilitate private investment and service delivery in the water and sanitation sector (MSWR, 2020; Appiah-Effah et al., 2019). The creation of the new ministry seems to yield results, since it has so far partnered with the private sector to commence construction of 16 waste recovery plants in the regional capitals.

Owusu-Sekyere et al. (2015) found that solid waste management policies in Ghana are inadequate and, in some cases, outdated and duplicated. With changing urbanization trends, characteristics and amounts of solid waste, the guidelines must be constantly updated to make them relevant and effective. Policy misalignment and poor coordination is a major challenge. Some policies that are supposed to reinforce each other are implemented by different ministries and departments with little coordination. The concept of the circular economy, while somehow practiced by a number of organizations, is relatively unknown (Kessman, 2019). As a result, there is no functional policy for the targeted

promotion of the circular economy in Ghana. The drafted plastic waste management policy aimed at promoting circular economy in the plastic industry in Ghana is yet to be fully implemented

2.3.1 Decentralized local governance system and MSWM in Ghana

Ghana is divided into 16 administrative regions, which are subdivided into 261 Metropolitan, Municipal and District Assemblies (MMDAs) representing the Local Governance System. The MMDAs are overseen by the Ministry of Local Government and Rural Development (MLGRD). The newly enacted Local Government Act (Act 936, 2016) mandates MMDAs to dispose of solid waste directly or through the private sector. The management of solid waste by the private sector follows the Public Private Participation (PPP) policy framework of Ghana. MMDAs are also expected to develop sanitation regulations to promote quality of local environmental conditions, including the safe management of MSW. Metropolitan Assemblies are divided into Sub-Metropolitan Assemblies and further into Areas Councils. The Municipal and District Assemblies are divided into urban and zonal councils and further into unit committees. The decentralized local governance system for waste management is shown in Figure 2.1.

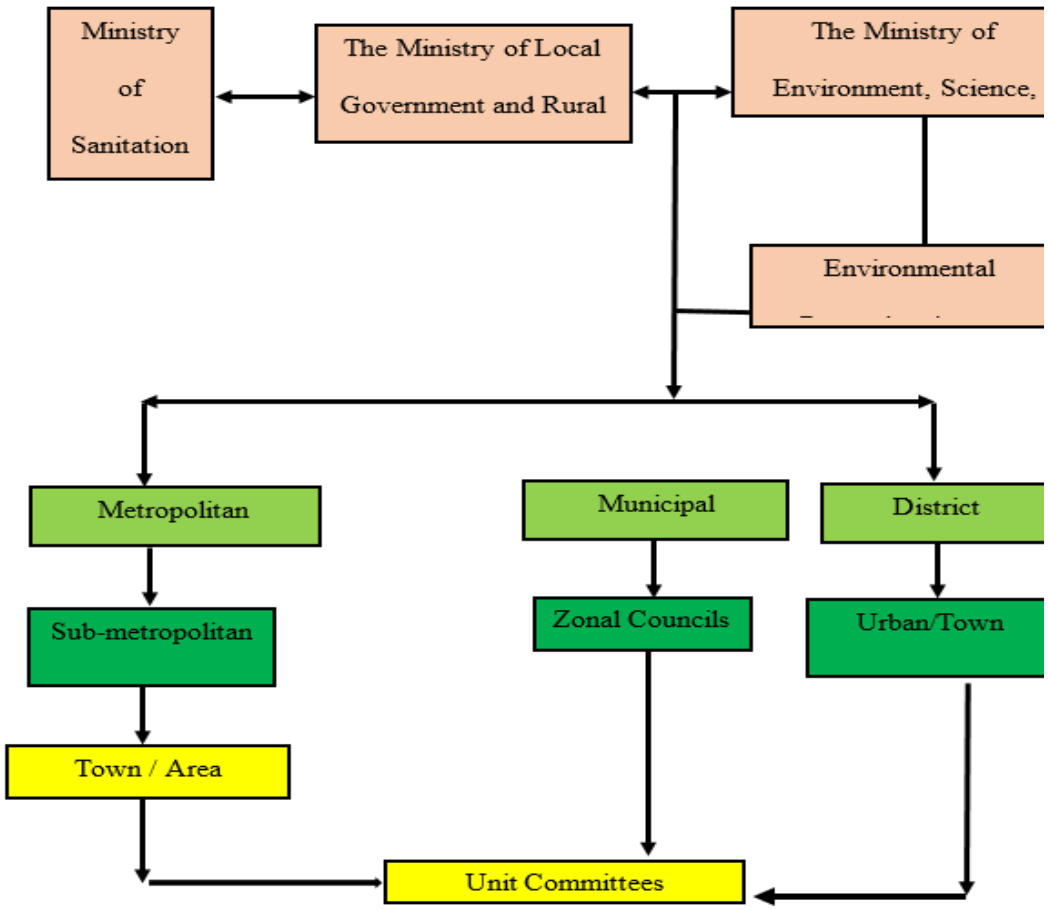

Figure 2.1: Decentralized local governance system and MSWM in Ghana

Source: Modified from Oteng-Ababio (2012)

As depicted in figure 2.1, the institutional governance structure for solid waste management is complex and overlaid by national and sub-national institutions. The top level consists of sector Ministries. This layer is responsible for providing policy and strategic directions for MSWM in Ghana. Prior to the formation of the Ministry of Sanitation and Water Resources (MSWR) in 2017, the responsibility for policy direction on sanitation rested with the MESTI and MLGRD. The MSWR, which took on this responsibility, is supposed to harmonize all policies in the sanitation and waste sectors. The MESTI is responsible for the overall environmental compliance of the MSWM sector,

which is performed through the Environmental Protection Agency (EPA) at the lower levels, while the day-to-day oversight and monitoring of service delivery at the local level is handled by MMDAs.

The MMDAs are supervised by the MLGRD. The re-enacted Local Government Act (Act 936, 2016) gives the mandate to MMDAs to manage solid waste directly or through the private sector. MMDAs are supposed to develop sub-national plans based on the national strategy. However, this essential function is often overlooked due to pressure on little resources and operational issues such as frequent breakdown of trucks at the local level (World Bank, 2021).

2.4 Ghana's national policy on PPPs

The approbation of the PPP framework reflects the Government of Ghana (GoG)'s desire to provide high-quality, cost-effective and timely public infrastructure and services. The policy also shows the government's commitment to the obligatory legal and regulatory framework, as well as a clear financial, legal and administrative framework to remove bottlenecks in PPP agreements (MoFEP, 2011). According to MoFEP (2011), the main objectives highlighted in Ghana's PPP policy are to leverage public assets and funds with private sector resources from local and international markets to accelerate the needed investments in infrastructure and services; encourage and facilitate private sector investment by creating enabling environment for PPPs where value for money for government can be clearly demonstrated; increase the availability of public infrastructure and services and improve service quality and

efficiency of projects and protect interest of partners including users, government and the private sector among others.

2.4.1 Guiding principles of Ghana's PPP policy

All PPP arrangements including solid waste management are guided by the key principles including value for money, which indicates that the use of PPPs should be grounded on the principle of value for money. PPPs should give greater value for money than the best realistic public sector project design with similar waste management service inputs and outputs. With the accountability principle, all lay down processes for selecting the waste management partner must be followed to ensure that decisions and objectives are in consonance with law and government policies. Government should sensitize the public on the costs, benefits and risks of solid waste management PPPs. The next principle is transparency, which stipulates that there shall be well defined procurement processes with equal access to information and instructions to all interested bidders. In addition, PPPs should be designed to ensure partners (public and private sectors) of waste management share information on results and outcomes of projects with citzens. The competition principle indicates that solid waste management PPPs shall be subjected to competitive process to get value for money and efficiency. PPP programmes should be structured to ensure ongoing functional markets for the waste management sector. Where market operators in waste management sector are few, authorities should structure the tendering process to allow other operators to enter the market.

The rest of the principles are stakeholder consultation, which states that there shall be identification, and adequate consultation of all relevant stakeholders to

ensure awareness, understanding and support for PPP arrangement. Each PPP arrangement must have objectives and outputs that it seeks to achieve. In terms of affordability, the principle is that the ability of the end users to pay shall be the key consideration of PPPs. Any solid waste PPP arrangement option must demonstrate long-term affordability to the public and government budgetary sustainability. For efficient risk allocation, PPP policy recommends the principle of optimization rather than maximization in risk allocation between parties. Risk is identified, defined, measured and then be allocated to a party best able to manage them to maximize value for money. On safeguarding public interest and consumer rights, the policy says that all PPP arrangements shall have positive impact on the public interest. This is achieved by setting affordable user charges and tariffs. Lastly on local content and technology transfer, the policy recognizes that partnership with relevant local bodies is fundamental in any form of development cooperation. As much as possible, PPP arrangements shall promote participation of local industries to transfer skills and build local capacity.

2.4.2 Evolution of PPPs in solid waste management in Ghana

The concept of subcontracting to private companies is deeply rooted in history and was used by the Roman Empire to ship grain to residents via private ship owners. However, the concept of subcontracting public services to the private sector in the scientific community literature is a modern development (Leitao et al., 2018). Public-Private Partnership is closely related to the 'New Public Management' (NPM) for public services' policy, established in the United

Kingdom, United States and Australia in the 1980s to make public services more efficient (Leitao et al., 2018).

In Ghana, the concept of private sector involvement in the delivery of public services has existed for over 25 years. The push to change the standard model of public procurement and management of infrastructure and services began with the macroeconomic collapse resulting from high public debt in the 1970s and 1980s (Odier-Bio, 2014). In an effort to improve solid waste services, Waste Management Departments (WMDs) was established in Ghana's largest cities (Accra, Kumasi, Tamale and Secondi-Takoradi). Despite the resourcing of WMDs with support from the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), they did not deliver expected levels of solid waste management services, particularly when the GTZ project support ended (Boadi & Kuitunen, 2004; Akateeba & Yakubu., 2012). By the 1990s, the momentum for starting PPPs had developed to such an extent that the government began to involve the private sector in the delivery of services in the waste collection and disposal, energy, telecommunications and sanitation sectors. In the mid-1990s, public-private procurement slowed due to social backlash. This resulted from confusion between private sector participation (PSP) and privatization, the overlooking of the social agenda by some PSP programs, and the perception that private companies were making inappropriate profits at the expense of the public. To clear up this confusion, Ghana developed the first PPP policy guidelines. However, these guidelines were not used until 2011 when the current PPP policy framework was improved and harmonized with the guidelines (Odier-Bio, 2014).

The involvement of PPPs in the waste management industry became prominent in the 1990s when the World Bank supported Ghana through the implementation of the Urban Environmental Sanitation Project (UESP1) in five major cities (Accra, Kumasi, Tamale, Secondi-Takoradi and Cape Coast) from 1997 to 2003 (World Bank, 1999). The project provided financial and technical support for private sector involvement in solid waste management. As a result, the project led to an increase in the number of private companies involved in waste management and subsequently led to an improvement in Ghana's solid waste collection rate from 10-60% in 1997 to 57-77% in 2004 (Oduro-Kwarteng, 2009; Oduro-Kwarteng, 2013). Currently, a larger percentage of solid waste collection and disposal services are provided by the private sector in the large cities and towns of Ghana.

2.5 Role of Public-Private Partnerships (PPPs) in solid waste management

Sustainable waste management in Ghana necessitates sophisticated structures and processes and involves a wide range of stakeholders (UN-Habitat, 2010; Owusu-Sekyere, 2019). The geographical and conceptual diversity of waste is even more ubiquitous than it has ever been due to the complex dynamics of population increase and economic development, which are regarded a function of garbage generation (Kyere et al., 2019; Alhassan et al., 2020). In Ghanaian cities, improper waste management has been a persistent concern for citizens and city authorities (Kapepula et al., 2007). The problem has piqued academic and policy interest throughout the years, not because city governments are actively modifying their management strategies and policies (UNEP, 2012; Owusu-Sekyere & Nkuah, 2012), but because the various systems in place

appear insufficient to handle waste volumes ad complexities. This is demonstrated by piles of uncollected trash, clogged gutters, and beaches polluted with plastic debris. To address the issue, state authorities have agreed to the World Bank's suggestion of cost-sharing and have welcomed the private sector into the waste management system (UN-Habitat, 2011; World Bank, 2015; Oteng-Ababio et al., 2017).

According to the World Bank, the private sector has the operational capacity to organize long-term waste management services in terms of collection, transportation and the final solid waste disposal (Post, Broekema, & Obirih-Opareh, 2003; UN Habitat, 2010). Alhassan et al. (2017) indicated that door-to-door collection service in particular has improved since the emergence of the private sector and that the general rate of waste collection, which stood at 40% of total waste generation, has increased to over 67% as of the year 2008. According to results from other research works, the private sector has introduced and is still implementing integrated waste management strategies throughout the waste management stream, from collection to haulage, transfer, sorting, and recycling (Oteng-Ababio, Owusu-Sekyere, & Amoah, 2017). In the last fourteen years, private waste companies have constructed waste composting and recycling plants and have created over one million jobs directly (Alhassan et al., 2020).

2.6 Models of Public-Private Participation (PPP) in waste management

There are various models of public-private participation, but the most common models in waste management are contracting, concession and franchising (Cointreau-Levine, 1994). While concession models such as Build, Operate,

and Own (BOO) and Build, Operation, Own, and Transfer (BOOT) are considered appropriate for waste treatment and disposal facilities, franchising and contracting are more preferred as management alternatives for waste management (Massoud & El-Fadel, 2002). There is evidence from cities in developing countries that there is no single model that fits every situation (Wilson et al., 2017). Each city customizes a mix of models that fit the local context and are capable of delivering the desired solid waste services. The adapted operator models also vary according to the type of services to be provided, which may include primary collection, secondary collection, street cleaning, operation of transfer stations, landfill operation, recycling and disposal.

In Ghana, the dominant partnership arrangement with the private sector is service management, particularly for waste collection. Whichever model is adapted, it should be consistent with the local context, and the agreement must specify the timeframe, partner roles and responsibilities, level of service, and sanctions for non-compliance (Osei-Kyei & Chan, 2017). Partner on-boarding processes should be guided by the principles of Ghana's PPP policy – transparency, accountability, competitiveness, fairness, priority for local partners and value for money.

2.8.1 Contracting

In contracting, government agencies contract out the provision of waste management services to private companies on a fixed-term basis through a competitive bidding process in which the private contractors are paid by the local municipal authorities out of revenue from the contracted service. Services

typically contracted include waste collection, public cleaning, operation of transfer stations, management of landfills and operation of waste treatment plants. With appropriate regulation and a competitive bidding process in developing countries, procurement has emerged as the most promising form of private participation that has the ability to reduce waste management costs. Due to this advantage, the collection of waste in cities in Ghana can be outsourced.

The government may enter into a management contract with a private company for the management of government assets in the waste management sector. This type of arrangement transfers responsibility and maintenance of state-owned enterprises to private companies, while retaining responsibility of expansion to the government. Management contracts are typically used when government-managed waste facilities do not offer the required value for money for investment. Meanwhile, it is also difficult to obtain investment commitments from the private sector (Navarro, 2005). Most landfills and dumpsites in Ghana are managed under management contracts.

In the procurement of waste management service, contract length is a very important factor in motivating significant private sector investment. According to Cointreau-Levine (1994), the duration of the contract should be long enough to allow the private sector to fully write off its capital expenditure in order to achieve low contract costs. The economic life of solid waste collection vehicles is typically six to eight years for single shift operation and four to five years for heavy use. Thus for solid waste collection, the contract period should be at least four years to allow contractors to write off (dispose of) their trucks. In a well-developed market where there is competition for private participation, the

duration of waste collection and disposal contracts is less important as companies can dispose of their collection vehicles if the contract is not renewed. In Ghana, the PPP market is immature, which makes the length of the PPP contract a big deal. The duration of existing solid waste collection contracts with Metropolitan, Municipal and District Assemblies is most often between two and four years (Personal Communication, Director Monitoring and Service Quality, Zoomlion, 2020). This poses a challenge in disposing of or finding an alternative use for waste management equipment if the contract is not renewed. In such a situation, many of the smaller waste management companies are reluctant to invest heavily in equipment.

2.8.2 Franchise

In the franchise model, private partners provide waste collection services directly to individual households and institutions and collect agreed fees directly from customers. Consequently, the private partner bears the costs of billing and collection of fees. Since billing and charging costs are estimated to be 10% of service costs, franchise results in higher service costs for service users than contracting (Cointreau-Levine, 1994). The process of franchise allocation is considered to be prone to corruption, especially in large cities. In the case of franchises, the government has no administrative involvement and is not responsible for collecting revenue to pay private companies (Massoud & El-Fadel, 2002).

2.8.3 Concession

With the ongoing construction of 16 Integrated Recycling and Composting Plants (IRECOPs) in Ghana, the form of the PPP agreement is concession.

According to Kupisz (2022), concession is an arrangement whereby the private sector funds and owns a solid waste facility for a specified period of time, usually long enough to recoup its investment. In the agreement, the private company is granted access to a specified quantity and quality of solid waste resources. The concessionaire, the private operator of a concession, pays the government a concession fee and/or a share of the profits from operating the waste facility. Depending on the agreement, private operators can sell products or services to the government or directly to the public. In cases where the government is the sole purchaser of the product or service from the waste facility, a long-term agreement will be entered into on a take-or-pay basis. Concessions are considered to be the best option for building and operating waste treatment and disposal facilities. The concession agreement sets performance standards against which private companies are monitored and evaluated, and penalties for cases where performance standards are not met (IMF, 2004). Concession arrangements can take a number of forms, which fall into three categories: Design-Build-Finance-Operate (DBFO) schemes, Buy-Build-Operate (BBO) and Build-Operate-Transfer (BOT) schemes.

Design-build-finance-operate (DBFO) schemes: In this arrangement, the private sector designs, builds, owns, develops, operates, and manages an asset with no obligation to transfer ownership to the government. This type of arrangement can be variously described as build-own-operate (BOO), build-develop-operate (BDO), and design-construct-manage-finance (DCMF) (Kupisz, 2022). This model is based on the belief that when the private sector is given shared responsibility for the design, construction, financing and operation of an asset,

there is efficiency (IMF, 2004). Massoud and EL-Fadel (2002) pointed out a limitation of this agreement as it placed local authorities in a weak negotiating position and a loss of control over the resource (waste) management system. The elimination of municipal authorities owning and operating waste services in the agreement makes it more difficult for municipalities to get back into business as they may have lost the skills, experience, staff and equipment in this sector during the contract period. The advantage however of this model is that there is hardly any burden on metropolitan or municipal budgets, as there are no initial costs for the local authorities to bear. The private company also assumes all financial risks in this agreement.

Buy-build-operate (BBO): The private sector buys or receives a lease of an existing asset from the government, refurbishes, modernizes and or expands it, and then operates the asset, again with no obligation to return ownership to the government (Cointreau-Levine, 1994). The variant of this agreement can also be referred to as Lease-Develop-Operate (LDO) and Wrap-Around Addition (WAA).

Build-operate-transfer (BOT): The private sector designs and builds an asset, operates it, but is obligated to transfer ownership to the government at the end of an operating agreement or at an agreed time. The variants of this type of license are build-own-operate-transfer (BOOT), build-rent-own-transfer (BROT), build-lease-operate-transfer (BLOT) and build-transfer-operate (BTO). Massoud and EL-Fadel (2002) claimed that the low risk associated with BOT arrangements makes them suitable for long-term services such as solid waste treatment and disposal facilities. It is also important that BOT agreements

specify the maintenance requirements by the private sector and the final condition of the facilities at the time ownership is transferred to government agencies. This reduces the risk of abuse and mismanagement of facilities (Massoud & EL-Fadel, 2002).

2.7 Municipal solid waste management

The concept of municipal waste management includes the collection, transportation, treatment, and disposal of waste in a manner that maximizes resource-use efficiency and minimizes negative economic, social, and environmental impacts on the society (Schuebeler et al., 1996; Oteng-Ababio et al., 2013). Historically, the basic approach (out-of-sight) was used to move residential waste to open dumpsites without considering negative rippling effects. Since this approach has proven to be unsustainable, the new approach is to treat and recover resources from waste. This approach has the potential to contribute to the attainment of some of the Sustainable Development Goals (SDGs) (Lenkienwicz & Webster, 2017). Consequently, applying the 4R principles (Reduce, Reuse, Recover, Recycle) has become the standard for any sustainable waste management system. Until 2020 when the Jospong Group of Companies started to invest heavily in the construction 16 integrated composting and recycling plants (IRECOPs) in Ghana, the focus had been on collection and transport rather than safe disposal and treatment (Kessman, 2019). The reason for this previous trend was because of the participation of the private sector was more limited collection than treatment of waste. The high investment costs for treatment and disposal can also be responsible for this imbalance (more investment in collection than treatment). About 80% of waste

management services in Ghana, mainly collection and disposal services, are provided by private sector companies (Table 2.3 lists the main companies). Apart from Zoomlion Ghana Limited, all solid waste companies dealing with solid waste management in Northern Ghana are quite new with just about eight years of operation experience.

Table 2.3: List of solid waste management companies in Ghana and scope of operations

Company	Year of operations	Operational areas	Scope of operations
Zoomlion Ghana Limited	2006	All regions in Ghana, Liberia, Togo, Angola	Public cleansing, collection and transportation services
Waste Landfills Company Limited	2014	All regions in Ghana	Operation and maintenance of transfer stations, design and construction and management of landfills
J Stanley – Owusu (JSO) Company Ltd.	1961	Accra & Kumasi	Recycling services, hazardous waste management, disposal sites management
Jekora Ventures	2003	Accra	Household waste collection, management, Recycling of organics and plastics, compost
Asadu Royal Seed & Waste Management	2002	Accra, Kumasi & Takoradi	Solid waste collection services
Zoompak Ghana Limited		Accra	Transfer stations management, treatment of infectious waste
Zoom Domestic Service Limited	2008	Accra	Household waste collection
Zoil Services Limited	2013	Takoradi	Chemical disposal, remediation of contaminated soils, drilling waste management
Alliance Waste		Accra	Solid waste collections services
Sewerage System Ghana Limited (SSGL)	2012	Accra	Liquid waste treatment
Urban Waste Limited (UWL)	2014	Upper West Region	Solid waste collection services & plastic recovery
Savannah Waste Management Service Limited (SWMSL)	2014	Northern and Savannah Regions	Solid waste collection services & plastic recovery

Source: Environment & Sanitation Group (2021)

Table 2.3 Cont'd: List of solid waste management companies in Ghana and scope of operations

Company	Year of operations	Operational areas	Scope of operations
Upper East Waste and Environmental Services Limited	2014	Upper East Region	Solid waste collection services
Metropolitan Waste & Allied Services Limited	2014	Accra	Solid waste collection services
Meridian Waste Limited	2014	Tema	Solid waste collection services
Volta Waste Limited	2014	Volta and Oti Regions	Solid waste collection services
Ashanti Waste Service Limited	2014	Ashanti Region	Solid waste collection services
Accra Compost and Recycling Plant (ACARP)	2012	Accra	Organic compost, Recovered Plastics, Refuse Derived Fuel (RDF)
Universal Plastic Products and Recycling (UPPR)	2013	Accra	Plastic products from recovered materials
Integrated Recycling and Compost Plant (IRECOP)	2019	Accra	Material recovery: Organic compost, recovered plastics, metal, and pap
Kumasi Compost and Recycling Plant (KCARP)	2020	Kumasi	Material recovery and liquid waste management

Source: Environment & Sanitation Group (2021)

2.8 Cost of waste management

Assessment and determination of cost of waste management is often very difficult for developing countries due to poor quality of data. Costing is therefore based on estimates. Table 2.4 shows the global cost of waste management according to the World Bank (2018)

Table 2.4: Global reported and expert cost estimates of solid waste management

Activity	Low-income/ USD		Lower middle-income/USD		Upper middle income/USD		High-income/ USD	
	Reported	Expert	Reported	Expert	Reported	Expert	Reported	Expert
Collection and transfer	40	20-50	16	30-75	98	50-100	121	90-200
Disposal								
Landfill	-	10-20	-	15-40	-	25-65	53-99	40-100
Open dumping)	7	2-8	25	3-10	-	-	-	-
Recycling	-	0-25	-	5-30	-	5-50	202	30-80
Composting	-	5-30	-	10-40	-	20-75	-	35-90
Waste-to-energy incineration	N/A		N/A -		-	60-150	134	40-200
Anaerobic digestion	N/A			20-80	-	50-100	-	65-150

Source: World Bank (2018)

Bartolacci et al. (2018) determined factors that drive operational cost and developed cost functions for MSW collection systems in Metropolitan, Municipal, and District Assemblies (MMDAs) in the Ashanti, Brong Ahafo and Upper East Regions of Ghana. The study identified fuel consumption, quantity of waste hauled, and distance travelled as the main cost drivers in MSW collection. In a report on the costs of house-to-house solid waste collection by compaction vehicles (Table 2.5), the following cost components were considered and reported on; fuel, repair and maintenance, depreciation, staff

salaries, PPE, license and insurance. Others included waste bin costs, revenue collection costs, and tipping fees.

Table 2.5: Reported cost per ton of solid waste collection in Ghana using compaction trucks

Region	Cost/ton USD
Ashanti	49
Northern	13
Central	24
Eastern	25
Bono	27
Average	28

Source: Zoomlion Ghana Limited, 2022

The average cost of $28 is below the World Bank's reported minimum cost per tonne of $30. The cost of collection is influenced by the number of shifts/days, working hours/day, working days/week and working days/year, truck capacity, distance to disposal, waste composition and collection frequency. These factors account for cost variations in waste collection (World Bank, 2018). In some cases, costs have been underestimated due to poor data quality or intentional exclusion of some costs. Recommended cost components for determining cost/ton include wages, third party contracts, energy, fuel, lubricants, maintenance and repairs, tyres, insurance, amortization including interest on loans and bank charges (World Bank, 2018).

The cost-efficiency analysis determines the percentage of cost components and compares actual costs with estimated or reported costs based on international experience. When identifying areas for efficiency improvements, attention should be paid to the major cost drivers; labour costs and truck operating costs.

2.9 Solid waste collection

In Ghana, effective solid waste collection and disposal remains an illusion. Collection coverage varies greatly among cities, ranging from 28% in Wa to 80% in Accra (Oteng-Ababio et al., 2017; MSWR, 2020; Volsuuri et al., 2022b). Solid waste collection in the country is carried out by both formal and informal sectors (Owusu-Sekyere, 2019). In addition to inadequate collection containers, container distribution is influenced by local politics and community pressures. Only 33% of households' waste is collected; this proportion is higher in urban (51.4%) than in rural (5.8%) areas. Higher proportions (57.3%) of rural households use public/open dumps as disposal sites compared to 24.6% of urban households (GSS, 2021).

The absence of an adequate and efficient collection system results in indiscriminate dumping in drains and open spaces in many cities and towns nationwide. Various stakeholders have introduced new waste collection fleets or treatment plants to nib the problem. Still, the success rate has not been the utmost due to the lack of local capacity to adequately maintain equipment. Distribution imbalances of collection and disposal infrastructure create proximity and accessibility challenges leading to illegal dumping (Medina, 2005; UN-Habitat, 2010; Weghmann & van Niekerk, 2019). Meanwhile,

LeBlanc (2017) argued that efficient placement and collection of waste containers in cities is an important waste management phase.

In recent times, population size and urbanization of Northern Ghana have witnessed a growth, increasing from 4,228,116 (17% of national population) in 2010 to 5,825,879 (19% of national population) in 2021 (GSS, 2021). This has resulted in increase in waste generation, making waste management an arduous task for authorities to address. To address the issue of collection, authorities have placed communal containers (CC) and household waste bins (HWB) across municipalities.

Despite these measures, collection services have remained poor with a lot of indiscriminate dumping, container waste overflow, clogged drains, under-coverage and inequity of services within the communities (Oduro-Appiah et al., 2017; Owusu-Sekyere, 2012; Amoah & Kosoe, 2014). Distribution imbalances create proximity challenges leading to illegal dumping (van Niekerk & Weghman, 2019, Mwelwa, 2020). This has caused filthy environments leading to public health risks in municipalities. Information on the right quantities and spatial distribution pattern of waste containers, which are required for effective planning and decision making by municipal authorities, are often not available (Owusu-Sekyere et al., 2017; Mwelwa; 2020).

Waste collection is a fundamental step toward effective waste management and forms a major cost component of the solid waste management process (Antwi, 2019; Bello et al., 2016). It is approximated that of the total expenditure on solid waste management, 70-80% is spent on collection and transportation (UN

Habitat, 2010). Considering the tight budget authorities operate under, efficient distribution of collection containers is important for enhancing accessibility and effective collection. However, collection has remained a major problem for state authorities in Africa. According to the Global Waste Management Outlook (GWMO), the rate of solid waste collection in Africa varies between 25-70%, with an average collection of about 55% (UNEP, 2015). About 37.5% of the collection is through the communal container system (United Nations Environment Programme, 2018). In addition, collection services are best described as unreliable, irregular and inefficient.

Although efficient solid waste collection is fundamental for efficient solid waste management (Antwi, 2019), the manner of solid waste collection varies greatly between countries, cities and even between areas of the same city (Mpofu, 2013). Depending on the spatial plan and area income level, collection vehicles can range from the use of wheelbarrows, manual tricycles, motor tricycles, bola taxis, mini-compaction trucks, large compaction or dump trucks to long trailers (van Niekerk & Weghman, 2019). While the standard collection rate is 100%, global collection rates vary from 39% for low-income countries to 96% for high-income countries (World Bank, 2012). While Europe, Central Asia and North America collect at least 90% of garbage, Africa collects about 55% of solid waste in urban areas. While collection in urban areas in sub-Saharan Africa remains low at 44%, collection in rural areas is worse and, in some cases, non-existent (UN Habitat, 2010). In Ghana, solid waste collection is carried out by both formal and informal sectors, and the collection is often limited to city centres and high-class residential areas (Medina, 2005). The absence or

inadequate collection system results in indiscriminate dumping of waste in drains and open spaces in many cities and towns across the country.

2.10 Formal waste collection system

There are three main formal collection systems in many cities in Ghana; public cleaning, door-to-door collection and communal container collection. The public cleaning and the communal container collection (CCC) are operated in two model projects; Waste and Sanitation Model (WSM) and Sanitation Improvement Package (SIP). The SIP is a Public-Private Partnership (PPP) agreement between the private sector and MMDAs for daily solid waste collection with communal containers. According to National Solid Waste Management Strategy (2020), SIP is the largest, extensive and crucial solid waste collection contract in Ghana. Over 70% of municipal solid waste collection is done through communal collection. It is a signed contract between a single private sector company and MMDAs with defined terms, roles and responsibilities, typically for a period of four years. Under this arrangement, the private sector provides and manages an agreed number of collection vehicles and containers for a service fee payable quarterly from the District Assembly Common Fund (DACF).

Under the CCC system, equitable and economic location of containers in municipalities is often a challenge. Communal containers are inefficiently distributed due to the interplay of many factors including local politics, availability of space, and community acceptance or rejection considerations. Distribution of CCs are mostly concentrated in the Central Business Districts (CBDs). Studies by Naibbi and Umar (2017) in Kano found a concentration of

CCs in the central part of the city compared to the peri-urban areas. Fuseini et al. (2020), in a study in Ejisu Municipality in Ghana, concluded that CCs distributions were concentrated in the northern part of the municipality where commercial activities were high. In a study by Katsina in Nigeria, it was discovered that there was more indiscriminate dumping in the peri-urban areas than the city centre due to limited collection containers in the peri-urban areas (Danbuzu et al., 2014). Odonkor et al. (2020) made similar observations in a large district in Ghana, where CCs collection points were far away from households and residents have to commute far distances to dispose of waste. The second form of collection system, door to door collection, is limited to high class residential areas, who have the ability to pay. In this system households sign unto a service provided by the private sector at an agreed rate for a specified number lifting per week, usually one week. All these lapses in the distribution and collection of waste containers are evidence of a structural problem with the existing solid waste management system in Ghana that need further studies, analyses and interventions.

2.10.1 Informal waste collection system

Beyond the formal waste collection agreement with the private sector, there is a very important emerging sector of informal waste collectors that cannot be ignored. According to Ali and Cotton (2001), formal waste collection at most municipal assemblies do not extend to low-income, peri-urban and less accessible areas, creating a service gap. This gap has provided a livelihood niche for urban poor and vulnerable groups who struggle daily to make a living amid rising unemployment and high cost of living in cities across Africa (Oteng-

Ababio, 2012). Owusu-Sekyere (2019) highlighted the important role of informal garbage collectors in cleaning up the city of Kumasi in Ghana. Referring to the informal waste collectors as "Kaya Bolas" (KBs), Owusu-Sekyere (2019) stated, *"beyond keeping the city clean, KBs have also emerged as a campaign to combat joblessness, social exclusion, urban discontent, and spatial fragmentation associated with rigid labour arrangements under the neoliberal economic restructuring"*.

The activities of informal waste collectors have become so critical that any waste management system that does not integrate their activities will be ignoring an important waste management value chain (Oteng-Ababio et al., 2017). Informal collectors, who use various equipment including wheelbarrow, manual tricycle, *aboboya* (motorized tricycle), and *bola taxi*, move from house to house to collect waste. Dumping by informal collectors is unregulated and indiscriminate. Another important community service provided alongside informal collection is waste sorting by scavengers. Informal collectors sort recyclables from waste to sell to middlemen or women. The middlemen or women then aggregate and supply the recyclables to recycling companies. Informal collectors enter into informal and verbal agreements with households to collect their waste, including segregated valuables (Oteng-Ababio, 2012; Ali, 2010).

Segregation is typically practiced by marginalized groups and women in the household as a source of income (Weghmann & Van Niekerk, 2018). The community members' view of waste as a resource and the habit of separating recyclables should be seen as a positive attitude that can be used to promote

source separation and recycling in Ghana. Given the important role performed by the informal sector in collection and material recovery, the extent to which informal sector activities are regulated and integrated into the formal sector is an important indicator of MSWM's performance in Ghana. Consequently, the 2020 National Solid Waste Management Strategy (NSWMS) has captured the regulation and inclusion of informal waste collection as major private sector arm of governance in the solid waste management system.

2.10.2 Economics of mode of waste collection

Door-to-door waste collection in low-income and slum communities tend to be less economical due to limited accessibility, which tends to increase operational costs. If such a problem is not taken into account when designing PPP, the private sector can concentrate its services in well-developed and well-planned areas where profitability is inherently high, leading to a variation in services between affluent and poor neighbourhoods (van Niekerk & Weghmann, 2019). The most efficient way to address this challenge, as currently practiced in most cities in Ghana, is through community collection or a bell ringing system in low-income and poorly planned areas, in which residents participate by bringing their waste to central collection points.

In the municipal collection system, the participation and sensitization of local residents in planning and operation is crucial for success. According to Cointreau-Levine (2004), the challenge of imposing direct user charges on residents in the municipal collection system tends to impact private sector revenue mobilization. In cases where *Pay-as-You-Dump* is used, some residents

tend to resort to illegal dumping due to laxity in enforcement of sanitation bye-laws.

Recently, the use of compaction vehicles in door-to-door waste collection in Ghana has gained prominence. While the use of these trucks is convenient, easy and sanitary, it may not be appropriate for cost recovery purposes in rural areas as well as poorly planned urban slums. According to Cointreau-Levine (1994), compactor vehicles are suitable for solid waste collection in well-planned urban areas with a waste density between 100-150 kg/m^3, where the waste can be compacted to 400-500 kg/m^3 as an economic load (compaction ratio 4:1-5:1). Typical solid waste densities in many cities in Ghana, including the study areas, are between 250 and 400 kg/m^3 and usually contain abrasive sand and ash (Volsuuri & Mensah, 2018). Consequently, the use of compaction trucks tends to result in high operating costs and they are prone to severe damage due to the presence of abrasive materials.

Location analysis of solid waste containers

Historically, location analysis is a well-established technique in regional science. The concept is often applied to understand the allocation of resources, goods, and services in a particular geographical space (Tong & Murray, 2017). In its broadest sense, it is also used to determine where an event or a phenomenon can best be organized to achieve the best results. Scholars credited for pioneering the concept include Johann Heinrich von Thunen, Walter Christaller, August Lösch, Alfred Weber, and Harold Hotelling. For instance, von Thunen, in 1826, used location theory to explain the reasons for different land uses in agriculture. Weber (1909) focused on factory location in terms of

the best location that reduces transportation costs and enhances profit optimization. Hotelling (1929) studied the location strategies of two firms and their prices, considering demand, transport cost, and competition. On his part, Christaller (1933) conceptualized human settlements as a system and developed the theory of centrality to explain the spatial organization of towns and cities. These ground-breaking works set the foundations for location analysis by showing how location choices are linked to different economic activities. Since then, new locational models have been used to interlock various parts for effective decision making in the distribution of resources (Fischer et al., 2013).

2.10.3 Solid waste disposal

The Africa Waste Management Outlook Report (2018) identified four main waste disposal methods practiced in many African countries including Ghana; fly-tipping or indiscriminate dumping, open or uncontrolled dumping, controlled disposal and sanitary engineered landfilling. Table 2.6 shows the number and status of the large landfills and dumpsites in Ghana. Although not appropriate, open dumping is the most common disposal practice in many cities in Ghana (Kessman, 2019). Apart from the regional capitals, where there is some form of landfilling or controlled dumping, about 50% of solid waste goes to open dumps. Also, although about 30% of solid waste is disposed of in official engineered landfills, poor management of these landfills has turned them into open dumps (United Nations Environment Programme, 2018).

Apart from the Tamale landfill, disposal in the study areas is generally by open dump methods, where there is virtually no form of management. Due to negative health impacts of open dumpsites, there are rampant agitations from

surrounding communities for relocation of dumpsites. It has become common to see open burning in landfills and dumpsites, threatening the public health of surrounding communities. In smaller towns and cities, indiscriminate dumping and open burning have become the norm.

For cities still struggling with unsafe disposal, the first step is to phase out unauthorized dumpsites and upgrade open dumps to a type of controlled dumpsite, where waste is compacted and covered daily for safe disposal. The second step is the development of engineered landfills where waste can be disposed of safely without contaminating ground and surface water (UN-HABITAT, 2009). The most advanced step, for which many Africa cities are struggling, is the establishment of waste processing facilities. In recent times, Ghana seems to show the way with the construction of 16 integrated composting and recycling plants (IRECOPs) in the regional capitals. The potential challenge is a sustainable source of financing for the operationalization of these plants going into the future.

Table 2.6: Location and status of major disposal sites in Ghana

Name of site	Town/ community located	Type (engineered landfill/ controlled dump/open dump)	Status (operational or not operational)	Land size (acres)	Capacity (tons/ day)	Remarks
Tamale	Gbalahi Landfill	Engineered landfill	operational	56.83	300 –350	
Kumasi	Oti Landfill	Engineered	Operational			
Takoradi	Osofokrom Landfill	Engineered	Operational		350 – 400	
Tema	Kpone Landfill	Engineered	Not Operational	38 acres		Under decommissioning
Tema	Kpone Old site	Not engineered/ controlled	Operational	24 acres	1,200 – 1,500	
Wa	Siriyiri	Open dump	Not in operation	40 acres	130 – 160	
Wa	Busa road	Controlled dump	operational	25 acres	130 – 160	
Bolgatanga	Shirigu	controlled dump	Operational	20 acres	50 -60	
Ho	Ziavi-Adukope	controlled dump	Operational	20 acres	65 -90	
Ho	Akrorfu	Engineered Landfill	Not in operation	30 acres	N/A	Under construction
Koforidua	Akwadum	Controlled dump	Operational	18 acres	250 – 300	
Sunyani	Poly GET Fund road	Not engineered Controlled	Operational	25 acres	150 – 170	
Cape Coast	Nkanfoa	Not engineered/ Controlled	Operational	42 acres	180 – 200	
Nsumia	Nsumia	Reengineered Abandoned Quarry	Operational	12 acres	800 – 1,200 Tons/day	Nsumia site to be closed soon
Adipa	Adipa	Engineered	Operational	150 acres	500-600Tons/day	Operational
Oblogo	Oblogo	Controlled	Not in operation	N/A	N/A	Decommissioned
Kwabenya	Kwabenya	Controlled	Not in operation	N/A	N/A	Decommissioned

Source: Waste Landfills Company Limited (2021)

2.11 Recycling/Recovery of material from waste

Unfortunately, resource recovery from waste, the most sustainable option, is very low in many African cities. The African Union Commission's target of recycling 50% of solid waste by 2023 can be described as too ambitious given the current estimated average recovery rate of 4% through formal recycling systems (The African Union Commission, 2015; United Nations Environment Programme, 2018). Solid waste processing in Ghana has been minimal with few material recovery facilities in Accra and Kumasi (Table 2.7). In 2020, Ghana took a major step towards achieving this goal by initiating the construction of 16 material recovery facilities, known as integrated composting and recycling plants (IRECOPs), in all regional capitals (see Table 2.7). Construction of the IRECOPs along with 10 medical waste treatment facilities in 10 regional capitals is expected to be completed in 2022. With the operation of the existing three solid waste recovery plants in the most populous cities of Accra and Kumasi by Accra Composting and Recycling Plant (ACARP) and Kumasi Composting and Recycling Plant (KCARP) of the Jospong Group of Companies (JGCs), as shown in Table 2.8, the formal recycling capacity for municipal waste was 17% in 2020. The completion of the IRECOPs is expected to dramatically improve the formal material recovery rate in Ghana. The biggest challenge in many cities is the inability to get reliable data on recycling. The challenge stems from the fact that large-scale recycling activities are carried out by the informal sector, which does not keep accurate data on the quantity of materials recovered (UNEP, 2018). Many individual level initiatives such as using waste as animal feed and compost in backyard gardens constitute material

recovery but cannot be estimated due to of lack of data (van Niekerk & Weghman, 2019).

Table 2.7: Locations and processing capacities of Integrated Recycling and Compost Plants (IRECOPs) under construction in Ghana

S/N	Region	Metropolis/ Municipality	Municipal Capital	Community	Processing Capacity (Tons/day)	
					1 shift	2 shifts
1	Upper West	Wa	Wa	Kperisi	200	400
2	Savannah	Damongo	Damango	Damango	200	400
3	Northern	Tamale Metropolis	Tamale	Gbalahi	400	800
4	North East	East Mamprusi	Nalerigu	Nalerigu	200	200
5	Upper East	Bolgatanga	Bolgatanga	Sherigu	200	400
6	Bono	Sunyani	Sunyani	Nwawasoa	200	400
7	Bono East	Techiman	Techiman	Fiaso	200	400
8	Ahafo	Asunafo North	Goaso	Fawoheden	200	400
9	Oti	Dambai	Dambai	Dambai	200	400
10	Volta	Ho	Ho		600	1200
12	Central	Mfantseman	Mankessim	Mankessim	600	1200
13	Eastern				600	1200
14	Western	Afia-Kwesimintsim	Kwesimintsim	Assakae	600	1200
15	Greater Accra				600	1200
16	Western North	Sefwi Wiaso	Sefwi wiawso	Aboanidua	200	400
	Total					

Source: Project Management Office, IRECOPs, Jospong Group (2021)

Table 2.8: MSW processing plants operating in Ghana

Recovery facility	Location	Year of commencement of operations	Recovery capacity per day (tons)	Products
Accra Compost and Recycling Plant (ACARP)	Accra	2012	600	Pure organic compost, Recovered Plastics, Refuse Derived Fuel (RDF)
Universal Plastic Products and Recycling (UPPR)	Accra	2013	Not available	Plastic products from recovered materials
Integrated Recycling and Compost Plant (IRECOP)	Accra	2019	400	Organic compost, recovered plastics, metal, and paper
Kumasi Compost and Recycling Plant (KCARP)	Kumasi	2020	1200	Organic compost, recovered plastics, metal, and paper
Total			2400	

Source: Environment and Sanitation Group, Jospong, 2021

2.11.1 Health and safety of waste workers

The uncomfortable truth is that waste management workers in Ghana typically work in highly hazardous conditions that put their safety and health at risk. Workers, both formal and informal, are exposed to hazardous chemicals such as carcinogens, including lead, in their daily activities. The situation is particularly debilitating for informal waste workers who work without basic personal protective equipment (PPE) such as gloves, nose masks and safety

boots. It is therefore not uncommon to find waste workers with cuts, bruises, upper respiratory tract infections, diarrhoea, fungal infections and worm infestations, among others (van Niekerk & Weghman, 2019). The health of waste workers is important and should be protected. It is therefore important that when assessing the waste management performance of MMDAs, the health and safety conditions of the waste workers are taken into account.

2.12 Stakeholder participation and relationships in MSWM

Stakeholder engagement is the mechanism for building relationships with stakeholders in the waste management sector to gain their support for the development of waste management policies, programs and plans (US EPA, 2020). Stakeholder involvement has become an essential part of MSWM and one of the cornerstones of sustainable waste management. Stakeholder involvement is essential to improve the efficiency and effectiveness of waste management (UNEP, 2009). No matter how well a waste management policy or system is designed, it cannot achieve its intended goals and objectives without effective stakeholder collaboration and cooperation. Therefore, it is important to involve stakeholders in decision-making during the design, implementation, monitoring and evaluation phases of a waste management system or policy. For example, collaboration between waste collectors and producers is likely to increase collection coverage; and the recycling rate can improve when there is effective cooperation and collaboration between recyclers, on the one hand, and waste collectors and producers on the other.

In general, stakeholder engagement occurs at three levels; inform, consult and active involvement. In order to engage stakeholders effectively, it is important

to conduct a stakeholder analysis to identify the interests, influence (power), needs and risks of the key stakeholders in the sector (US EPA, 2020). This will determine how, where and when to engage each stakeholder. The relationships among stakeholders are important in MSWM. Identification of the relationships and assessing their effectiveness is useful in measuring and improving the performance of municipal solid waste institutional governance.

2.12.1 Institutional arrangement for MSWM in Ghana

The institutional governance of MSWM is complex and overlaid by national and sub-national institutions. As shown in figure 1.2, the top level consists of sector ministries (MSWR, MLGRD, MESTI). This layer is responsible for providing policy and strategic directions for MSWM in Ghana. Prior to the formation of the MSWR in 2017, responsibility for policy and direction rested with the MESTI. The MSWR, which took on this responsibility, was supposed to harmonize all policies in the sanitation and waste sectors. The MESTI is responsible for the overall environmental compliance of the MSWM sector, which is conducted by the Environmental Protection Agency (EPA), while the day-to-day oversight and monitoring of service delivery is handled by MMDAs, while Regional Coordinating Councils (RCCs) assume coordination responsibility.

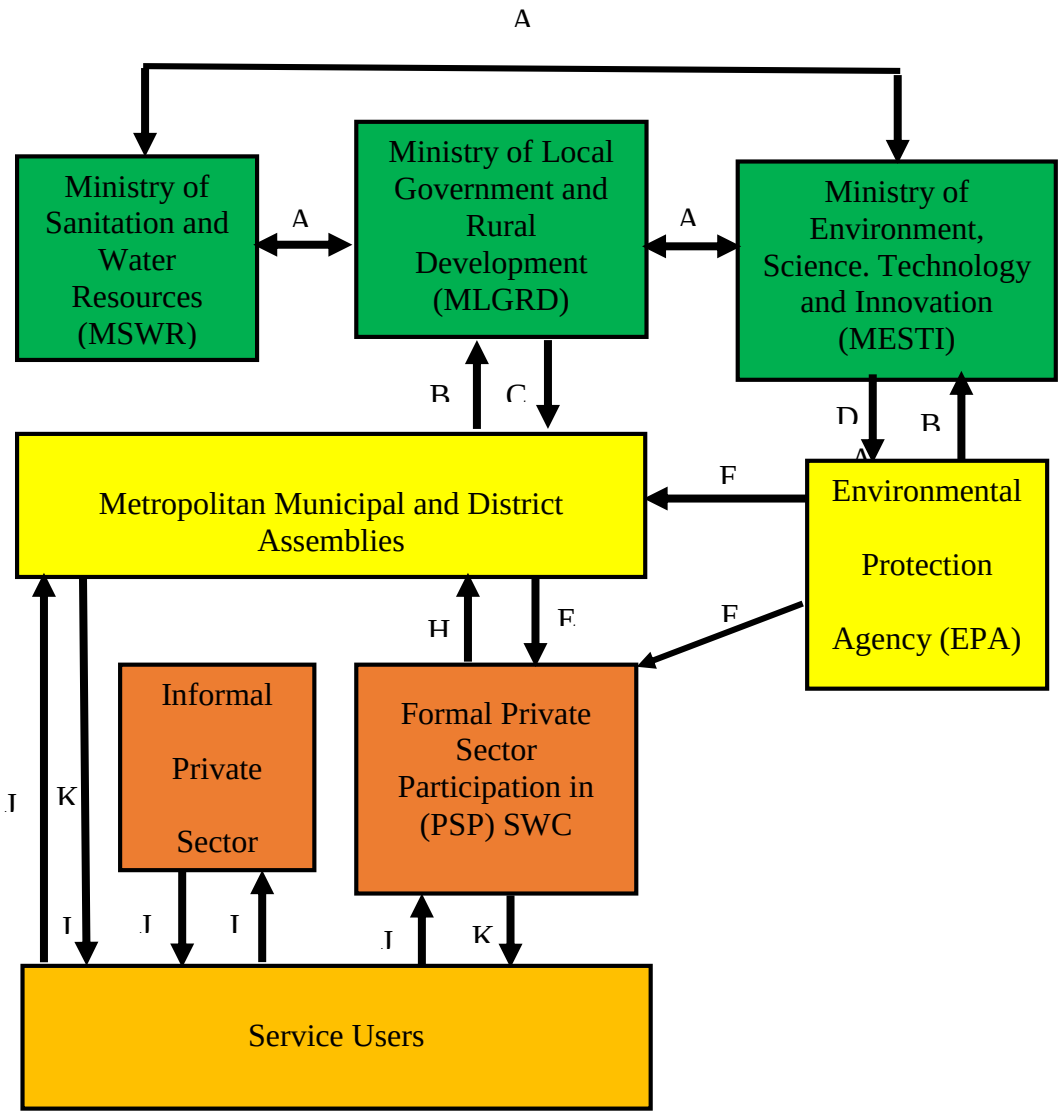

Figure 2.2: Relationships among major institutions in MSWM in Ghana

Source: adapted from Oduro-Kwarteng (2009)

A - Institutional collaborations between ministries for policy formulation on governance of SWM

B - Provision of reports, feedback and accounting for resources

C - Enabling environment: Development of appropriate policy, legal and institutional framework that support private sector participation in SWM and provision of resources to MMDAs

D - Formulation of policies to regulate environmental quality

F - Supervision and monitoring of regulatory standards

J - Channelling of feedback and complaints to service providers

H - Submission of performance reports and payment of charges to MMDAs

I - Provision of SWM services by unregulated informal private sector to service users

K - Service delivery by private sector and MMDAs to service users

E - Engagement of private sector for SWM service delivery; guided by the principles in the PPP policy of Ghana.

2.13 Sustainability in waste management

Sustainability means maintaining a balanced and resilient ecosystem by using natural resources in a way that meets the productive and consumptive needs of the present generation without compromising the capacity of those same resources to meet the needs of future generations (United Nations, 1987). The concept of sustainability focuses on the balance between the three pillars of sustainability – environment (planet), economy (profit) and society (people) - taking into account present and intergenerational justice (equity). The concept of sustainability in waste management is based on the principles of Integrated Sustainable Solid Waste Management (ISWM). UNEP (2009) defined integrated waste management as a comprehensive and strategic waste management program, designed and implemented in a holistic, collaborative,

consultative and participatory manner, using resources and practices in efficient, complementary ways to achieve economic, environmental and social efficiencies. It optimizes the value of resources along the value chain from generation, separation, collection, transfer and transportation, treatment and disposal (US EPA, 2002). The purpose of any ISWM system is to achieve resource sustainability; economic efficiency, environmental sustainability and social acceptance and justice.

The principle of economic efficiency means that the benefits of waste management are greater than the costs of waste management. This can be achieved by implementing practices and technologies that cost less, use fewer resources and produce less emissions. Environmental or ecological sustainability means that there is minimal adverse impact on the environmental and ecological systems from the technologies and practices used in waste management. Prioritization of technologies and practices should be based on the waste hierarchy model of 4Rs (reduce, reuse, recycle and recover) before disposal.

The principle of social sustainability means that the practices are accepted and adapted by the community members. Social sustainability also includes a fair use of benefits and cost sharing from waste management. To ensure social sustainability, collaborative participatory modelling where participation includes a broad range of partners who are involved in the co-design and shared decision-making processes are always are abreast with developments in waste management systems (Basco-Carrera et al., 2017). Community members should be involved in making decisions about the ISWM program. Contributions and

ideas of users should influence the nature of the ISWM system. The involvement of community members generates active citizen participation, which leads to the success of ISWM.

It should be noted that an effective and efficient ISWM program starts with a good policy that clearly defines goals, priorities and responsibilities of different stakeholders. Such a good policy should adopt the transactive rationality model of the policy design process, in which scientific (technical), democratic, moral, and environmental considerations feed into policy-making (Kuruvilla & Dorstewitz, 2009). A well-crafted policy requires the support of citizens to work. The waste management practices that individuals adopt in their homes determine the effectiveness of an ISWM policy.

The development of an effective and efficient ISWM program should be based on reliable waste data and information. Information on waste quantity and quality, per capita generation, waste composition, landscape and development plan, including population and demographic characteristics, and cultural and social characteristics of the communities are needed to support the development of an integrated waste management system. The availability of reliable waste data is often the challenge for most developing countries, including Ghana, particularly in the study areas of this research. Consequently, the practice of integrated sustainable waste management in developing countries is still at the infancy stages.

ISWM require that all aspects of SWM ranging from managerial, technical and financial are implemented together and complementarily. It also requires that

all streams of solid, liquid and gaseous waste be integrated into waste management systems (UNEP, 2009). A good ISWM system is based on the principle of waste hierarchy, 4Rs-reduce, reuse, recycle and recover. The top priority of an effective ISWM system is waste reduction. Waste reduction includes initiatives to minimize resource use and waste generation. This can be achieved by using efficient technologies, fewer raw materials, reusing waste materials for other purposes, and recycling waste materials into other useful forms. Waste reduction can be effective at the decision-making levels (individuals and commercial), where households and industries only buy what they need. For example, if a family cooks just enough food for itself, all of the food is consumed without waste. At the household level, multiple materials can be reused to reduce waste generation. For example, water bottles can be refilled several times for use. Demolition waste can also be used for road construction.

2.14 Conceptualization and evolution of service quality

In the service literature, the concept of service quality has evolved over time and gone through various stages of refinement, with multiple authors contributing their different viewpoints. Lehtinen and Lehtinen (1982) postulated three components of service quality - interactive, physical and corporate quality; and Gronroos (1984) conceptualized service quality as a three-dimensional structure of functional, technical and reputational quality. Other conceptualizations included Leblanc and Ngyen's (1988) five-dimensional classification; structural internal organization, corporate image, physical system support, employee-customer interaction, and level of customer satisfaction and Garvin's (1988) nine components (performance, features,

reliability, durability, service, conformance, reliability, response and aesthetics). Parasuraman et al. (1988) conceptualized service in five quality dimensions: reliability (R), responsiveness (R), Assurance (A), empathy (E) and tangibility (T). Parasuraman et al. (1988) further developed the SERQUAL model for measuring service quality; the model adapted for this study.

2.15 Definition of service quality

The definition of service varies between provider and consumer. From the provider's point of view, service is a process consisting of delivery, human interactions and personal attention. However, customers view service as a partial life experience made up of needs, choices and emotional content that impact each customer differently. Service is an intangible act offered by one party to another party in exchange for a benefit with no change in ownership (Deng, Lu, Wei, & Zhang, 2009; Tamilselvi, 2016). The main purpose of a service is to meet the needs of customers, which ultimately leads to satisfaction. Therefore, the number one ingredient customers look for in a service is quality. According to Edvardsson (1998), service should be approached and defined from the customer's perspective. Customers are considered the ultimate beneficiaries and therefore are the best judges of service quality; their satisfaction is the basis of business. This study looks at waste management service and analyses its quality from the consumer's perspective.

Quality has multiple definitions depending on the perspective, focus, and context in which it is used (Hardie & Walsh, 1993; Sower & Fair, 2005; Wicks & Roethlein, 2009). Quality can be defined as the set of characteristics and properties of a service that enable it to meet customer needs (Kotler et al., 2002).

Service quality is the extent to which service meets customer requirements (Zeithaml et al., 1990). It is also defined as the extent and direction of the difference between customer expectation and perception (Parasuraman et al., 1988). Service quality is defined for the purposes of this study as the extent to which customers of waste management service are satisfied with waste collection on their premises. Difficulties are always encountered in identifying and defining customer requirements for quality. The concept of quality of service begins with understanding customer expectations and how the perceived service meets the expectations. When perceived service falls short of expectations, a gap is created. The analysis of how the gap arises and how it could be closed is the basis for the Gap Model (Odayor, 2003). This is within the framework that this study is contextualized and analysed for waste management service quality.

Service Quality performance of PPPs is based on the 3Es (Efficiency, Effectiveness and Equity) driven by customer perception, expectation and satisfaction. While effectiveness relates to how well solid waste is collected and disposed of according to technical specifications (technical efficiency), efficiency relates to how government and private waste company customers and private contractors themselves get value for money received for the waste management services provided. Equity/fairness indicates how accessible and affordable solid waste collection and disposal services are to all classes of the public irrespective their economic and social status (social efficiency).

2.16 Dimensions of service quality

The aspects of service quality considered in this study are functional quality, technical quality and corporate (image) quality. Hassan and Islam (2015) defined technical quality as managing waste according to international standards in a sustainable manner. Corporate quality is the sum of perceptions in the minds of stakeholders about an organization (Cobanoglu & Della Corte, 2021), Functional quality encompasses the way in which the service is delivered and its dimensions are reliability, responsiveness, safety, empathy and tangibility; Tangibility - appearance of physical facilities, equipment, personnel and communication materials of waste company; Responsiveness- willingness of waste company and staff to help and respond to customer needs and requests; Assurance- knowledgeable and courteousness of staff and their ability to instil trust and confidence in customers; Empathy- caring, individual attention that the waste management company offers its customers.

Technical quality in waste management is the delivery of waste management services according to governance, physical and regulatory standards as set out in the Wasteaware Indicators Framework (Wilson et al., 2015) and the National Solid Waste Management Strategy (NSWMS) for Ghana (MSWR, 2020). The indicators of physical component of technical quality covers protection of public health (collection and disposal), environmental control (treatment), and resource value (reuse, recovery, and recycling)

2.16.1 Reliability

Reliability is a measure of the waste management company's capacity to deliver the service as promised (Khan & Fasih, 2014). This is an important dimension

when evaluating waste management service quality, as many customers like doing business with companies that deliver on their promises (Ramya et al., 2019). Odayor (2003) used the 1-10 Likert scale to measure customer expectations and perceptions of solid waste collection services in three cities (Durban, Pinetown, Richards Bay) in South Africa. The results of this study recorded generally moderate expectations; 6.30, 6.16, 6.14, 6.12, and 5.85 for reliability, empathy, responsiveness, assurance, and tangibility, respectively. Reliability recorded the highest expectation of 6.30 while Tangibility recorded the lowest expectation of 5.85. For waste management service, reliability is very important since failure to pick waste as promised may lead to bad odour in premises of customers. Waste management companies must therefore make every effort needed to be considered reliable by their customers.

Technical quality in waste management is the delivery of waste management services according to governance, physical and regulatory standards as set out in the Wasteaware Indicators Framework (Wilson et al., 2015) and the National Solid Waste Management Strategy (NSWMS) for Ghana (MSWR, 2020). The indicators of physical component of technical quality covers protection of public health (collection and disposal), environmental control (treatment), and resource value (reuse, recovery, and recycling).

2.16.2 Responsiveness

According to Zikry (2017), responsiveness is the service provider's ability to respond promptly to customer concerns. Responsiveness focuses on promptly resolving customer complaints, inquiries, questions and problems (Berry et al., 2006). It is the period when customers have to wait for their concerns to be

addressed after they have submitted complaints. Responsiveness also includes the service provider's ability and willingness to assist and adapt the service to the needs of the customer.

2.16.3 Assurance

Assurance is the capability of the service provider and its employees to inspire trust and confidence (Edvardsson, 1998). The assurance dimension is very important for services that contain personal and confidential information. Customer expectations for assurance may vary depending on the type of service. Trust by customers is largely built by the employees who often engage with customers on behalf of the company (Kaura et al., 2012). Employees must be aware of this and create trust between their customers and them in order to gain customer loyalty and competitive advantages

2.16.4 Tangibility

Tangibility is the appearance of the service organization's physical facilities, equipment, personnel and communication materials (Chingang & Lukong, 2010). Tangibility influences customer expectations of service providers. For example, waste companies with state-of-the-art equipment may have higher customer expectations compared to companies with legacy waste treatment equipment. The professional appearance of refuse collection personnel, including clothing, uniform and personal hygiene, affects recognisability and affects customer expectation and perception (Zikry, 2017). Due to high-cost of waste management equipment and short durations of contracts, small and medium size waste management companies are unable to procure state-of- the-art equipment (Cointreau-Levine, 1994).

2.16.5 Empathy

Empathy shows how waste management service providers care for and treat customers individually (Lin & Foo, 1999). In an emerging trend of high demands for better treatment from service providers, customers demand more attention and empathy from service providers during service delivery (Khan & Fasih, 2014). Customers expect a sincere apology for any inconvenience caused during service delivery. While appearance is not the main crucial aspect of service, how customers perceive your business makes a difference, especially when your brand promises a premium experience. Attention to a neat and well-groomed appearance shows that service providers value customer comfort highly.

2.17 Relative importance of service dimensions

There is an increasing demand for higher standards of service quality as customers become more demanding and aware of their rights and privileges (Verma & Sachdev, 2004). The continuous evolution of customer expectations and perceptions has made it increasingly difficult to define, measure, and manage service quality. Therefore, paying attention to each dimension and understanding how customers evaluate each dimension is crucial for service management. It is imperative for service providers to examine the relative importance of all service quality attributes in order to allocate resources to meet customer priorities. The relative importance of service dimensions can vary by service type, industry and locations. Results from studies by Lin and Foo (1999) on library services in Singapore showed the following relative importance of

dimensions in descending order: reliability (23.79%), responsiveness (23.26%), safety (19.77%), tangibility (18.71%) and empathy (14.47%).

2.18 Service Quality Gap Model

The SERVQUAL model (gap model) was adapted as the basic concept of the study. The Gap (SERVQUAL) model was originally developed by Parasuraman et al. (1988) to explain problems related to customer satisfaction. The SERVQUAL instrument is preferable because it offers a strong customer-centric approach to service evaluation (Lin & Foo, 1999; Hebert, 1994). The model remains the most reliable, desirable, and legitimate tool for measuring service expectation and satisfaction (Ho & Lin, 2010; Kassim & Abdullah, 2010). The model provides key service gap information that can be used by managers to enhance the overall performance of waste management service delivery (Rodrigues et al., 2011). Figure 2.3 shows the service gap model with five gaps.

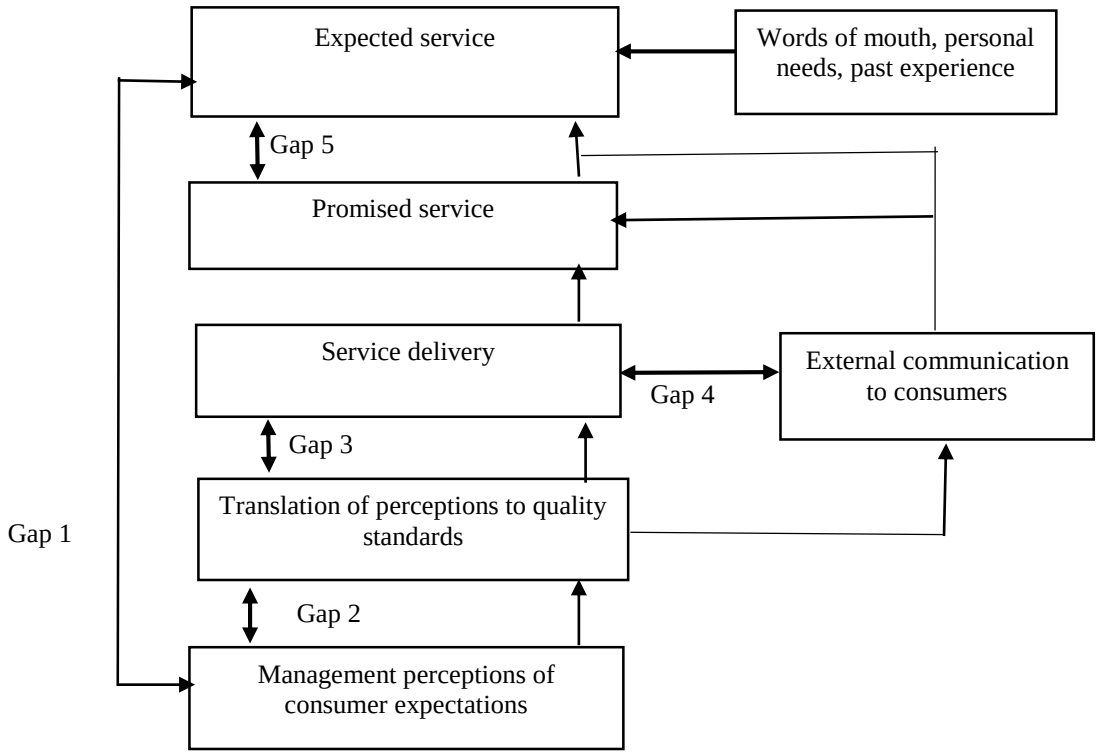

Figure 2.3: Service Quality Model

According to Odayor (2003), the gap model identified five service gaps that should be addressed in order to meet customer expectations. These are knowledge, policy, deployment, communication, and customer gaps. A study analysing gaps in waste management in three cities (Durban, Pinetown and Richard Bay) in South Africa revealed large service gaps, resulting in low customer satisfaction for the waste service industry. Empathy and Reliability recorded the highest gaps of -3.02 and -3.0, while Assurance and Tangibility recorded the lowest gaps of -2.87 and -2.0 (Odayor, 2003).

2.19 Gap 1 (knowledge gap)

Knowledge gap occurs when the management of the service company does not understand what customers expect (Shahin, 2006). This is caused by insufficient

engagement between management and customers, poor communication between management and employees, insufficient research and a lack of attention to customer complaints. This can be addressed by striving to understand the customer through customer research, including incorporating analysis of results from complaints into decisions; and by increasing interactions between customers and management on the one hand and between management and employees on the other.

2.20 Gap2 (standard/policy gap)

This gap occurs when the service provider's management fails to translate its understanding of customer needs into delivery procedures and standards or specifications (Timilselve, 2016). The gap is brought about by lack of customer service standards, poorly defined service standards, and a failure to regularly update service standards based on changing customer needs. This gap is common in developing countries as waste management is an emerging service with less stringent procedures and standards. Although there are some waste management service standards in Ghana, service providers sometimes flout them with no consequences. The gap is closed by creating appropriate service standards by aligning management evaluation with service quality, conducting training and communicating quality standards to all employees, rewarding employees when quality targets are met, and regularly updating service quality standards to meet customer needs.

2.21 Gap 3 (delivery gap)

This gap arises when the actual service provided deviates from the service specified in the delivery policies and standards (Nadiri & Hussain, 2005). It

occurs as a result of employee skill shortages, lack of necessary equipment and inadequate human resource policies, and poor service skills of employees. In Ghana, due to the high cost of waste handling equipment, especially trucks, many service providers rely on old trucks, which are weak and frequently break down. The net effect is poor delivery of waste collection services. The gap can be closed by deploying the necessary equipment and technology, training and empowering people with the appropriate skills and knowledge, and retaining high-performing employees. An Integrated Waste Management Information System (IWMIS) has recently been implemented by most service providers to improve service quality. This system has financial, operational communication and customer service components. The full deployment of all components of the system is an important step towards improving service quality and customer satisfaction.

2.22 Gap 4 (communication gap)

This gap is the difference between promised and delivered performance. This results from over-promising, disparity between external and internal communication, and poor communication between operations and advertising teams (Zeithaml & Bitner, 2003). The communication gap can be closed by including employee input in advertising campaigns, using real customers and employees for advertising and managing customer expectations (Nadiri & Hussain, 2005). This gap often occurs in waste management because the promised picking frequency of waste containers differs from the actual picking frequency.

2.23 Gap 5 (customer gap)

This is the difference between customer expectations and perceptions. This difference is considered as perceived quality of service and is the basis for customer satisfaction (Kumar et al., 2009). Gap 5 is the result of one or more of the four gaps. G5 can be closed by closing the other gaps if they occur. Customer expectations and perceptions are aligned once the other four gaps are closed.

2.24 Gap analysis

Based on the model, customer satisfaction is determined by perception and expectation (Negi, 2009). Whenever customer perception falls short of expectations, a service gap arises. When customer expectation meets perception, customers are said to be satisfied, and when perception is below expectation, customers are said to be dissatisfied. Therefore, in order to improve customer satisfaction, these gaps must be closed.

2.25 Customer and consumer satisfaction

There are several definitions of customer satisfaction, but a widely accepted definition is that satisfaction is the consumer's fulfilment response and a judgment that a product or service itself has provided or is offering a comfortable level of consumption-related fulfilment, including levels of under- or over- fulfilment (Deng et al., 2009). This definition is remarkable because it puts the consumer, not the customer, at the centre. This is because the consumer uses the service or product while the customer may just be paying for the product or service but might not use the product or service directly. Satisfaction with a product or service is a construct that requires experience and use of a product or service. Individuals who pay for a product or service but do not use

that product or service will not experience the form of satisfaction or dissatisfaction that a product or service user (the consumer) will have. It is therefore cardinal to link the concept of customer satisfaction to consumer satisfaction (i.e. user satisfaction) and not to buyer satisfaction (which can also include non-users) (Sureshchandar et al., 2002). Contentment is a feeling and can easily change due to changing circumstances. Satisfaction is not an observable behaviour like product choice, complaints and repurchase, but is in the mind of the user. It is key to note that consumer satisfaction has a lower and an upper level. The lower level is the level of inadequacy or under-achievement resulting in a gap while the upper level is the level of over-accomplishment. This shows that consumer satisfaction can be affected when too much good is given (Oliver, 1997). However, as the lower level of under-fulfilment is common in the service industry, it was considered as the basis for the analysis of service gaps in this study.

2.29 Choice of the SERVQUAL model for the study

Literature abounds in criticisms against the SERVQUAL model ranging from validity basis of conceptualization (Cronin & Taylor, 1992; 1994; Anderson, 1992), functional (process) orientation (Mangold & Babakus, 1991; Cronin & Taylor, 1992; Richard & Allaway, 1993; Sureschander et al., 2001), dimensionality (Carman, 1990; Peter et al., 1993; Smith, 1995) and psychometric problems detailed in Smith (1995) and Buttle (1996). Following the criticisms, Cronin and Taylor (1992) developed the SERVPERF instrument as an alternative instrument. Their claim of superiority of the SERVPERF over the SERVQUAL in terms of conceptualization, measurability and applicability

remains contested. Despite all the criticism against SERVEQUAL, none of the critics has been able to develop an alternative instrument of same level of general appeal and market dominance. SERVQUAL framework remains relevant and robust in contemporary research and widely used by many researchers without severe modifications (Saraei & Amini, 2012). The SERVQUAL model continues to be strong, legitimate, dependable and desirable in literature (Rodrigues et al., 2011). This research therefore found the SERVQUAL suitable and draws on it with little modifications to assess service quality in the solid waste service industry that is still in its primordial stages of development in Ghana.

2.30 Concept of service efficiency

According to Agboje et al. (2014), many African countries spent 20-50% of annual municipal budgets on waste management, but collected 20-80% of solid waste. Therefore, efficiency is a paramount issue. There are numerous definitions of efficiency in the literature. Efficiency is defined as how well services meet customer needs and customer expectations, and how well services respond to changing user needs (Entwistle & Andrews, 2013). Efficiency can be classified as productive efficiency, allocative efficiency, equitable efficiency, and dynamic efficiency (Entwistle & Andrews, 2013). Allocative efficiency is how well demand for services matches supply. It is the extent to which waste disposal services are accessible to users. Equitable efficiency, sometimes referred to as distributional efficiency, is the extent to which services are distributed fairly among users. Dynamic efficiency is the extent to which new technologies are deployed to satisfy the needs of the present and the future.

In my view, waste management efficiency is the extent to which waste management meets the needs, costs and demand of customers in a fair, affordable and accessible manner, while also meeting the profitability requirements of service providers. Productive efficiency, also known as cost or technical efficiency, which is the focus of this study, means doing a lot with fewer resources. It is the extent to which the input resources are reduced for the same level of output.

According to the World Bank (2004), many residents of urban slums and sparsely populated rural areas in developing countries have no access to basic standard waste collection services, and those who do, receive poor services. The effectiveness of any waste privatization strategy must be measured not only by its ability to improve convenience for people who already have access to the service, but also to extend basic waste management services more areas. Other important aspects of efficiency are affordability and equity. Although residents in most developed countries may be sensitive to the price of services such as waste disposal, they have the ability to pay and are comfortable with enhanced services that come with higher prices.

The situation is different in developing countries like Ghana. Many residents may need the services but are constrained by their ability to pay due to their limited income. Therefore, providing services at the minimum price that users can pay is very important when it comes to defining efficiency. Efficiency in this context means ensuring social justice and universal access by setting prices that balance economic efficiency and social justice (Contreau-Levine, 1994). This type of pricing will allow private investors to earn moderate returns on

their investment in waste management while providing affordable and equitable services to users. In pursuing the balancing act between economic efficiency and social equity, care must be taken not to fall into the trap of longstanding under-pricing of services, which has the potential to constrain the availability of services due to under-investment (Contreau-Levine, 1994).

The conceptualization of modern efficiency was initiated by the work of Farell (1957). Following the work of Koopmans (1951), Farell defined efficiency in the context of multiple inputs. He proposed that efficiency should consist of two components: technical efficiency, which is an organization's ability to maximize output from a given set of inputs, and allocative efficiency, which is an organization's ability to use inputs in an optimal ratio, considering their respective prices. The product of the two efficiency measures gives economic efficiency. There are currently two basic approaches used to estimate bounds for determining efficiency measures - parametric and non-parametric approaches. A key feature of the parametric approach is that it adopts an explicit functional form for technology and distribution inefficiency terms (Lovell & Schmidt, 1988; Bauer et al., 1988). Data Envelopment Analysis (DEA) is a non-parametric approach that extends relative efficiency analysis from a single input-output relationship of (Farell, 1957) to multiple input-output relationships (Charnes, Cooper, & Rhodes, 1978). No functional form is taken in DEA, but efficiency of Decision-Making Units (DMUs) is estimated relative to all other DMUs (Seiford & Thrall, 1990).

The concept of evaluating the efficiency of solid waste collection began in 1969 when various government agencies published environmental protection

guidelines. The World Bank supported this concept by funding an advisory study in 1984 that included academic approaches to SWM in different countries (Bartone et al., 1990). Since the 1990s, various approaches and models have been proposed and used to assess the efficiency of solid waste management. According to Sanjeevi and Shahabudeen (2015), the 1992 UN Conference in Rio categorized SWM models into two groups; one deals with models for minimizing waste generation and the other with resource requirements (input efficiency) for solid waste management.

Due to the attention gained by efficiency measurement of MSWM, various researches and efficiency measurements on input efficiency have been conducted. By using the number of containers, total number of vehicles, total number of direct workers as input indicators and tons of refuse of organic material collected as output indicators, Bosch et al. (2000) applied DEA and FDH (Free Disposal Hull), non-parametric approaches to analyse technical efficiency of waste collection in 75 municipalities in Spain. Benito et al. (2010) applied a one-stage DEA method to assess efficiency of solid waste collection in Murcia Region of Spain, where number of tons of solid waste and houses in which refuse is collected daily were used as output indicators and costs of personnel, current transfers of personnel as input indicators. Also, selecting capital investment for MSW maintenance and construction, fixed assets investment in the public facilities of municipal environmental sanitation as input indicators and quantity of MSW transported by airtight vehicle and MSW harmless treatment rate as output indicators, Zhou et al. (2019) adopted one stage DEA model and analysed MSWM efficiency in 34 cities in China. The

results of the above studies generally showed low management efficiencies, recommending improvement in the service delivery processes.

2.31 Data Envelopment Analysis (DEA)

Gap analysis of customer perceptions and expectations are often simple and useful but may produce subjective assessment results (Huang et al., 2010). To remove subjectivity in efficiency assessment, selected Aggregate Indicators (AIs) are used to conduct empirical analysis. This study adapted the DEA Charne Cooper and Rhodes (CCR) model to support the subjective assessment of the SERVQUAL model (Charnes et al., 1978). Apart from achieving objective assessment of efficiencies of service delivery process, the use of DEA is an appropriate approach for examining the conversion efficiency of waste management inputs into waste management outputs (Goksen et al., 2015).

Data Envelopment Analysis is a non-parametric method for evaluating relative efficiencies of a set of Decision-Making Units (DMUs) that perform similar tasks under varying conditions and for which inputs and outputs measurements are available. DMUs refer to entities to be evaluated in terms their ability to convert inputs into outputs (Goksen et al., 2015); in the case of this study, municipalities and metropolis the DMUs studied. DEA is a linear programming (LP) method used to contruct a frontier (efficient boundary) over data to allow for calculation of efficiencies relative to the frontier (surface) via input orientation or output orientation (Coelli, 1996). The best DMUs are used as the boundary to construct the frontier.

The use of computer based programs for DEA have become common. The use of Data Envelopment Analyisis Programme (DEAP 2.1) comes in three main versions. First, the standard Constant Return to Scale (CRS) and Variable Return to scale (VRS) DEA models as detailed in Fare et al. (1994), which is used to calculate technical and scale efficiencies; second, an extension of the standard models to estimate cost and allocative efficiencies; and third, the application of Malmquist DEA models as outlined in Grosskopf et al. (1994) to calculate indices of total factor productivity (TFP).

DEA provides objective assessment of service efficiency (cost and time efficiencies) by focusing on Key Performance Indicators (KPIs) of the service delivery process. The inability to separate inefficiency from statistical noise and/or measurement error is the main drawback of DEA (Abdulai et al., 2018). The standard DEA model of Banker, Charnes, Cooper and Banker (1984), under the assumption of convexity of inputs and outputs with variable return to scale (VRC), is suitable for analysing DMUs that do not operate under perfect competitive environment (Bogetoft et al., 2000). Consequently, the use of this model is appropriate as municipalities and metropolis under study do not operate under perfect competition in the waste management sector.

The study adopted the input-oriented CCR model of DEA for assessing efficiencies. This model is appropriate because inputs quantities as the primary decision variables of waste management firms can be controlled by managers of waste service delivery systems (Coelli et al., 2005). The main strength of input-oriented model DEA is its ability to identify slacks (excess inputs) in each

DMU. A firm is defined as fully technically efficient when the DEA score is 1 with no slack values for the production inputs (Koopmans, 1951).

Although further modifications are being done to better capture the complex processes of solid waste management, DEA has become dominant method of efficiency measurement in solid waste management world-wide. Globally, application of DEA has been widely relied on to analyse efficiencies in health and agricultural sectors (Bosch et al., 2000; Worthington & Dollery, 2001; Marques & Simões, 2009; Benito et al., 2010; Rogge & De Jaeger, 2012). However, the use of DEA in efficiency measurement in MSWM is limited in Ghana. A critical challenge that limits the application DEA in solid waste management is the lack of data or unreliable data. Notwithstanding the challenge of data, this research presents a novel approach to efficiency measurement in MSWM and contributes to the general knowledge and information on the application of DEA to determine efficiency of MSWM in Ghana.

The use of DEA to assess efficiency has a number of advantages over other approaches. DEA has the ability to handle multiple inputs and outputs and need not specify a restrictive functional form as in Stochastic Frontier Analysis (SFA) (Fried et al., 2008; Coelli et al., 2005). DEA has the ability to break down efficiency into its components. Apart from DEA being unit invariant and requiring (Pastor & Aparicio, (2015). Lovell & Pastor, 1996) no standardization, it is useful for target setting, as best practice DMUs (firms) are identified for other DMUs to emulate (Pastor, 1996).

2.32 Chapter Two Summary and Gaps in Literature

The literature reviewed shows that municipal solid waste management is fundamental for protecting the environment and promoting public health. It is also important for resource recovery and job creations. According to Lenkiewicz & Webster (2017), effective waste management can directly contribute to the achievement of many of the sustainable development goals, especially goals 6 (ensure access to water and sanitation), 3 (good health and wellbeing), 11 (inclusive, safe, resilient and sustainable cities) and 12 (responsible consumption and production).

However, the existing waste management systems as pertain in many cities in Ghana are inadequate in running an effective and efficient waste management service delivery. The physical systems in terms in collection and transfer, disposal and processing are inadequate. The policy, governance, institutional and the financial arrangements are challenged. The adoption of private sector participation as the gold-standard solution to the funding and performance challenges is undergoing a process of reformation and refinement. Although the coming in of the private sector has injected some form of momentum into the sector, it is failing to meet the expectations of citizens in terms of service quality.

A review of the literature also revealed a limitation in the assessment of waste management efficiency in Ghana. Although various efficiency models have been applied in assessing solid waste management efficiency in advanced countries, the application of such models in Ghana are limited due to lack of accurate waste data. Data Envelopment Analysis (DEA), which has been

widely applied in assessing efficiencies in agricultural and health sectors in Ghana, has recently been extended to the solid waste management industry. Notwithstanding the challenge of data, this research identified and presented a need for efficiency determination in MSWM to contribute to general knowledge in deepening the understanding of efficiency issues of MSWM in Ghana.

From the review of literature, it was observed that the various authors could not link the waste management system and the private sector participation model to the quality and efficiency of waste management services in the study municipalities in Northern Ghana. The literature also fell short of how the operationalization of the private sector participation model meets the principles of PPPs in terms of accountability, transparency, competitiveness and value for money. Waste management service quality development and assessment remains embryonic and still undergoing a process of maturation. First, waste management service operational standards are not clearly refined, and accessible data on the quality of service provided by private sector is sparse. Second, while we acknowledge that assessing the outcome of privatization is a difficult task, the discussion of Ghana's privatization process should draw on lessons from empirical data and experiences from the field. However, while some data on service quality was available in literature, empirical data on resource use efficiency of private-led sector service delivery was limited. Given the fact that privatization has become part and parcel of Ghana’s development paradigm, there is the need for further research to dissect and examine the nitty-gritties of waste privatization and its impact on waste service quality and efficiency in Ghana as it goes through the process of maturation. Therefore, this

research work seeks to fill the literature gap by assessing how the existing waste management system including private sector participation contribute to waste management service quality and efficiency in four selected municipalities and metropolis in Northern Ghana.

2.4 Theoretical and conceptual framework

Theoretical and conceptual frameworks direct the path of research and provide the basis for establishing its dependability and acceptance (Adom et al., 2018). Theoretical framework provides a general set of ideas based on existing theories or theories in the literature on which research is grounded (Adom et al., 2018; Peshkin, 1993).

2.4.1 Theoretical framework

This study is underpinned by systems theory. A system is a unit of interconnected and interdependent parts. According to Mele et al. (2010), a system is an entity that is part of a whole, with a boundary being perceived to identify internal and external factors, and input and output factors related to the system. According to Tien and Berg (2003), a system can be man-made (e.g. government), natural (e.g. river), physical (e.g. vehicle), conceptual (e.g. waste management plan), static (e.g. recycling plant), closed or open. A system is analysed as a whole; with an emphasis on how the elements in the system are aligned and add to the overall outcome or goal of the system (Mele et al., 2010).

Waste management is viewed as a system residing within a complex urban management system composed of physical (hard) subsystems made up of equipment and infrastructure and a governance (soft) subsystem made up of

policies and institutions. The application of systems theory for the study is therefore appropriate. Adams et al. (2014) defines systems theory as the study of systems. A systems theory is a multidisciplinary and theoretical perspective that analyses a phenomenon, with a focus on the implications of the interactions between factors rather than the implications of the individual factors (Copra, 1997; Mele et al., 2010). UN-Habitat (2010) emphasized the comprehensive view of waste management as a system by stating that:

"What most low- and middle-income cities miss is organization, specifically, a clear and functioning institutional framework, a sustainable financial system, and a clear process for pushing the modernization agenda and improving the system's performance. If there is no overarching framework, the mixture remains a cluster of disjointed sub-systems that do not function well together – or at all".

The quote underlines the importance of a functional integrative waste management system in which all components of the system work and reinforce each other and the overall outcome of the system. An effective waste management system also integrates with and supports the city urban management system.

2.4.2 Conceptual framework

According to Kumar et al. (2017), a conceptual framework is a structure of interrelated concepts, empirical research, and major theories. It may be the researcher's own construct or an adaptation of existing theories or theories to systematize and explain relationships between the main variables in research (Camp, 2001). Figure 1.4 has been adapted as the main conceptual framework

for the study. The interactions of physical (hard) and governance (soft) factors determine the quality and efficiency of waste management services in a city. The interactions of the factors are also influenced by the waste-related data and background characteristics of the city.

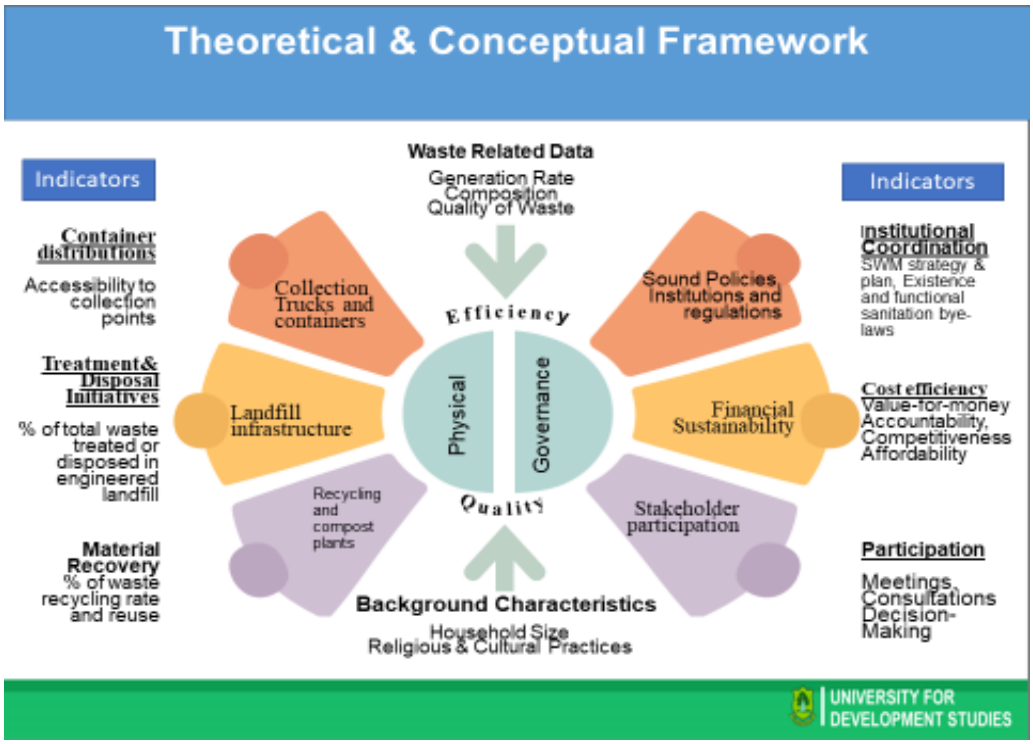

Figure 2.4: Conceptual framework for assessment of integrated sustainable (solid) waste management (Wilson et al., 2015)

Waste-related data such as per capita generation and percentage of major solid waste components impact issues such as collection and treatment facility design, policy formulation, and strategic planning for effective management. Background factors such as population growth, educational level, income levels and socio-cultural aspects are very important in developing efficient waste management policies and programmes. The indicators are interpreted in the

context of background characteristics and waste-related data to provide information for a proper comparison of performance between cities.

The key variables in the conceptual framework (Figure 1.4) that contribute to assessing the performance of private sector participation the Solid Waste Management System are described under the Physical (Hard) Subsystem and Governance (Soft) Subsystems.

The interaction of between the Physical Subsystems and the Governance Subsystems in with context of background characteristics such as household size and cultural practices and the waste-related characteristics such as generation rate, percentage composition of waste influence the quality, equity and efficiency of waste management services delivered by the private sector within the selected Municipalities.

The key performance variables (indicators) to be measured under the physical sub-system are shown in Table 1.9 and include following:

i. Collection infrastructure and coverage (% of households having access to waste collection services), quality of collection

ii. Treatment infrastructure and amount of total waste treated or disposed of in an engineered landfill

iii. Material Recovery infrastructure and amount of waste recycled and reused waste.

The main variables (indicators) for the Governance (Soft) Subsystem are the availability of functional institutions and policies, the equality of services, and the level of stakeholder involvement, which are described as the following:

i. Institutional collaboration and coordination

ii. Level of stakeholder participation

iii. Compliance with principles of good waste governance (value for money, competitiveness, accountability, service equity)

iv. Cost efficiency of collection (financial sustainability)

2.4.3 Wasteaware Integrated Solid Waste Management (ISWM)

The Wasteaware ISWM Benchmark Framework was adapted as a measurement framework for the study. The reason for adapting the Framework is its ability to provide multi-dimensional assessment of MSW. The Framework is an enhanced UN-Habitat ISWM framework, approved by the International Solid Waste Association (ISWA) as a tool for assessing MSWM performance and the recycling system in a community or metropolitan area. The framework enables a municipality to assess its own MSWM performance to provide information on priority areas for decision-making related to the use of scarce resources. The Wasteaware ISWM Benchmark Framework addresses the weaknesses related to the UN-Habitat ISWM indicator set and offers opportunities for continuous improvement. The Framework provides an overview of a city's MSWM performance and allows for benchmarking of intercity performance. It also helps to identify areas of strengths and weaknesses and highlights improvement actions needed (Wilson et al., 2015). The performance standards and indicators

that were used to evaluate MSWM performance are detailed in Tables 2.9 and 2.10. Table 2.9 provides quantitative variable (indicators) that can be easily measured given the availability of data. Table 2 10. contains mostly qualitative variables (indicators) that cannot be easily measured. Therefore, *yes or no answers* to questions describing qualitative indicators are usually used for assessment of governance (Scheinberg et al., 2010; Sim et al., 2013).

Table 2.9: Physical quality, performance indicators and standards for solid waste management in Ghana

Aspect	Indicator	Standards
Collection	% of solid waste collected	Low (0-49%), Low/Medium (50-60%), Medium (70-89%), Medium/High (90-98%) High (99-100%)
	% of urban households that have access to door-to-door collection	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)
	% of household using standard waste bin	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)
	Number of waste management workers per population	
Transport	% of enclosed collection vehicles in use	100%
	Availability of Transfer stations	Yes
	% of waste transported to landfill	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)
Treatment	Availability of functional waste processing facility	Yes
	% of waste recycled/recovered/ Treated	Low (0-9%), Low/Medium (10-20), Medium (25-44%), Medium/High (45-64%), High (65% and above)
Disposal	Availability of engineered landfill/controlled dumpsite	Yes
	% of solid waste safely disposed in landfill	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)

Source: National Solid Waste Management Strategy (2020)

The governance aspect of technical quality covers stakeholder inclusivity, institutional capacity and financial sustainability. The key indicators and benchmarks are summarized in Table 2.10.

Table 2.10: Indicators of performance of governance in solid waste management in MMDAs

Aspect	Indicator	Benchmark
Policy/ Institutional capacity	Availability of municipal solid waste management strategy/plan	Yes
	Implementation of waste solid waste plan or strategy	Yes
	Availability of adequate resources for waste management departments in MMDAs	Adequate
	Availability of gazetted bye-laws on environmental sanitation	Yes
	Effective supervision and monitoring of private waste service providers	Yes
	Activities informal waste collectors/scavengers regulated	Yes
	Compliance of private sector procurement process with the guiding principles of Ghana PPP policy framework	Yes

Source: Adapted from Wilson et al. (2015)

Table 2.11 Cont'd: Indicators of performance of governance in solid waste management in MMDAs

Aspect	Indicator	Benchmark
Stakeholder inclusivity	Consultation of stakeholders	Yes
	Number of meetings held by environmental sanitation sub-committees	Quarterly
	Application of fee fixing resolution determine solid waste collection fees	Yes
	Participation of private sector in sanitation sub-committees meetings	Yes
Financial sustainability	Adequate annual budget for solid waste management in MMDAs	Yes
	Affordability of solid waste management fees to residents of MMDAs	Yes
	% of households using and paying directly for waste collection service	
	% cash collection for door to door solid waste collection services	90%

Source: Adapted from Wilson et al. (2015)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlined and examined the research methods/approach that was adopted for sourcing data or information in order to answer the research questions and achieve the study objectives. This chapter contained the description of the study area, research design, study population, sampling techniques and procedure, and sample frame and size determination. It also included types and sources of data, methods of data collection, data analysis procedures and ethical considerations.

3.2 Study area

The study was conducted in three municipalities and one metropolis located in the Savannah ecological zone of Ghana. The municipalities were, Sagnarigu, Wa, Bolgatanga and the Tamale Metropolis (see Figure 1.5 below). The justification for choosing the Municipalities is that, though the municipalities vary in terms of spatial layout and waste management infrastructure such as waste containers and trucks, the same waste management strategies and programmes are applied in managing solid waste. There was the need to assess how this approach influenced waste management service delivery in these municipalities. Additionally, these municipalities and metropolis were strategically chosen because they are the biggest municipalities in Northern Ghana and have experienced high increasing trend in population, urbanization and economic activities, resulting in overwhelming volume of solid waste. The

four local government areas have a combined population of 729,609 representing 13% of the entire population of Northern Ghana (GSS, 2021).

Tamale Metropolis is the most populous MMDA in Northern Ghana and the fifth (5th) most populous metropolis in Ghana, generating 2100 tons of MSW (Miezah et al., 2015). According to the Ghana St,tistical Service (2021), the Tamale Metropolitan Assembly (TaMA) had a population of 374,744 with 35,408 households and an average household size of 6.3 compared to a regional average of 7.8 and a national average of 4.4. Of the projected population for 2020, 80.8% lived in urban areas, a key segment contributing to solid waste generation.

The Sagnarigu Municipality with a population size of 341,711 inhabitants is the second largest MMDA in northern Ghana. The Tamale Landfill, the only engineered landfill in northern Ghana, is located in the Sagnarigu Municipality. The municipality is home to most of the educational institutions, often referred to as Education Ridge, consisting of Tamale Senior High School, Tamale College of Education, Bagabaga College of Education, Tamale Technical University, University for Development Studies (UDS) Graduate School and Tamale Sports Stadium. Other educational institutions such as the Business College of Education, Northern Business College of Education, School of Hygiene and Islamic Senior High School are all located in the municipality. Most of the well planned areas in the Northern Region such as Kalpohini Estates, SSNIT Flats and Russian Bungalows, are located in the municipality.

Wa Municipality has 19,184 households, which is 17.9% of the total number of households in the Upper West Region. The average household size is 5.4, which is below the regional average of 6.2 and above the national average of 4.4. Of the population aged 11 and over, 65.2% are illiterate. With reference to the 2020 projected population of 132,646 in the Wa Municipality, 88,475, or 66.7% live in urban areas (Ghana Statistical Service, 2020). Bolgatanga Municipality has 26,706 households, which is 15% of the total number of households in the Upper East Region. It has an average household size of 4.9, which is below the regional average of 5.8 but above the national average of 4.4. Out of a population of 128,548, 49.7%, live in urban areas. Of the population aged 11 and over, 64.6% can read and write, 10,110 out of the 26,706 households (37.9%) dispose of their solid waste openly (Ghana Statistical Service, 2014).

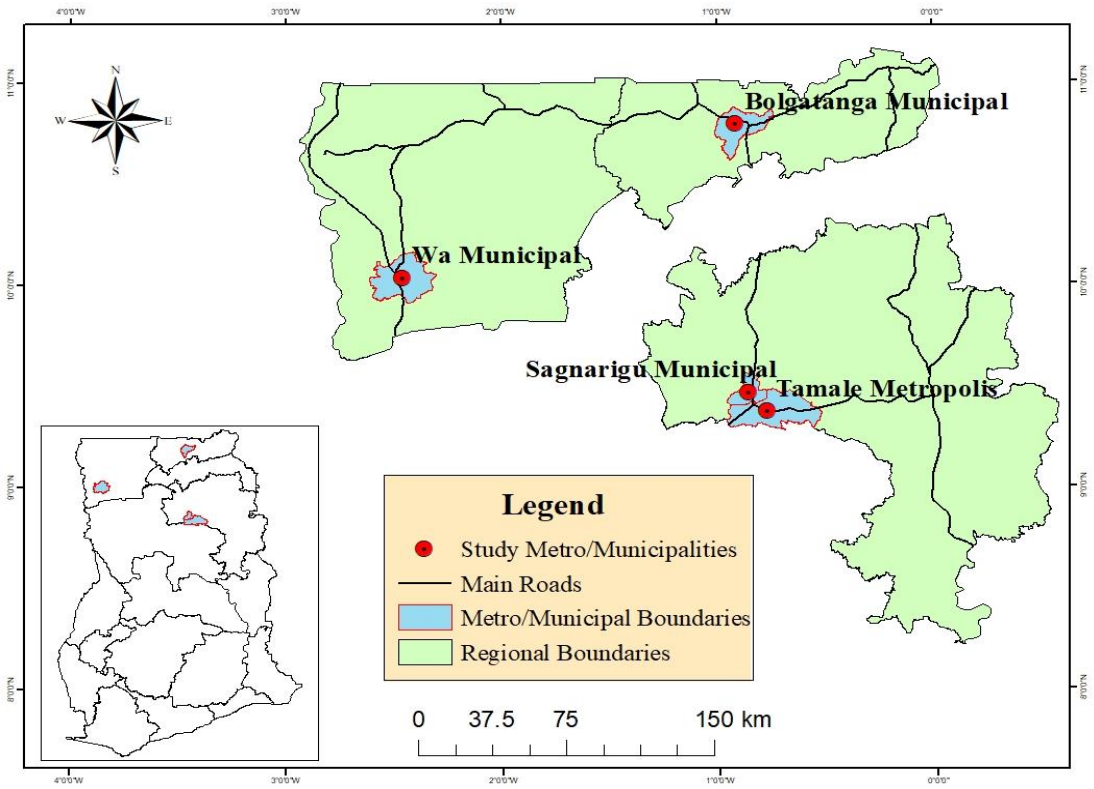

Figure 3.1: Maps of Ghana showing the study municipalities and metropolis

3.3 Philosophical Underpinnings of the Study

The research paradigm for this study was carefully selected since this influences the choice of methodology of a study. Researchers underpin their work on one or more philosophical perspectives (paradigms) depending on their beliefs, experiences, value system and what is being researched on. According to Guba and Lincoln (1994), a research paradigm is a set of beliefs and assumptions that influence a worldview. A paradigm shows a researcher's philosophical orientation that decides ontology (truth), epistemology (knowledge), axiology (value), and methodology (guide). Whether aware or not, researchers start their research journey within some framework of paradigm (Tuli, 2010). A paradigm

determines how a researcher views a phenomenon and how data is collected, analysed and applied (Tuli, 2010; Kivunja & Kuyini, 2017). This research is based on the pragmatist world view. According to Lincoln et al. (2011), researchers with this worldview place value on the practical application of research results and therefore tend to use multiple sources and methods of data collection to achieve the research objectives. The reason for choosing the pragmatist philosophical worldview for this study is that pragmatist paradigm fits this research, and fits the researcher's personal beliefs and research value system. Ontologically, there is a reality out there that solid waste management influences generally waste management service quality and efficiency. Epistemologically, pragmatist believes the best way to solve a problem or acquire knowledge is to approach it from several viewpoints (Descombe, 2010). This study assessed solid waste management system from several perspectives; governance, service quality, customer satisfaction and efficiency of application of waste management resources in the selected municipalities and metropolis. Axioslogically, I value the practical application of knowledge to solve the waste management problems that confront the selected municipalities and metropolis rather than just to understand how the waste management system works. Methodologically, as a pragmatist, the mixed method design was employed to collect and analyse data for the study. Quantitative data collection instruments such as questionnaire and qualitative instruments such as interview guide and focus group discussion (FGD) guide were applied in collecting data. In addition, descriptive analysis such as Data Envelopment Analysis and thematic narratives were used to analyse and interpret the data.

3.4 Research design

The cross-sectional design was adopted for the study because it was cost-effective, fast and allowed for multiple analysis of variables at the same time. As a cross-sectional study, the mixed research method (concurrent triangulation mixed method) was adopted. The purpose of this design was to obtain different but complementary data on the same topic to best resolve the research problem (Creswell & Clark, 2007). According to Terrel (2012), the concurrent mixed design is used for purposes of getting a clearer understanding of the research area and this is achieved by collecting both qualitative and quantitative data concurrently, analysing them separately and merging the two results for interpretation.

3.5 Sources and types of data

Primary and secondary data were collected from relevant sources. Primary data were collected from primary sources using questionnaire, interview and Focused Group Discussions (FGDs). Secondary data was sourced from reports, policies, journal, articles, and books. The types of secondary data collected included quantity of waste hauled, amount of revenue generated, number of waste containers and trucks deployed. Others included distance travelled by trucks, fuel consumption and number of operatives deployed.

3.6 Study population

The study population included all persons that exhibit the characteristics of interest for the study. The target population for the study were heads of households or their representatives, waste management officials, and staff of relevant government agencies and non-governmental organizations. The reason

for targeting these groups of populations was that they could provide the relevant information to address the research objectives. Household heads paid for waste collection services and were capable of providing the right information in terms of their expectations and perceptions of the service.

3.6.1 Determination of sampling frame and sample size

The sample frame for the study was 18847, which represents the number of households in the study communities with waste bins. With a known sample frame, N= 18847, the sample size was determined using the Yamane (1967) formula for sample size determination;

$$n = \frac{N}{[1 + N\,(a)^2]}$$

Where; n = sample size, N = Sample frame (all households in the selected study communities), and α = margin of error estimated at (0.05). Substituting the values into the formula,

$$\text{Sample size (n)} = \frac{18{,}847}{1 + 18{,}847(0.05)^2} = \frac{18{,}847}{18{,}847(0.05)^2}$$

Sample size (n) = **400 households**

This sample size was then allocated proportionally among the study municipalities/metropolis (Table 3.1) $by\ \frac{No.of\ HHs\ for\ MMDA}{Total\ Number\ of\ HHs\ in\ MMDA}$ X100%.

Table 3.1: Allocation of samples among municipalities/metropolis

S/N	City	MMDA status	2021 population	Study communities	HHs with waste bins	HHs surveyed
1	Wa	Municipality	132,646	15	3773	80
2	Bolgatanga	Municipality	128,548	15	4029	85
3	Tamale	Metropolis	281,619	15	7006	149
4	Sagnarigu	Municipality	186,796	15	4029	86
	Total		**729,609**	**60**	**18,847**	**400**

3.7 Sampling techniques and procedures

A multi-stage sampling technique was employed to select communities and household heads. This technique was used because it was difficult and resource consuming to sample from all the households. In the first stage, four municipalities and Metropolitan with the highest population in the savannah ecological zone of Ghana, according to the 2021 population and housing census, were purposively selected. In the second stage, the four municipalities and metropolis were each clustered into high-income communities (single unit/full-detached housing structures), middle-income communities (semi-detached housing units) and low-income communities (compound housing units) based on an already stratified settlements plan designated by the city authorities and this resulted in 12 residential classes. Simple random sampling was used at the third stage to select communities from each of the clustered residential classes. In all, 60 communities, that is five each were selected from each of the 12

residential class within the four study areas. In selecting the communities, the Excel's RAND function was used to generate random numbers for each of the community. The total number of households for each sampled community was obtained from the Ghana Statistical Service regional offices. This was to ensure that the total household populations in the various sampled communities were accurate. The lists of the communities were then sorted in an increasing order of their corresponding random numbers till the required number of communities within each residential class was reached. This was to remove researcher biasedness.

The final stage of the multistage sampling was used to select households within the sampled communities. Systematic random sampling was used to select households for the study. A sampling interval (a fixed periodic interval) was first determined by dividing the number of households in each community by the number of samples apportioned to that community to obtain the number of households to be administered questionnaire. Then convenient sampling technique was used to select houses with waste collection bins and household heads or representatives that were available and willing responded to the questionnaire.

3.8 Data collection tools and techniques

Data for the study were collected from primary and secondary data sources. Quantitative data were collected through observations, Geographic Positioning System (GPS) and questionnaires. Qualitative data were collected through interviews and Focus Group Discussions (FGDs). Respondents for qualitative

study were purposively selected based on their in-depth knowledge and experience in waste management policy, planning and operations.

3.8.1 Questionnaire

Questionnaires are most appropriate for the collection of statistically quantifiable information from many respondents within a short period of time (Twumasi, 2001). Considering the limited time frame for the study, questionnaires were used to collect responses from heads of households covering socio-demographic characteristics, expectations and also, the perceptions of respondents with regards to waste management service quality in their communities.

3.8.2 Interview

Interviews are the most appropriate tools to use when a researcher wants to gain better understanding of respondents' perceptions, values, feelings and opinions of issues being studied (Denscombe, 2010). Therefore, semi-structured interviews were used to solicit responses from key informants on issues of waste governance structure (institutional and policy arrangement), and compliance of PPPs with the guiding principles of Ghana's PPP policy.

3.8.3 Focused Group Discussion (FGD)

Focus Group Discussions were used to gather views, opinions, feelings and perceptions on solid waste governance, especially on existing solid waste Public-Private Partnership agreements, the challenges and solutions for solid waste management problems in the study areas.

3.8.4 Observation

Observations were employed to appreciate the state of waste management service delivery, facilities and equipment in the study areas. In the process, pictures of the state of some waste management facilities were captured.

3.9 Data collection procedures and analysis

Data collection procedures and analysis are described and arranged according to the research objectives as follows:

3.9.1 Assessing the solid waste management service quality

The Servqual questionnaire was used to collect data to address the problem of waste management service quality in household collection system. *Two (2) attributes under* ***Assurance Dimension*** *were modified as follows, "waste collectors empty waste bins without damaging assets of customers, waste management companies deliver service without noise and bad odours''. one attribute under Tangibility was added, "companies deliver service with visually appealing trucks and waste bins, giving 23-item scale.*

Thus with these additional attributes, a 23-item questionnaire was developed to reflect important issues of waste management services. The modified questionnaire was then administered to the sampled 400 heads of households/their representatives. As recommended by Verma and Sachdev (2004), a five-point Likert scale was adopted and thus the study respondents scored each service attribute on a scale of 1-5; '1' indicating strongly dissatisfied, and '5' indicating strongly satisfied.

In applying the SERVQUAL model, the gap pertaining to each service quality dimension was obtained by deducting the expected score from the perceived

(experienced) score. The SERVQUAL scores for the five dimensions were averaged to derive an entire measure of perceived service quality. The following steps were used to determine service gaps:

i. The average score for each service attribute of perception and expectation was determined by the equation (1): mean score = $\bar{X}_{score} = \frac{\sum_{i=1}^{n_j} X_{ij}}{n_j}$, ..(1)

ii. The standard deviation for each service dimension was determined by the equation (2)

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n_j}(X_{ij}-\bar{X}_j)^2}{n_i-1}}, \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where n_i is the number of attributes in the i^{th} dimension.

iii. The service gap (SG) for an attribute was determined by the equation (3):

$\mathbf{SG_i = P_i - E_i}$,, ...……(3)

where SG_i is the service gap for the ith attribute, P_i is the perceived quality for ith attribute and E_i, is the expected quality for the ith attribute.

iv. The Service quality for the ith dimension was computed by t**he** equation:

$$SQ_j = \frac{\sum_{i-1}^{n_j}(P_{ij}-E_{ij})}{n_j}, \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where SQ_j is the service quality of dimension j, P_{ij} is perceived quality of ith attribute in dimension j, Eij is the expected quality of the ith attribute in dimension j and n_j is the number of attributes in dimension j. Also, respondents rated the relative importance of the service dimensions and indicated their overall satisfaction with the solid waste management service.

Data analysis was done through gap analysis; where the mean perceived service scores by customers were deducted from the mean expected service scores to determine gap scores for each dimension. The gap scores were presented as cross-tabulation according to the operational areas (MMDAs); and the statistical difference of association between respondents' perception and expectations was determined using the paired correlation analysis at 95% confidence level. The results were interpreted as;

If the mean score < 0, then perceived service is less than expected service (negative gap). If mean score > 0, then perceived service is greater than expected (positive gap). If mean score = 0, then perceived service is the same as expected (customers are satisfied).

3.9.2.1 Technical quality

Technical quality indicators and procedure used to collect data are detailed in Table 3.2.

Table 3.2: Indicators and methodology for assessing technical/physical quality of solid waste management service

Aspect of physical quality	Indicator	Methodology	Standard/Benchmark
Collection	% of solid waste collected	Information on quantity of solid waste collected (tons) obtained from MMDAs and Waste Management Companies and expressed in % of total generation in tons	Low (0-49%), Low/Medium (50-60%), Medium (70-89%), Medium/High (90-98%) High (99-100%)
	% of urban households that have access to door to door collection	Number of urban households that have access to door-to-door waste collection was obtained from Waste Management Companies expressed in % of total number of urban households in MMDA	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)
	% of household using standard waste bin	Number of households that use standard waste bin were obtained from Waste Management Companies and expressed in % of the total number of households in MMDA	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)
	Number of management workers per population	Number of workers in waste management department and waste management companies were obtained and expressed in % of the total population in MMDA	

Source: Wilson et al. (2015); Wilson et al. (2013)

Table 3.2 Cont'd: Indicators and methodology for assessing technical/physical quality of solid waste management service

Transport	% of enclosed collection vehicles in use	Information on number of waste collection vehicles that are covered were obtained and express in % of total number of waste collection vehicles	100%
	Availability of Transfer stations	Information on availability of waste transfer station in MMDA was obtained	Yes
	% of waste transported to landfill/controlled dumpsite	Quantity of waste (tons) disposed in landfill/ controlled dumpsite was obtained from Waste Landfill Company Limited and expressed in % of total waste collected in MMDA	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)
Treatment	Availability of functional waste processing facility		Yes
	% of waste recycled/ recovered/ treated	Quantity of recovered waste obtained from informal scrap and plastic waste dealers and expressed in % of total generation	
Disposal	Availability of engineered landfill		Yes (engineered landfill available)
	% of solid waste safely disposed in landfill/ official disposal site	Quantity of waste (tons) disposed in landfill/ controlled dumpsite was obtained from Waste Landfill Company Limited and expressed in % of total waste collected in MMDA	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)

Source: Wilson et al. (2015); Wilson et al. (2013)

3.9.2 Assessing the efficiency of solid waste management service delivery

Purposive sampling techniques were used to select key informants for questionnaire administration and for interviews. In addition to that, a review of secondary data including annual/monthly waste management reports were undertaken to extract data for 2018 and 2019 operational years from waste management companies. Though an extended years of assessment would be appropriate for determining trends of efficiency waste collection, study was limited by resources. Also, private collection prior to 2018 was not well organised, resulting in difficulty in obtaining reliable data. Researcher therefore used 2018 and 2019 as the base years to establish a foundation for future trend analysis of efficiency of collection in the selected municipalities.

The key Performance Indicators; quantity of waste hauled and revenue generated were selected considering data availability and applicability. Using Microsoft Excel Solver Version 2013, the input- oriented Charnes, Cooper and Rhodes (CCR) model under Constant Returns to Scale (CRS) was applied for DEA analysis of relative efficiencies. This model was chosen because the Decision-Making Units (DMUs) did not operate in perfect competition and there was more control over inputs by waste companies.

With *relative efficiency ratios as* model outputs, the following variables were set as inputs data; Value of total assets *(U_1)*, number of trucks *(U_2)*, number of collection containers *(U_3)*, number of clients *(U_4)*, and number of personnel deployed *(U_5)*. The quantity of waste hauled *(V_1)* and amount of revenue generated *(V_2)* were set as the output factors for the four DMUs; Wa

Municipality, Bolgatanga Municipality, Tamale Metropolis, and Sagnarigu Municipality.

The following models were used for efficiency assessment of the 2018 and 2019 operational years:

DEA CCR model for a given DMU in 2018 was formulated as follows:

Target DMU (Max θ) $= v_1 y_{1o} + v_2 y_{2o} + \cdots + v_r y_{ro}$

s.t. $u_1 x_{1o} + u_2 x_{2o} + \cdots + u_m x_{mo} = 1$

$v_1 y_{1i} + v_2 y_{2i} + \cdots + v_r y_{ri} \leq u_1 x_{1i} + u_2 x_{2i} + \cdots + u_m x_{mi}$, $\quad i = 1, \ldots, n$

$u_1, u_2, \ldots., u_m \quad \geq 0$

$v_1, v_2, \ldots., u_r \quad \geq 0.$

y_r= amount of output r

v_r= weight assigned to output r

x_i= amount of input i

u_i= weight assigned to input i

The linear programming formulated out of the data:

Max: Tamale = $51045v_1 + 3922v_2$;

Subject to: $1358u_1 + 9u_2 + 5962 + 5789u_4 + 79u_5 = 1$;

$51045v_1 + 3922v_2 - (1358u_1 + 9u_2 + 5962 + 5789u_4 + 79u_5) \leq 0$;

$26870_1 + 1459v_2 - (1864u_1 + 5u_2 + 3165u_3 + 1413u_4 + 76u_5) \leq 0$

$26640v_1 + 846v_2 - (1245u_1 + 3u_2 + 3525u_3 + 1313u_4 + 71u_5) \leq 0$;

$13208v_1 + 1289v_2 - (298u_1 + 3u_2 + 1893u_3 + 1751u_4 + 55u_5) \leq 0$;

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Max: Wa = $26870_1 + 1459v_2$;

Subject to: $1864u_1 + 5u_2 + 3165u_3 + 1413u_4 + 76u_5 = 1$;

$51045v_1 + 3922v_2 - (1358u_1 + 9u_2 + 5962 + 5789u_4 + 79u_5) \leq 0;$

$26870_1 + 1459v_2 - (1864u_1 + 5u_2 + 3165u_3 + 1413u_4 + 76u_5) \leq 0$

$26640v_1 + 846v_2 - (1245u_1 + 3u_2 + 3525u_3 + 1313u_4 + 71u_5) \leq 0;$

$13208v_1 + 1289v_2 - (298u_1 + 3u_2 + 1893u_3 + 1751u_4 + 55u_5) \leq 0;$

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Max: Bolgatanga = $26640v_1 + 846v_2;$

Subject to: $1245u_1 + 3u_2 + 3525u_3 + 1313u_4 + 71u_5 = 1;$

$51045v_1 + 3922v_2 - (1358u_1 + 9u_2 + 5962 + 5789u_4 + 79u_5) \leq 0;$

$26870_1 + 1459v_2 - (1864u_1 + 5u_2 + 3165u_3 + 1413u_4 + 76u_5) \leq 0$

$26640v_1 + 846v_2 - (1245u_1 + 3u_2 + 3525u_3 + 1313u_4 + 71u_5) \leq 0;$

$13208v_1 + 1289v_2 - (298u_1 + 3u_2 + 1893u_3 + 1751u_4 + 55u_5) \leq 0;$

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Max: Sagnarigu = $13208v_1 + 1289v_2;$

Subject to: $298u_1 + 3u_2 + 1893u_3 + 1751u_4 + 55u_5 = 1;$

$51045v_1 + 3922v_2 - (1358u_1 + 9u_2 + 5962 + 5789u_4 + 79u_5) \leq 0;$

$26870_1 + 1459v_2 - (1864u_1 + 5u_2 + 3165u_3 + 1413u_4 + 76u_5) \leq 0$

$26640v_1 + 846v_2 - (1245u_1 + 3u_2 + 3525u_3 + 1313u_4 + 71u_5) \leq 0;$

$13208v_1 + 1289v_2 - (298u_1 + 3u_2 + 1893u_3 + 1751u_4 + 55u_5) \leq 0;$

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Similar DEA CCR models for given DMUs were formulated for operational years 2019 (see Appendix X)

3.9.3 Examining the governance structure of solid waste management system

Using the Wasteaware Indicator Framework as a guide, data on governance were collected through questionnaire administration to 68 purposively selected respondents. The respondents were selected from the following departments/units/committees as detailed in Table 3.3.

Table 3.3: Departments/units/committees and number of participants selected to respond to questionnaire

Department/unit/ Committee	Number of respondents	Designations	Remarks
Waste Management Companies	8	Regional Managers, Operation Managers	2 participants each from 4 companies
Waste Management Department (WMD)	2	Director of Waste Management and Solid Waste Officer	2 participants from Tamale Metropolis
Environmental Protection Agency (EPA)	4	Regional Directors/Scheduled officer	1 participant each from 4 municipalities
Municipal Environmental Health Unit (MEHU)	8	Municipal Environmental Health Officer, officers in charge of solid waste	2 participants each from 4 municipalities
Environment and Social Services Committee	8	Chairman of committee, deputy or any other member	2 participants each from 4 municipalities
Local Municipal Assembly	16	Assembly members	4 participants each from 4 municipalities
Regional Environmental Health Unit	4	Regional Environmental Health Officers (REHOs)	1 participant each from 4 municipalities
Informal waste collectors	8	Operators of plastic buy-back centres	Buyers and pickers
Sachet water producers associations	4	Municipal chairmen of associations	1 participant each from 4 municipalities
Traditional Authorities	8	Major chiefs and queen mothers	2 participants in each from 4 municipalities
Total	**70**		

The departments and number of respondents selected for the study was informed by the following; direct involvement in waste management, and deep expertise and knowledge on issues of solid waste governance. The key areas of governance and the number of indicators used were stakeholder inclusivity (12 indicators), financial viability and sustainability (4 indicators), national policy and institutional adequacy (8 indicators), and local institutional adequacy (11 indicators). In all a total of 35 indicators were considered. Descriptive statistics were used to present the data. Association between viewpoints were analysed by the use of the Spearman correlation coefficient (Rho) at a 95% confidence interval. Independent t-test analysis was used to establish equality of means of governance indicators being adequate or inadequate among respondents. Levene statistic was used to test the homogeneity of variances for indicator measures of PPP principles. For the study 'municipalities', which are four, analysis of variance (ANOVA0 was used to establish the difference of PPP principles.

In addition, qualitative data was collected through in-depth interviews with 14 purposively selected participants from waste collection companies, waste management departments (WMDs), environmental health units, Environmental Protection Agency (EPA), and Local Assembly Members (Table 3.4).

Table 3.4: List of departments/units/committee and key informants selected

Department/unit/Committee	key informants	Designations
Waste Management Companies	3	Regional Managers, Operation Managers
Waste Management Department (WMD)	1	Director of Waste Management and Solid Waste Officer
Environmental Protection Agency (EPA)	1	Regional Directors/Scheduled officer
Municipal Environmental Health Unit (MEHU)	3	Municipal Environmental Health Officer, officers in charge of solid waste
Environment and Social Services Committee	2	Chairman of committee, deputy or any other member
Local Municipal Assembly	2	Assembly members
Regional Environmental Health Unit	2	Regional Environmental Health Officers (REHOs)
Total	**14**	

The interviews were audio-recorded and transcribed. The transcripts were validated against the audio files and imported to NVivo 11.0 software for analysis. Through the processes of induction and deduction, content analysis was done. The transcripts were thoroughly read to determine the patterns of views of participants. A follow-up process to classify views into sub-themes was undertaken. Through inductive analysis, sub-themes were merged into main themes. The results were presented as narratives supported by quotes from participants.

Performance in relation to governance was assessed based on compliance to the guiding principles of the PPP policy framework of Ghana. Data on compliance

to PPP principles was rated on a scale of 1 (very low) to 10 (very high). Nine key principles were assessed and they included value for money, accountability, competitiveness, broader stakeholder participation, service affordability, clear objectives and targets for agreements, clear roles and responsibilities for partners, length of the agreement, and general performance on service delivery.

3.9.4 Assessing the spatial distribution of waste collection points

To address this objective, in-depth interviews, observations and global positioning system (GPS) were used for data collection. Key informant interviews with 13 purposively selected participants from relevant agencies/departments/units (Waste management department-1; Environmental health unit-4; Waste management companies-4; Local assembly subcommittees-4) were conducted to collect qualitative data. Interviews were audio-recorded and transcribed. The transcripts were validated against the audio files and imported to NVivo 11.0 software for analysis.

Transcripts were thoroughly read to determine patterns of views of participants. A follow up process to classify views into sub-themes was undertaken. Through inductive analysis, sub-themes were merged into main themes. The results were presented as narratives supported by quotes from participants

GPS coordinates of household waste bins, communal containers and disposal sites were taken with a mobile GPS device (Garmin 64s). Data was then imported to ArcGIS and the Nearest Neighbour Index (NNI) tool of the software was used to analyse the distribution pattern of waste bins in the study areas. NNI of 0 meant exclusively clustered distribution (where there was no travel distance

to collection containers). NNI of 1, represented an absolute random distribution of containers (least travel distance) and NNI of above 1, implied propensity to disperse. The analysis on the distribution of waste bins for the study areas was guided by the null and alternative hypotheses:

H_o: There is no random distribution of communal containers in the study areas

H_1: There is random distribution of communal containers in the study areas

The quality of communal container collection was assessed by observing and collecting information on the number of overflows from containers over a two-month period to determine averages. Observation was done by existing Container Site Attendants for communal containers in January-February for the dry season and June-July for the wet season within the hours 5pm to 6pm, after close of work. This was done to find out if there were variations in the quality of services for the wet and dry seasons. During the observation, pictures of overflowing containers and indiscriminate dumpsites were taken. Seasons (wet and dry) were taken into consideration in the analysis.

3.9.5 Examining the challenges of municipal solid waste management

To examine the problems of solid waste management and the possible solutions for them, four Focus Group Discussions consisting of nine members each from the following categories of workers; Environmental Health Officers and staff of waste management companies were organized. A focus group discussion guide was used to guide the discussion.

3.10 Data analysis

Statistical Package for Social Science (SPSS) version 20 was used to analyse quantitative data. The SPSS software aided to determine descriptive statistics such as frequencies, percentages, standard deviations, variance and arithmetic mean to analyse data. Relative importance and associations between variables that affect customer satisfaction were determined by Spearman's rank-order correlation analysis. Significance of associations between variables were established by Pearson Chi-square analysis. Resource efficiency of DMUs were analysed by relative efficiency ratios. Results generated were presented in tables, frequencies, and percentages. Thematic description of qualitative data from interviews was carried out to support quantitative data. In the qualitative analysis phase, the researcher initially crafted a coding template sheet grounded in the interview questions. This entailed identifying key issues as variables from the interview guide, recording specific responses, and organizing them into broad and sub-themes aligned with the research inquiries. The researcher then encapsulated these themes in quotations to reflect the perspectives of the interviewees or focus group discussion participants. Subsequently, the researcher described and elucidated upon these themes, employing a narrative approach. Consequently, the qualitative analysis in this study assumed a narrative structure to complement and elaborate on the quantitative findings, evaluating their alignment or deviation from previous studies discussed in the literature.

3.11 Quality controls for data reliability and validity

Research assistants were trained on the protocols and procedures for field data collection. All data collection tools were pre-tested before use. The purpose of the pre-test was to assess the validity of the questions and instructions, the reliability, appropriateness and completeness of the questions, and the respondents' understanding of the questions. The principal investigator directly supervised the data collection. The data was checked for correctness, completeness and consistency of the answers in order to rule out errors. Each day's work was reviewed to identify and resolve challenges and provide feedback for subsequent days until data collection was complete. The Cronbach Coefficient Alpha was used determine the reliability and validity of the quantitative data on service quality

3.12 Ethical considerations

Respondents' consent was obtained after the intention, procedure, expected risks and benefits of the study were explained to them. In addition, confidentiality and anonymity and the right to withdraw at any stage of the study were stated in the consent process. Permission from Waste Management Departments (WMDs) and Environmental Health Units (EHUs) was obtained from the MMDAs and other waste management service providers involved before their data was collected and used. The study duly recognized and referenced all contributors and researchers whose information was used.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the analysis of field data and discusses the results obtained from respondents on performance assessment of municipal solid waste management system. The chapter discusses the results of the objectives of the research, which include: assessing solid waste management service quality, assessing solid waste service delivery efficiency, examining the governance structure of solid waste management system, analysing the geospatial distribution of solid waste collection containers and finally examining the challenges of solid waste management systems.

4.2 Assess solid waste management service quality

This section answers research question one and objective one of the study, which is to examine service quality in the selected municipalities. To achieve the objective, the gap score analysis, which measures customers' perceptions on services provided were examined. This was followed with the analysis of the expectations of customers with respect to services envisaged from private companies. These two variables were then used to compute the gap between perception and expectation. The analysis is approached from the customer perspective since they are at the receiving end of service provision and can provide a proper perspective on the performance of the companies.

4.2.1 Customer perceptions

Table 4.2 presents customers' perception of all the five service quality dimensions. The service quality dimensions covered were reliability,

responsiveness, assurance, empathy and tangibility. In the area of reliability, it was observed that even though the mean and standard deviation results varied across all municipalities and metropolis, the total reliability of waste collection services in the four operational areas was rated by customers as sufficient (Mean value = 4.32, SD = 0.82). In terms of responsiveness, the findings showed that across all operational municipalities and metropolis, customers' perceptions of providers' service quality were considerably good (Mean = 3.63; SD. = 0.65). It was nonetheless, low in comparison to their reliability score (Mean = 4.32, SD = 0.82).

Customers' perception of service providers' assurance remained good (Mean = 3.80; SD. = 0.53) throughout all operational municipalities, and metropolis. There were however, variations in customer perception across all municipalities and metropolis - Sagnarigu (Mean = 3.80, SD. = 0.69); Wa (Mean = 3.77, SD. = 0.53); Tamale (Mean = 3.55, SD=0.75) and Bolgatanga (Mean =3.48, SD = 0.60). Empathy dimension of waste management service delivery was also probed. The results indicated that regardless of the variations, customers' perception on companies' empathy were positive (Mean = 4.21, SD. = 0.89). Finally, in terms of tangibility, clients in the four operational municipalities and metropolis rated the tangibles provided by waste management companies as good (Mean = 4.56, SD = 0.59) regardless of the variations among individual municipalities and metropolis (Tables 4.2).

Table 4.2: Perception of waste management service quality among customers in four municipalities/metropolis in Ghana

Specific items/Service dimension	Sagnarigu Municipality (n = 87)		Tamale Metropolis (n = 146)		Bolgatanga Municipality (n = 83)		Wa Municipality (n =78)		Total (N = 394)	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Reliability										
Company provides service as promised	3.29	1.532	3.43	1.237	3.59	1.048	3.76	1.009	3.50	1.23
Company is dependable in handling customers' service	3.14	1.047	3.34	.928	3.47	.967	3.79	.858	3.41	.972
Company provides service right at first time	4.28	.996	3.68	1.022	3.93	1.057	3.71	.968	3.87	1.037
Company provides service as the promise time	3.36	1.294	3.27	2.104	3.49	1.052	3.45	1.089	3.37	2.135
Company maintains error free records	3.54	.643	3.18	.794	3.63	.893	3.22	.989	3.36	.848
Total	**3.7663**	**.85077**	**3.6507**	**.71394**	**3.8514**	**.63278**	**3.8205**	**.63834**	**4.3162**	**.81797**
Responsiveness										
Company keeps customers informed on when their services will be performed	3.18	1.581	2.69	1.257	3.23	1.233	2.62	2.16	2.90	2.34
Company delivers prompt services to customers	2.86	1.212	3.11	.955	3.28	1.086	3.24	.942	3.12	1.049
Company is willing to help customers	2.71	1.293	3.08	1.218	3.45	.978	3.71	.808	3.20	2.167
Company is always ready to respond to customers request	3.44	2.361	3.30	1.013	3.28	1.203	3.62	.825	3.39	2.112
Total	**3.2391**	**1.00410**	**3.2370**	**.75713**	**3.4458**	**.78481**	**3.4359**	**.54582**	**3.6278**	**.67729**

Source: Field Survey, 2021

Table 4.2 Cont'd: Perception of waste management service quality among customers in four municipalities/metropolis in Ghana

Specific items/Service dimension	Sagnarigu Municipality (n = 87)		Tamale Metropolis (n = 146)		Bolgatanga Municipality (n = 83)		Wa Municipality (n =78)		Total (N = 394)	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Assurance										
Employees instil confidence in customers	3.61	.881	3.41	1.015	3.27	.964	3.63	.854	3.47	.952
Company makes customers feel safe in their transactions	3.80	.926	3.43	1.037	3.28	1.004	3.82	.936	3.56	1.008
Employees of the company are consistently courteous	3.80	.900	3.42	1.016	3.37	.851	3.71	.758	3.55	.924
Employees are knowledgeable to answer customers questions	3.80	.887	3.49	.970	3.51	.817	3.72	.737	3.61	.885
Total	**3.8046**	**.69079**	**3.5507**	**.75111**	**3.4843**	**.59602**	**3.7744**	**.53487**	**3.8011**	**.53355**
Empathy										
Employees gives customers individual attention	2.67	.858	3.16	2.131	3.23	.888	3.82	.849	3.20	1.039
Employees of company deals with customers in a caring manner	2.69	.880	3.37	.961	3.52	.771	3.76	.825	3.33	.950
Company has interest of customers at heart	2.71	.901	3.38	1.026	3.31	.679	3.72	.804	3.29	.950
Employees understand the needs of their customers	2.62	.825	3.42	2.107	3.20	.793	3.86	.801	3.29	1.015
Company provide service at convenient business hour	2.93	.900	3.49	.991	3.06	.915	3.59	.904	3.29	.973
Total	**3.1034**	**.63197**	**3.6370**	**.77994**	**3.5542**	**.51080**	**3.9573**	**.57575**	**4.2137**	**.88899**

Source: Field Survey, 2021

Table 4.2 Cont'd: Perception of waste management service quality among customers in four municipalities/metropolis in Ghana

Specific items/Service dimension	Sagnarigu Municipality (n = 87)		Tamale Metropolis (n = 146)		Bolgatanga Municipality (n = 83)		Wa Municipality (n =78)		Total (N = 394)	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Tangibles										
Company uses modern equipment to deliver services	4.37	.794	4.48	.613	3.57	.952	3.76	.759	4.12	.855
Company uses visually appealing facilities to deliver services	4.44	.773	4.38	.600	3.64	.820	3.71	.870	4.10	.826
Employees of company are neat and professional during service delivery	4.22	.993	4.34	.790	3.41	.797	3.73	1.089	3.99	.976
Company successfully delivers services without damaging asset of clients	4.47	.587	4.34	.677	3.55	1.027	3.97	2.173	4.13	.922
There is no unnecessary noise, odour and emission from trucks during service delivery	4.36	.821	4.20	.987	3.40	.855	3.09	2.186	3.85	1.093
Total	**4.4751**	**.50420**	**4.4543**	**.44744**	**3.7610**	**.60441**	**3.8761**	**.52391**	**4.5607**	**.59784**

Source: Field survey, 2021

4.2.2 Customer expectations about waste management service quality

The assessment of expectation alongside perception is vital to assess the service gap. Table 4.3 provides detail results of customers' expectation on services to be provided by private waste management companies. Across all operational municipalities and metropolis, customers had high expectations in the area of reliability of service (Mean = 4.58, SD = 0.45). Even though the extent of customer expectation was high, it varied across all the four operational areas. On responsiveness, the result showed that customers have high expectations of service providers to be responsive (Mean = 4.10, SD = 0.34). For instance, they expected providers to keep customers informed about when services would be delivered (Mean = 4.07, SD. = 0.81), to be prompt (Mean = 4.26, SD. = 0.76), to assist customers with their requests (Mean = 4.29, SD. = 0.76), and to be ready to respond to customer needs at all times (Mean = 4.29, 0.69).

Respondents across all operational municipalities and metropolis expressed very high expectations of assurances from waste management service providers (Mean = 4.04, SD = 023); and on the empathy dimension, the results showed that respondents across all four operating areas had high expectations (Mean = 4.69, S.D. = 0. 36). The sum of the various service quality dimensions expected revealed that while customers had very high expectations of all service quality dimensions, tangibility was the topmost priority they expected much from providers (Mean = 4.69), followed by reliability (Mean = 4.58), empathy (Mean = 4.45), responsiveness (Mean = 4.10), and assurance (Mean = 4.04) respectively. Table 4.3 provides detailed analysis of customer expectation about waste management service quality.

Table 4.3: Customers' expectation of waste management service quality in northern Ghana

Specific items/Service area	Sagnarigu Municipality (n = 87)		Tamale Metro (n = 146)		Bolgatanga Municipality (n = 83)		Wa Municipality (n =78)		Total (N = 394)	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Reliability								.		
Company should provide services as promise	4.1379	0.61327	4.2260	0.54798	4.0361	0.52836	4.2179	52589	4.1650	0.5578
Company should be dependable in handling customers' service performed	3.9770	.83495	3.7397	.66493	4.0723	.57981	4.0513	.48073	3.9239	.67246
Company should provide service right the first time	4.1954	.60692	4.0479	.61400	4.0241	.58385	4.1667	.52016	4.0990	.59072
Company should provide services at the promise time	3.9195	.57503	4.0068	.61584	4.1325	.55811	4.1795	.47656	4.0482	.57533
Company should maintain error-free records	4.1954	.69615	4.1164	.60470	4.2169	.56414	4.2949	.58352	4.1904	.61517
Total	**4.2375**	**.42350**	**4.1895**	**.31235**	**4.2470**	**.28675**	**4.3184**	**.24053**	**4.5823**	**.44955**
Responsiveness										
Company should inform customers on when services will be delivered	4.1954	.84687	3.9178	.80949	4.3133	.76394	3.9744	.78912	4.0736	.81784
Company should will deliver prompt services to customers	4.0575	.88075	4.1370	.73934	4.4337	.75212	4.5385	.52699	4.2614	.76180
Company should be willing to help customers on their requests	4.1379	.80943	4.2397	.71732	4.3494	.77197	4.5256	.71577	4.2970	.75876
Company should always be ready to respond to customers' requests	4.2874	.60824	4.2397	.72687	4.1928	.77236	4.5256	.59706	4.2970	.69578
Total	**4.1356**	**.49696**	**4.1068**	**.41831**	**4.2578**	**.50705**	**4.3128**	**.31016**	**4.1018**	**.34218**

Source: Field survey, 2021

Table 4.3 Cont'd: Customers' expectation of waste management service quality in northern Ghana

Specific items/Service area	Sagnarigu Municipality (n = 87)		Tamale Metro (n = 146)		Bolgatanga Municipality (n = 83)		Wa Municipality (n =78)		Total (N = 394)	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Assurance										
Employees should instil confidence in the customers who patronize services	4.1379	.50973	4.3493	.61692	4.4940	.59209	4.5000	.57547	4.3629	.59493
Company should make customers feel safe in their transaction	3.8966	.40447	4.2603	.51266	4.1205	.39502	4.4487	.50058	4.1878	.49962
Employees should be consistently courteous to customers on their service demand	3.8276	.43687	4.0548	.48110	4.0000	.38255	4.1410	.38560	4.0102	.44539
Employees should be knowledgeable to answer customer questions	3.4713	.54643	3.8425	.75830	3.8434	.42718	4.1923	.55963	3.8299	.65694
Total	**3.8667**	**.22343**	**4.1014**	**.34220**	**4.0916**	**.21931**	**4.2564**	**.29347**	**4.0428**	**.23426**
Empathy										
Employees should give customers individual attention	3.0115	.70701	3.5137	.81568	3.7108	.53030	4.0000	.58109	3.5406	.76808
Employees of company should deal with customers in a caring manner	3.8506	.44536	3.9178	.58140	3.9880	.45516	4.0128	.54638	3.9365	.52280
Company should have the customer's best interest at heart	3.7356	.51624	3.8699	.64609	3.6867	.49208	4.1026	.41372	3.8477	.56366
Employees should understand the needs of their customers	3.4253	.49725	3.9384	.70684	3.7831	.41462	4.2308	.60136	3.8503	.64631
Company should provide service at convenient business hour	3.4368	.58471	3.8288	.73681	3.7108	.45613	4.0385	.65351	3.7589	.66557
Total	**3.7433**	**.28280**	**4.0114**	**.46389**	**3.9799**	**.19373**	**4.2308**	**.29818**	**4.4460**	**.57807**

Source: Field survey, 2021

Table 4.3 Cont'd: Customers' expectation of waste management service quality in northern Ghana

Specific items/Service area	Sagnarigu Municipality (n = 87)		Tamale Metro (n = 146)		Bolgatanga Municipality (n = 83)		Wa Municipality (n =78)		Total (N = 394)	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Tangibles										
Company should use modern equipment to deliver service	4.4943	.60758	4.5753	.52306	4.1446	.47196	3.9487	.50703	4.3426	.58554
Company should use visually appealing facilities and materials to deliver service	4.6207	.51130	4.5411	.51363	4.0602	.50242	4.0385	.52080	4.3579	.57191
Employees of company should be neat and professional during service delivery	4.4943	.50287	4.5479	.49941	4.0723	.37557	4.3590	.50899	4.3985	.51055
Company should successfully deliver services without damaging assets of clients	4.5287	.50207	4.4110	.54673	4.1566	.39761	4.4231	.52271	4.3858	.51778
Company should deliver service without unnecessary noise, emissions, odour from trucks	4.4713	.62578	4.4315	.56211	3.9277	.34156	3.8590	.55184	4.2208	.60066
Total	**4.6015**	**.31475**	**4.5845**	**.30840**	**4.2269**	**.17573**	**4.2714**	**.23124**	**4.6991**	**.36165**

Source: Field survey, 2021

4.2.3 Overall Customer GAP score

The overall SERVQUAL gap for all service dimensions was -0.31 (Table 4.4), which showed that customers of waste management companies were not satisfied with the quality of service they received. The study discovered significant relationship (R = 1.00, p-value = 0.000) between customers' perceptions and expectations. (Table 4.4). In terms of the individual SERVQUAL dimensions; reliability, responsiveness, assurance, empathy, and tangibility, customers were less unsatisfied with the kind of services provided by service providers (GAP Means = -0.26; -0.47; -0.24; -0.23; & -0.13) with a p-value = 0.000. Sagnarigu Municipality had a score of -0.51, Tamale -0.56, Bolgatanga -0.62, and Wa -0.57 all indicating poor service quality. Though the level of customer dissatisfaction was above 0.50 (50%) for all the municipalities, the lowest dissatisfaction was recorded in Sagnarigu Municipality (-0.51) and the highest dissatisfaction recorded in Bolgatanga (-0.62). Table 4.4 provides detailed results of the gap scores. The highest gaps were recorded in Responsiveness (0.47) and Reliability (0.27). The implications of this is that, for service quality and customer satisfaction to improve, private waste management companies should focus on addressing all issues that directly contribute to prompt and reliable service delivery.

Table 4.4: Customer GAP score analysis on service providers service quality

GAP Analysis	Sagnarigu Municipality	Tamale Metro	Bolgatanga Municipality	Wa Municipality	Total GAP	Paired Correlation	
	Mean	Mean	Mean	Mean	Mean	Coefficient	P-value
Perceived reliability	3.7663	3.6507	3.8514	3.8205	4.3162		
Expected reliability	4.2375	4.1895	4.2470	4.3184	4.5823	0.869	0.000
GAP (P - E)	**-0.4713**	**-0.5388**	**-0.3956**	**-0.4979**	**-0.2661**		
Perceived responsiveness	3.2391	3.2370	3.4458	3.4359	3.6278	0.617	0.000
Expected responsiveness	4.1356	4.1068	4.2578	4.3128	4.1018		
GAP (P - E)	**-0.8966**	**-0.8699**	**-0.8120**	**-0.8769**	**-0.4740**		
Perceived assurance	3.8046	3.5507	3.4843	3.7744	3.8011	0.320	0.000
Expected assurance	3.8667	4.1014	4.0916	4.2564	4.0428		
GAP (P - E)	**-0.0621**	**-0.5507**	**-0.6072**	**-0.4821**	**-0.2417**		
Perceived empathy	3.1034	3.6370	3.5542	3.9573	4.2137	0.945	0.000
Expected empathy	3.7433	4.0114	3.9799	4.2308	4.4460		
GAP (P - E)	**-0.6398**	**-0.3744**	**-0.4257**	**-0.2735**	**-0.2323**		
Perceived tangibles	4.4751	4.4543	3.7610	3.8761	4.5607	0.895	0.000
Expected tangibles	4.6015	4.5845	4.2269	4.2714	4.6991		
GAP (P - E)	**-0.1264**	**-0.1301**	**-0.4659**	**-0.3953**	**-0.1384**		
Perceived SERQUAL	4.3036	4.3496	4.2354	4.4156	12.7683	1.000	0.000
Expected SERQUAL	4.8127	4.9064	4.8529	4.9904	13.0766		
GAP (P - E)	-0.5091	-0.5568	-0.6175	-0.5748	-0.3083		

Source: Field survey, 2021

4.2.4 Relative importance of service dimensions

Finally, customers in all four operational areas ranked Reliability (24.7%), Responsiveness (23.9%), Assurance (19.4%), Empathy (17.5%) and Tangibility (14.5%) as 1st, 2nd, 3rd, 4th and 5th in order of importance (Table 4.5). Ranking Reliability and Responsiveness as priority in terms of importance was expected because, hauling waste out of sight is generally desired than having to see nice waste collecting vehicles in ones' compound**.** Again, while customers ranked

Reliability and Responsiveness as topmost priority dimensions, they recorded the highest gaps of dissatisfaction.

Table 4.5: Relative importance of service dimensions

Dimension	Wa Municipality		Tamale Metropolis		Bolgatanga Municipality		Sagnarigu Municipality		Mean
	RI(%)	Rank	RI (%)	Rank	RI(%)	Rank	RI(%)	Rank	
Reliability	25.9	1	23.9	2	23.8	2	25.1	1	24.68
Responsiveness	23.7	2	24.6	1	24.2	1	23.2	2	23.93
Assurance	19.5	3	18.7	4	19.1	3	20.3	3	19.40
Empathy	17.6	4	20.1	3	17.3	4	14.9	5	17.48
Tangibility	13.3	5	12.7	5	15.6	5	16.5	4	14.53
Total	**100**		**100**		**100**		**100**		**100.00**

RI=Relative Importance

The results revealed that there were gaps between customer perception and expectation. There were also variations in mean and standard deviation scores across the different geographical regions (Table 4.4). For instance, in terms of the responsiveness dimension ratings, Bolgatanga (Mean = 3.45, SD. = 0.78) and Wa (Mean = 3.44, SD. = 0.54) were viewed as higher than those at Tamale (Mean = 3.24, SD. = 0.76) and Sagnarigu (Mean = 3.24, SD. = 1.00). Responsiveness is the service provider's ability to respond promptly to customer concerns. It focuses on promptly resolving customer complaints, inquiries, questions and problems. It is the period when customers have to wait for their concerns to be addressed after they have submitted complaints. Responsiveness also includes the service provider's ability and willingness to assist and adapt the service to the needs of the customer (Ramya et al., 2019). The variation in service go a long way to support the assertion that the spatial and theoretical complexity of waste is even more pronounced in Africa than any other region

due to the complex dynamics of population growth and economic development (United Nations Environment Programme, 2018). The findings of this research are similar to the findings of Akateeba and Yakubu (2012), who recorded perceived responsiveness for waste collection in Wa Municipality as moderately higher than that of Tamale and Bolgatanga.

In general terms, the literature indicates that the introduction of the private sector leaves the public sector with some form of an inertia and this in turn builds high customer expectation on the private companies (Moshan et al., 2011; William & Naumann, 2011). It was therefore not surprising that the results showed that customers had very high expectations across the operational areas for all the service dimensions; reliability (Mean=4.58, SD. =0.45), responsiveness (Mean=4.10, SD. =0.34), assurance (Mean=4.04, SD. = 0.23), empathy (Mean=4.45, SD. =0.56) and tangibility (Mean=4.70, SD. =0.36). These findings are in sync with the findings of Zikry (2017), where high expectations were recorded for reliability, responsiveness, assurance, empathy and tangibility. The results are also in line with that of Odayor (2003) who conducted a study in three cities (Durban, Pinetown, Richards Bay) in South Africa, recording moderately high expectations from customers in all service dimensions. The variations in results among the different operational areas might have been caused by differences in social settings and experiences of respondents in the study areas.

Additionally, while customers had very high expectations for all service quality dimensions (Table 4.3), Tangibility was the topmost priority (Mean = 4.69), followed by Reliability (Mean = 4.58), Empathy (Mean = 4.45), Responsiveness

(Mean = 4.10), and then Assurance (Mean = 4.04) as the least. During the study, it was discovered that there were new compaction trucks in all the operational areas. This might have accounted for high expectations on Tangibility. Tangibility is the appearance of the service organization's physical facilities, equipment, personnel and communication materials (Odayor, 2003). It influences customer expectations of service providers. For instance, waste companies with state-of-the-art equipment may have high customer expectations compared to companies with legacy waste management equipment. The professional appearance of refuse collection personnel, including clothing, uniform and personal hygiene, affects recognisability and customer expectation and perception.

The findings of the study on SERVQUAL gaps analysis showed that the service gaps for all dimensions were less than zero (Table 4.4). This meant that service providers failed to meet customer expectations on all the service dimensions assessed. In Gap analysis, if gap score is 0, it means customer expectations are met, if it is less than 0, it means expectations are not met, creating a service gap. There was a statistically significant positive relationship (R = 1.00, p-value = 0.000) between customers' perceptions and expectations. The implication is that as more is expected, more is perceived. While there was a very strong significant positive association between expected and perceived Reliability, Responsiveness, Empathy and Tangibility, the association between expected and perceived Assurance was very weak (Table 4.4; R = 0.320, p-value= 0.00). The implication is that increased expectations would very much lead to an increase in perceptions for Reliability, Responsiveness, Empathy and

Tangibility, while an increase in expectation would very less result in an increase in perception for Assurance.

The results showed that Responsiveness and Reliability dimensions recorded the highest service gaps (Table 4.4). Reliability for instance is a measure of the service provider's ability and commitment to deliver the service as promised. This is an important dimension when evaluating service quality, as many customers like doing business with companies that deliver on their promises (Ramya et al., 2019; Tan & Foo, 1999). These findings affirmed the results of a study by Odayor (2003), which recorded the highest gaps in Reliability and Responsiveness and lowest gaps in Tangibility. The implication is that customers were less concerned about the state-of-the-art equipment and empathy, but more concerned about reliability and responsiveness of service (waste lifted away promptly from their premises). These results were expected because the more the service providers delayed in lifting waste the more likely that the organic fraction of the waste would decompose and produced bad odour. To close the service gaps and improve customer satisfaction, service providers must focus attention on improving reliability and responsiveness. This also means that all business processes and practices that improve Reliability and Responsiveness are key decision priorities for the running of waste management companies.

In terms of relative importance of service dimensions, respondents ranked Reliability and Responsiveness as the most important and Empathy and Tangibility as the least important (Table 4.5). The results of the ranking affirmed the results of a study on waste collection services in Selayang

Municipality in Malaysia by Zikry (2017). Ranking Reliability and Responsiveness as the most important was expected because, hauling waste out of customers' premises regularly and promptly was generally desired than having to be served by the most empathetic staff and nice waste collection vehicles.

4.3 Efficiency of municipal solid waste management service delivery

Table 4.6 summarizes the descriptive statistics of the results on the efficiency of waste management companies. The maximum efficiency score was 1.00 for all the operational years. An efficiency score of 1 means that the DMU is efficient. An efficiency score below 1 means the DMU is inefficient. The minimum efficiency score was $5.19*10^{-4}$ and 0.81 for 2018 and 2019, respectively. The efficiency score average for 2018 and 2019 were 0.75, 0.95, respectively.

Table 4.6: Descriptive statistics for DEA results

Item description	Scores	
	2018	**2019**
Total number of DMUs	4	4
Number of efficient DMUs	3	3
Number of inefficient DMUs	1	1
Maximum efficiency	1	1
Minimum efficiency	5.19*10-4	0.81
Average efficiency	0.75	0.95

Source: Author's construct, April 2022

The result in Table 4.6 shows that the input for an average unit may be reduced by 25% and 5% for 2018 and 2019 respectively to improve overall efficiency of a company. The average efficiencies obtained in the study are similar to 0.85 relative efficiencies of the majority of DMUs (municipalities and metropolis) reported by Bosch et al. (2000) in Spanish municipal refuse collections. Apart from the average efficiency (0.75) in 2018 that was within the efficiency range of 0.60-0.80 for MSW collection in Australia (Worthington & Dollery, 2001), efficiency score for the other operational years were above the range reported in Worthington and Dollery's (2001) study. The wide efficiency range of 0.0005 to 1 was different from 0.1 to 1 obtained by Huang et al. (2011) for waste collection in 307 local government areas in Taiwan. Differences in population density, road traffic conditions, nature of roads and route planning might have accounted for the wide variation in efficiencies of collection among the municipalities and metropolis. DMU3 was used as the target for the analysis of efficiency other DMUs.

2018 operational year:

Table 4.7: Efficiency scores of the DMUs (municipalities/metropolis)

DMUs	Efficiency
DMU1 (Tamale)	$5.19*10^{-4}$
DMU2 (Wa)	1.00
DMU3 (Bolgatanga)	1.00
DMU4 (Sagnarigu)	1.00

Source: Author's construct, April 2022

Table 4.8 shows the scores of efficiencies for the four municipalities/metropolis obtained from DEA using CCR model. These efficiency scores were arrived at under the following conditions:

1. All data and all weights are positive
2. Efficiency scores must lie between zero and unity
3. The same weights for the target DMU are applied to all DMUs for the year 2018 In the efficiency analysis for the operational years, efficient DMU1 is set as the target.

The following DMUs (DMU2, DMU3 and DMU4) had efficiency score of one and were considered to be efficient in the utilization of waste management resources compared to DMU1 (0.000519), which was considered inefficient. DMU1 efficiency can be determined by comparing it to any of the three efficient DMUs.

Table 4.8: Optimal weights with DMU3 as the target

Description	Original value	Final value
Weight (V_1) Quantity of waste hauled (tons)	1.0000	3.86324E-05
Weight (V_2) Revenue generated'000 (GHS)	1.0000	0
Weight (U_1) Total assets (000) GHS	1.0000	7.12322E-05
Weight (U_2) Number of trucks deployed	1.0000	0
Weight (U_3) Number of dustbins serviced	1.0000	0.000253798
Weight (U_4) Number of clients serviced	1.0000	2.37878E-05
Weight (U_5) Number of staff	1	0

Source: Author's construct, April 2022

In Table 4.8, the optimal solution to the linear programming (LP) has the value one (1) and the best input and output weights are represented by the Final values. Upon observing the differences that existed between the optimal weights, the following conclusions were made. For instance, the ratio between number of dustbins serviced and total assets $(\frac{U_3}{U_1}) = 3.56$, suggested that it was advantageous for DMU1 to weigh input of number of dustbins serviced 3.56 times more than input of total assets in order to maximize its efficiency. In other words, a reduction in input number of dustbins serviced has a bigger effect on efficiency than does a reduction in total assets as input.

Again, the ratio between number of clients serviced and total assets $(\frac{U_4}{U_1}) = 5.17$, suggested that it was better for DMU1 to weigh input of number of clients serviced 5.17 times more than input of total assets in order to maximize its efficiency. In other words, a reduction in input number of clients serviced has a bigger effect on efficiency than does a reduction in total assets as input.

It is also worthy to note that the ratio between number of dustbins serviced and number of clients serviced $(\frac{U_3}{U_4}) = 18.41$. A value of 18.41 suggested that DMU1 will be better off weighing input of number of dustbins serviced 18.41 times more than input of number of clients serviced in order to maximize its efficiency. In other words, a reduction in input number of dustbins serviced has a bigger effect on efficiency than does a reduction in the number of clients serviced as input.

Generally, to maximize the efficiency of DMU1, the number of clients serviced, number of dustbins serviced and total assets should not increase for the same output. According to Suleiman et al. (2018), cost-effective municipal waste collection can be achieved by focusing on fuel consumption, distance travelled and maintenance cost of trucks. The number of trucks and number of staff had neutral effect on maximizing efficiency to get the same output for the year 2018. These findings differed from the conclusion drawn by Sulemana et al. (2018) that operating cost, which includes labour cost, is key to improving efficiency of waste collection.

To improve the efficiency of DMU1, the Input target=Actual input for inefficient DMU1 x Relative efficiency for inefficient DMU1. Hence, DMU1 will have efficiency inputs to be Input target = (2034total assets+ 4 number of trucks deployed+ 3645 number of dustbins serviced + 3561 number of clients serviced +51 number of staff) x 0.000519 = 2.1 total assets+ $2.1E^{-3}$ number of trucks deployed+ 2 number of dustbins serviced + 2 number of clients serviced + $2.6E^{--2}$ number of staff. This means that DMU1 will be efficient if it reduces its number of dustbins serviced and number of clients serviced to 2 and 2, respectively, with virtually zero for the rest of the inputs in order to yield the same output.

Table 4.9: Constraints of the Model Setting DMU3 as the target

Description	Cell value	Status	Slack
DMU3 Weighted input	1	Binding	0
DMU1 Working	-2804.66268	Not Binding	2804.66268
DMU2 Working	0	Binding	0
DMU3 Working	0	Binding	0
DMU4 Working	0	Binding	0

Source: Author's construct, April 2022

As shown in Table 4.9 there were three working constraints (DMU2, DMU3 and DMU4) with a slack value of zero. These working constraints were considered to be binding because they (constraints) were satisfied with equality at the Linear Programming (LP) optimal.

Table 4.10: Sensitivity report on the optimal weights with DMU3 as the target

Description	Final value	Reduced cost	Objective coefficient	Allowable increase	Allowable decrease
Weight (V_1) Quantity of waste hauled (tons)	3.86324E-05	0	25885	1E+30	0
Weight (V_2) Revenue generated'000 (GHS)	0	0	839	0	1E+30
Weight (U_1) Total assets (000) GHS	7.12322E-05	0	0	0	0
Weight (U_2) No of trucks deployed	0	0	0	0	1E+30
Weight (U_3) Number of dustbins serviced	0.000253798	0	0	2251.761624	0
Weight (U_4) Number of clients serviced	2.37878E-05	0	0	0	0
Weight (U_5) Number of staff	0	0	0	0	1E+30

Source**:** Author's construct, April 2022

In Table 4.10, the best input and output weight are shown in the Final value column. If the coefficient of V_1 is varied in the objective function, the solution for V_1 will be $3.86324E-05$ and the objective function coefficient for V_1 will be 25885. The allowable increase or decrease shows that provided the coefficient for V_1 in the objective function lies between 25885 + 1E+30=25886 and 25885-0 = 25885, the values of the variables in the optimal LP solution will remain unchanged.

The solution value for U_3 was 0.000253798 and the objective function coefficient for U_3 was 0. The allowable increase or decrease shows that provided the coefficient for U_3 in the objective function lies between 0+2251.761624 =2251.761624 and 0-0=0, the values of the variables in the optimal LP solution will remain unchanged. Similar conclusions may be drawn for U_2, U_4, U_5, and V_1.

Table 4.11: Sensitivity report on the constraints of the model with DMU3 as the target

Description	Final value	Shadow price	Constraint R.H. side	Allowable increase	Allowable decrease
DMU3 Weighted input	1	1	1	8314.411091	1
DMU1 Working	-2804.662675	0	0	1E+30	2804.662675
DMU2 Working	0	0	0	0.035479006	0.65738932
DMU3 Working	0	1	0	0.571492264	0.018797555
DMU4 Working	0	2.22045E-16	0	0.018642189	0.646503735

Source: Author's analysis, April 2022

In Table 4.11, we can study the effect of changing the right-hand side of DMU2 (Wa) constraint. If the right-hand side of DMU2 (Wa) constraint lies between 0+0.035479006=0.035479006 and 0- 0.65738932= -0.65738932, the objective function change will be exactly zero (0).

Again, if the right-hand side of DMU3 (Bolgatanga) constraint lies between 0+0.571492264=0.57149224 and 0-0.018797555 = -0.018797555, the objective function change will be exactly zero (0).

2019 operational year:

Table 4.12: Efficiency scores of the DMUs

DMUs	Efficiency
DMU1	1.00
DMU2	1.00
DMU3	1.00
DMU4	0.81

Source: Author's construct, April 2022

Table 4.12 shows the efficiency scores of the four DMUs obtained from DEA using CCR model foe 2019. These efficiency scores were arrived at under the following conditions:

1. All data and all weights are positive
2. Efficiency scores must lie between zero and unity
3. The same weights for the target DMU are applied to all DMUs for the year 2019

Three (3) DMUs (DMU1, DMU2, DMU3) were efficient and were considered to have better waste management services. These efficient DMUs have

efficiency scores equal to one (1.00) and on the efficient frontier. The three DMUs were more efficient in utilizing waste management resources compared to DMU4 (0.81), which was inefficient. The efficiency of DMU4 can be determined by comparing it to any of the three efficient DMUs.

Table 4.13: Optimal weights with DMU3 as the target

Description	Original value	Final value
Weight (V_1) Quantity of waste hauled (tons)	1	3.75375E-05
Weight (V_2) Revenue generated'000 (GHS)	1	0
Weight (U_1) Total assets (000) GHS	1	0
Weight (U_2) No of trucks deployed	1	0.046864131
Weight (U_3) Number of dustbins serviced	1	0.000239548
Weight (U_4) Number of clients serviced	1	2.14256E-05
Weight (U_5) Number of staff	1	0

Source: Author's construct, April 2022

In Table 4.13, the optimal solution to linear programming (LP) has the value one (1) and the best input and output weights are presented in the final value column. Upon observing the differences that existed between the optimal weights, the following conclusions were made. For instance, the ratio between number of trucks deployed and number of dustbins serviced ($\frac{U_2}{U_3}$) = 195.64), suggested that it was advantageous for DMU4 (Sagnarigu) to weigh input of number of trucks deployed 195.64 times more than input of number of dustbins serviced in order to maximize its efficiency. In other words, a reduction in input number of trucks deployed has a bigger effect on efficiency than does a reduction in number of dustbins serviced as input. Again, the ratio between

number of trucks deployed and number of clients serviced $(\frac{U_2}{U_4}) = 4101.68$, suggested that it was advantageous for DMU4 (Sagnarigu) to weigh input of number of trucks deployed 4101.68 times more than input of number of clients serviced in order to maximize its efficiency. In other words, a reduction in input number of trucks deployed has a bigger effect on efficiency than does a reduction in number of clients serviced as input.

It worth to note that the ratio between number of dustbins serviced and number of clients serviced $(\frac{U_3}{U_4}) = 20.97$, suggested that it was better for DMUs (Sagnarigu) MMDA to weigh input of number of dustbins serviced 20.97 times more than input of number of clients serviced in order to maximize its efficiency. In other words, a reduction in input number of dustbins serviced has a bigger effect on efficiency than does a reduction in the number of clients serviced as input. Generally, to maximize efficiency, the number of clients serviced, number of dustbins serviced and number of trucks should not increase for the same output. The total assets and number of staff have neutral effect on maximizing efficiency to get the same output for the year 2019. To improve the efficiency of DMU4 (Sagnarigu), the Input target=Actual input for inefficient DMU x Relative efficiency for inefficient DMU. Hence for DMU4 (Sagnarigu) will have efficiency inputs to be;

Input target = (298 total assets+ 3 number of trucks deployed+ 1893 number of dustbins serviced + 1751 number of clients serviced +55 number of staff) x 0.81 = 241 total assets+ 2 number of trucks deployed+ 1533 number of dustbins serviced + 1418 number of clients serviced + 45 number of staff. The

implication is that DMU4 (Sagnarigu) will be efficient with the same targeted output if it reduces its total assets, number of trucks deployed, number of dustbins serviced, number of clients serviced and number of staff to 241, 2, 1533, 1418 and 45, respectively.

Table 4.14: Constraints of the model with DMU3 as the target

Description	Cell value	Status	Slack
DMU3 Weighted input	1	Binding	0
DMU1 Working	0	Binding	0
DMU2 Working	0	Binding	0
DMU3 Working	0	Binding	0
DMU4 Working	-0.1182667	Not Binding	0.1182667

Source: Author's construct, April 2022

In Table 4.14, it can be indicated that the three working constraints; DMU3 (Bolgatanga), DMU1 (Tamale) and DMU2 (Wa) with a slack value of zero are binding because these DMUs were satisfied with equality at the LP optimal.

Table 4.15: Sensitivity report on the optimal weights with DMU1 as the target

Description	Final value	Reduced cost	Objective coefficient	Allowable increase	Allowable decrease
Weight (V_1) Quantity of waste hauled (tons)	3.75375E-05	0	26640	1E+30	0
Weight (V_2) Revenue generated'000 (GHS)	0	0	846	0	1E+30
Weight (U_1) Total assets (000) GHS	0	-2.137E-13	0	2.137E-13	1E+30
Weight (U_2) No of trucks deployed	0.046864131	0	0	0	0
Weight (U_3) Number of dustbins serviced	0.000239548	0	0	2562.995339	0
Weight (U_4) Number of clients serviced	2.14256E-05	0	0	0	0
Weight (U_5) Number of staff	0	0	0	0	1E+30

Source: Author's analysis, April 2022

From Table 4.15, suppose we varied the coefficient of V_1 in the objective function, the solution value for V_1 will be $3.75375E-05$ and the objective function coefficient for V_1 will be 26640. The allowable increase or decrease tells us that provided the coefficient for V_1 in the objective function lies between 26640 + 1E+30=26640 and 25885-0 = 25885, the values of the variables in the optimal LP solution will remain unchanged.

Again, the solution value for U_2 was 0.046864131 and the objective function coefficient for U_2 was 0, the allowable increase or decrease tells us that provided the coefficient for U_2 in the objective function lies between 0+0 =0 and 0-0=0, the values of the variables in the optimal LP solution will remain unchanged. Similar conclusions may be drawn for U_3, U_4, U_5, and U_1.

Table 4.16: Sensitivity report on the constraints of the model with DMU1 as the target

Description	Final value	Shadow price	Constraint R.H. side	Allowable increase	Allowable decrease
DMU3 Weighted input	1	1	1	1E+30	1
DMU1 Working	0	0	0	0.036216659	1.463564919
DMU2 Working	0	0	0	0.096016304	0.021276208
DMU3 Working	0	1	0	0.613959754	0.108747505
DMU4 Working	-0.118266695	0	0	1E+30	0.118266695

Source: Author's analysis, April 2022

From Table 4.16, we can study the effect of changing the right-hand side of Wa constraint. If the right-hand side of Wa constraint lies between 0+0.096016304=0.096016304 and 0- 0.021276208 = -0.021276208, the objective function change will be exactly zero (0). Again, if the right-hand side of Bolgatanga constraint lies between 0+0.613959754=0.613959754 and 0-

0.108747505 = -0.108747505, the objective function change will be exactly zero (0).

4.4 The governance structure of solid waste management system

This section answers research question three and objective three of the study, which assesses the extent of waste governance including stakeholder participation in the existing solid waste governance system in the municipalities.

4.4.1 Stakeholder participation in MSWM

The key stakeholders, their roles, interest and influence in MSWM in Ghana are described in Table 4.17. The identification of stakeholders and analysis of their roles, power and relationships are useful in assessing the performance of municipal solid waste institutional governance.

Table 4.17: Key stakeholders and their roles in solid waste management

Stakeholder	Examples	Roles	Interest	Influence
Waste generators	Households, institutions, industries	Pay for services	Good services	High
Waste companies	Zoomlion Ghana Limited, Waste Landfills Company Limited etc.	Provide waste management services	Make profit	Low
National government agencies	EPA, MLGRD, MSWR, MMDAs, MESTI	Formulate policies and regulations	Provide enabling environment for quality service delivery	High
Local government agencies	MMDAs, EPA	Supervision and monitoring of services according to standards	Compliance with set standards	High
NGOs	ESPA, CONNIWAS, UNICEF	Advocacy and sensitization	Behavioural change	Low

Source: Field Survey, 2022

Table 4.17 Cont'd: Key stakeholders and their roles in solid waste management

Stakeholder	Examples	Roles	Interest	Influence/Power
Local Authorities	Assembly members, unit committee members	Community mobilization	Active participation of citizens	High
Traditional Authorities	Chiefs, Queen mothers, *Tendaabas*	Community mobilization	Obtain benefits for traditional area	High
Informal waste collectors	Scavengers, Tricycle waste collectors *(Aboboyas)*	Recover materials from waste	Make livelihood	Low

Source: Field survey, 2022

In examining stakeholder participation, the analysis showed that differences in views among municipalities and metropolis on consultation of service users in solid waste management, transparency of processes of contracting private partners, and knowledge of Assembly Members in the processes of engaging private partner varied significantly (Table 4.17). Views of respondents on indicators of stakeholder inclusivity were not significant. Details of stakeholder inclusivity in waste management are shown in Table 4.17.

The factors used to assess stakeholder involvement centred on meetings, sensitization/awareness, consultations and collaborations. Generally, stakeholder meetings were organized quarterly. Participation of stakeholders in meeting was good but not effective. In terms of consultation, customers were generally left out in solid waste management decisions and planning. Stakeholders, especially service users were mainly informed at the implementation stages of strategies and plans. This was a major weakness in the waste management governance system. In terms of collaboration, it was revealed that the informal sector, which is a major stakeholder in the industry, was not adequately recognized and situated within the waste management systems despite their enormous contributions to waste management. These findings were corroborated by the Municipal Environmental Health Officer for Bolgatanga in an interview. He said:

"The activities of informal waste collectors such as scavengers are not regulated by the Assembly. They ravage the dumpsites, collecting anything they consider valuable. Most of them do not wear personal protective equipment, exposing them to cuts from sharps in the waste. What is disturbing about their

operations is their engagement in illegal dumping. They however play an important role in resource recovery and separation. I think it is time to regulate their activities to bring sanity into the waste management system." (Municipal Environmental Health Officer, Bolgatanga, July, 2021)

The findings of Oteng-Ababio (2010) in which the informal collectors in Accra were left out in the governance arrangement for waste collection corroborates the outcome of the study. A study by Baud et al. (2004) equally identified the exclusion of the informal collectors as a major issue. This is a major policy gap revealed by this research that has to be addressed to tap into the huge potential presented by the informal sector. In stressing the need for the involvement of the informal sector, Owusu-Sekyere (2019) indicated that the regulation of the activities of the informal sector such as scavengers and tricycle collectors *(Aboboyas or Kaya Bolas)* and bringing them into the waste governance system will greatly contribute to waste collection, sorting and source separation programmes. According to Bartolacci et al. (2018), collaboration and synergy among various actors was necessary for improved performance. However, this was found to be weak, especially between the government (MMDAs) and the informal sector.

Consultation and collaboration among stakeholders, especially customers (waste generators) and service providers, is fundamental for effective waste management. According to World Bank (2021), consultation serves as the right of participation of stakeholders in waste management planning. The majority of respondents believed there was not adequate consultation of stakeholders in waste management planning and decision making. These findings completely

differed from the opinions of stakeholders in Adongo et al.'s (2015), where 91% of stakeholders in the Tamale metropolis believed they were adequately consulted in waste management decisions. The difference between the findings of Adongo et al. (2015) and this current study might be due to the differences in number and nature of participants in the individual studies as well as the timing of the research. While this study included an extensive number of stakeholders (68) spanning a wide variety of backgrounds, Adongo et al. (2015) sought the opinions of limited stakeholders.

According to Anderson (2022), community education and awareness are fundamental in changing the attitude of indiscriminate dumping and promoting waste management programmes. Public sensitization creates support for waste management programmes and policies and helps manage stakeholder expectations (World Bank, 2021; US EPA, 2020). In terms of how often waste management units and waste management companies conducted public sensitization, the results revealed that most stakeholder sensitization programmes were done daily through daily house-to-house inspection and mass media and quarterly through in-person meetings (Table 4.17). In confirmation to these findings, Adongo et al. (2015) reported that 64% of stakeholder organizations in Tamale Metropolis organized at least one workshop annually to sensitize stakeholders in the waste management sector. The outcome of the study supported the findings by Adongo et al. (2015) that sensitization was mainly organized through mass media.

Table 4.18: Stakeholder inclusivity

Statements	Responses	Municipality/ Metropolis				Rho	P-value
		Sagnarigu	Tamale	Bolgatanga	Wa		
All sections of the town receive solid waste management service	No	8 50.0%	11 64.7%	17 89.5%	13 72.2%	-0.214	0.076
	Yes	8 50.0%	6 35.3%	2 10.5%	5 27.8%		
Customers of waste management services consulted in waste management	No	7 43.8%	7 41.2%	14 73.7%	14 77.8%	-0.308	0.010
	Yes	9 56.3%	10 58.8%	5 26.3%	4 22.2%		
Complaints redressal system in place for the public	No	9 56.3%	8 47.1%	3 15.8%	13 72.2%	-0.049	0.687
	Yes	7 43.8%	9 52.9%	16 84.2%	5 27.8%		
Stakeholders' meetings organized	Monthly	4 25.0%	2 11.8%	2 10.5%	8 44.4%	-0.193	0.110
	Quarterly	11 68.8%	15 88.2%	17 89.5%	10 55.6%		
	Half-Yearly	1 6.3%	0 0.0%	0 0.0%	0 0.0%		
Sanitation sub-committee of the Assembly meet	Monthly	2 12.5%	3 17.6%	2 10.5%	8 44.4%	-0.119	0.328
	Quarterly	14 87.5%	13 76.5%	14 73.7%	8 44.4%		
	Half-Yearly	0 0.0%	1 5.9%	3 15.8%	2 12.1%		

Source: Field Survey, 2022 (N=68)

Table 4.18: Cont'd: Stakeholder inclusivity

Statements	Responses	Municipality/ Metropolis				Rho	P-value
		Sagnarigu	Tamale	Bolgatanga	Wa		
How frequent does the waste management/environmental health unit carry out public sensitization	Daily	4 25.0%	7 41.2%	13 68.4%	8 44.4%	-0.145	0.230
	Monthly	4 25.0%	4 23.5%	3 15.8%	2 12.1%		
	Quarterly	8 50.0%	6 35.3%	3 15.8%	8 44.4%		
Partners participate in meetings of the environment and sanitation sub-committee and how	No	4 25.0%	3 17.6%	7 36.8%	5 27.8%	-0.071	0.561
	Yes	12 75.0%	14 82.4%	12 63.2%	13 72.2%		
Private partners consulted during annual budget preparation on waste management and sanitation	No	9 56.3%	8 47.1%	10 52.6%	9 50.0%	0.026	0.829
	Yes	7 43.8%	9 52.9%	9 47.4%	9 50.0%		
Informal waste collectors/scavengers organized into an association and their activities regulated	No	16 100.0%	14 82.4%	17 89.5%	15 83.3%	0.141	0.244
	Yes	0 0.0%	3 17.6%	2 10.5%	3 16.7%		
Standard mechanism for the determination of waste collection fees in the Assembly	No	9 56.3%	11 64.7%	10 52.6%	15 83.3%	-0.162	0.179
	Yes	7 43.8%	6 35.3%	9 47.4%	3 16.7%		

Source: Field Survey, 2022
(N=68)

Table 4.18 Cont'd: Stakeholder inclusivity

Statements	Responses	Municipality/ Metropolis				Rho	P-value
		Sagnarigu	Tamale	Bolgatanga	Wa		
Processes for contracting private waste management companies transparent	No	5	4	12	15	-0.443	0.000
		32.3%	23.5%	63.2%	83.3%		
	Yes	11	13	7	3		
		68.8%	76.5%	36.8%	16.7%		
Member of the assembly have an idea of the processes involved in engaging private waste collectors	No	5	3	11	17	-0.523	0.000
		32.3%	17.6%	57.9%	94.4%		
	Yes	11	14	8	1		
		68.8%	82.4%	42.1%	5.6%		

Source: Field Survey, 2022

(N=68)

4.5 Financial sustainability arrangement

It is argued that the nature of financing policy adopted influences decisions on sourcing and the expending of funds for solid waste management. That a good financing policy should clearly define issues of user charges, cost recovery, tariff regulation and subsidies (World Bank, 2021). Recognizing financial sustainability as one of the important indicators of MSWM governance, the study assessed the financial sustainability dimension of existing waste governance systems in the study area. In the research findings, stakeholders unanimously concluded that the yearly budget and revenue from waste services were not adequate to pay for complete cost of providing waste management services to the municipalities and metropolis (Table 4.19).

Table 4.19: Results of sustainable and transparent financial arrangement

Statements	Responses	Municipality/Metropolis				Rho	P-value
		Sagnarigu	Tamale	Bolgatanga	Wa		
Annual budget on waste management adequate to cover the full cost of providing waste management services	No	16	14	19	18	-0.107	0.349
		100.0%	82.4%	100.0%	100.0%		
	Yes	0	3	0	0		
		0.0%	17.6%	0.0%	0.0%		
Assembly members have full and accurate information on the cost of solid waste management within the municipality	No	13	16	14	15	0.047	0.702
		82.3%	94.1%	73.7%	83.3%		
	Yes	3	1	5	3		
		18.8%	5.9%	26.3%	16.7%		
Solid waste management service fees affordable	No	7	11	10	8	0.031	0.796
		43.8%	64.7%	52.6%	44.4%		
	Yes	9	6	9	10		
		56.3%	35.3%	47.4%	55.6%		
Those who cannot afford waste management services catered for through…	Free Services	7	9	15	11	-0.171	0.156
		43.8%	52.9%	78.9%	62.1%		
	Subsidized Rate	9	8	4	7		
		56.3%	47.1%	22.1%	38.9%		

Source: Field Survey, 2022 (N=68)

For solid waste funding to be sustainable, revenue from the sector should at least cover the cost-of-service provision (World Bank, 2021). This was not the case

for the study municipalities and metropolis; as funding mainly came from government through earmarked (statutory) funds. Very marginal population pay for waste collection services and the rates barely cover the cost of services. In support of these findings, a Regional Manager of a private waste collection company explained:

"The rates we currently charged are too low. This makes it extremely difficult to sustain our business. We currently charge between GHc30 and GHc50 per month for House-to-House collection with 240litre waste bins. If we have to sustain our business and run profitably under current economic challenges, our rates should not be lower than GHc100 per month for servicing a waste 240 litre bin."

(Interview, July 2022: Regional Manager, Private Waste Management Company)

This assertion is a clear manifestation of how unsustainable the existing funding arrangement for waste management services are. Kumar et al. (2017) and Yukalang et al. (2017) emphasized the lack of sustainable financing as one of the key challenges to solid waste management. In aligning with this view, Boateng et al. (2019) stated that waste management companies do not realize enough revenue from services as a result of low rates and service users' unwillingness or inability to pay. These findings were also affirmed by results of a study by Obirih-Opareh and Post (2002) who concluded that one of the major drawbacks of the privatization in the solid waste industry in Ghana is the lack of financial sustainability. This, according to Obirih-Opareh and Post

(2002), is due to political and social sensitivities (restrictions on the full implementation of cost recovery measures) championed by government for political reasons.

4.5.2 Waste planning, legal framework and governance in Ghana

An effective institutional framework is a bedrock for delivering a well-functional integrated waste management governance at all levels of government (World Bank, 2021). A review of waste governance documents conducted showed that Ghana has established some institutions responsible for providing policy and strategic directions for MSWM. Prior to the formation of the Ministry of Sanitation and Water Resources (MSWR) in 2017, the responsibility for policy and direction rested with the Ministry of Environment, Science, Technology and Innovation (MESTI) and Ministry of Local Government and Rural Development (MLGRD). The MSWR, which took on this responsibility, was supposed to harmonize all policies in the sanitation and waste sectors. The MESTI is responsible for the overall environmental compliance of the MSWM sector, which is performed through the Environmental Protection Agency (EPA), while the day-to-day oversight and monitoring of service delivery at local level is handled by MMDAs.

The re-enacted Local Government Act (Act 936, 2016) gives mandate to MMDAs to manage solid waste directly or through the private sector. The field experiences with the key informants revealed, however, that the essential functions of each agency are often not performed due to the overlap of responsibilities and pressure from other operational issues. For instance, it was observed that MMDAs are expected to enact bye-laws on sanitation to regulate

the local environmental conditions, a function to be performed with support from some other state agencies such as Environmental Protection Agency (EPA) and National Disaster Management Organization (NADMO). The bye-laws, even though in place, were rarely implemented.

4.5.3 National institutional adequacy

After identifying the national level institutions (figure 1) the research assessed respondents' perspective on national policy and institutional adequacy. Differences in views on all 8 indicators of national policy and institutional adequacy among respondents and municipalities were not correlated and significant **(**Table 4.20). Although waste management policies were believed to be largely comprehensive, there were major policies gaps that impacted negatively on governance and service delivery. As opined by ReVelle & Eiselt (2005), policies are living documents and should be constantly reviewed to reflect changing landscape of waste management, especially the need for resource recovery and recycling. However, the main policy document, the National Environmental Sanitation Policy, that guide solid waste management, was not reviewed for over well over a decade (2010 to 2023)

Table 4.20: National policy and institutional capacity

Statements	Responses	Selected Study Areas				Rho	P-value
		Sagnarigu	Tamale	Bolgatanga	Wa		
Policies that govern solid waste management in Ghana	No	1 6.3%	5 29.4%	2 10.5%	4 22.2%	-0.077	0.529
	Yes	15 93.8%	12 70.6%	17 89.5%	14 77.8%		
Are the policies comprehensive	No	7 43.8%	12 70.6%	5 26.3%	8 44.4%	0.099	0.401
	Yes	9 56.2%	5 29.4%	14 73.7%	10 55.6%		
Gaps in the policies	No	5 32.3%	5 29.4%	17 89.5%	15 83.3%	-0.492	0.000
	Yes	11 68.8%	12 70.6%	2 10.5%	3 16.7%		
National strategy for addressing for solid waste management	No	3 18.8%	5 29.4%	2 10.5%	2 12.1%	0.129	0.288
	Yes	13 82.3%	12 70.6%	17 89.5%	16 88.9%		
Clear guidelines for implementing the national strategy at the local level	No	8 50.0%	10 58.8%	5 26.3%	9 50.0%	0.073	0.550
	Yes	8 50.0%	7 41.2%	14 73.7%	9 50.0%		
A single institution that coordinates the implementation of solid waste management strategy	No	4 25.0%	9 52.9%	12 63.2%	9 50.0%	-0.178	0.141
	Yes	12 75.0%	8 47.1%	7 36.8%	9 50.0%		

Source: Field Survey, 2022 (N=68)

Table 4.20 Cont'd: National policy and institutional capacity

Statements	Responses	Selected Study Areas				Rho	P-value
		Sagnarigu	Tamale	Bolgatanga			Sagnarigu
How effective institutions coordinates and collaborate in solid waste management	Not effective	15 93.8%	11 64.7%	8 42.1%	16 88.9%	0.072	0.554
	Effective	1 6.3%	6 35.3%	11 57.9%	2 12.1%		
Regulatory agency (EPA) enforce legislation on solid waste management	No	11 68.8%	10 58.8%	15 78.9%	14 77.8%	-0.120	0.321
	Yes	5 32.3%	7 41.2%	4 22.1%	4 22.2%		

Source: Field Survey, 2022 (N=68)

There were no clear guidelines for executing national strategy on solid waste management at the local levels. This gap created misalignment in terms of policy focus between national and local levels. In supporting this, MSWR (2020) clearly pointed out that authorities of MMDAs at the local level were not abreast with the changing trend of the national policy environment. Although national policies were focused on recovery, processing and circular economy, many local level plans and actions were focused on addressing operational challenges in collection and disposal. Weak coordination and collaboration among key institutions was identified as policy gap (Table 4.20). This view was confirmed in an interview with the Regional Environmental Health Officer for Upper West Region, who stated:

"*Some of the policies are outdated and do not fit in the current situation. There are also duplications of roles among sector ministries".*

The weak coordination and collaboration issues is amplified and clearly demonstrated in literature by the MSWR (2020), which stated:

"Various policies were situated within different ministries that do not coordinate effectively. For example, major solid waste contract SIP rested with MLGRD, while sectoral responsibility was with MSWR."

4.5.4 Adequacy of local institutional capacity

As indicated by the World Bank (2021), national level policies and institutional strategies are expected to guide the local level operational plans and programmes for effective coordination of MSWM activities. Table 4.21 present the results of local institutional analysis. From all indications, MSWM in the municipalities were largely not guided by municipal level operational plans and strategies. For the municipalities and metropolis that had a plan, implementation was either not done or poorly executed. Waste Management Departments in all municipalities and metropolis were inadequately resourced and therefore, monitoring, supervision and evaluation of private service providers were not effective. Oduro-Kwarteng (2009) corroborated these findings by stating that Assemblies had limited capacity and resources to monitor and supervise private collection contractors to deliver services according to standards specified in agreements.

It also emerged that all municipalities and metropolis had legal frameworks in the form of bye-laws to regulate waste management but they were not adequately implemented. These findings are a reflection of the reality on the ground as many flouters of waste management bye-laws are not prosecuted by the Local Authorities. Bowan et al. (2020) corroborated these findings by affirming that Ghana had robust institutional and legal regime for solid waste management; the challenge is non-compliance and lack of enforcement. Lissah et al. (2021) stressed that failure to enforce the laws is part of the reason for indiscriminate dumping of refuse.

Table 4.21: Local institutional adequacy

Statements	Responses	Municipality/Metropolis				Rho	P-value
		Sagnarigu	Tamale	Bolgatanga	Wa		
Function of solid waste management service provision concentrated in one department	No	6 37.5%	8 47.1%	10 52.6%	13 72.2%	-0.244	0.041
	Yes	10 62.5%	9 52.9%	9 47.4%	5 27.8%		
Waste management department adequately resourced in human and equipment resources	No	13 82.3%	16 94.1%	18 94.7%	18 100.0 %	-0.238	0.047
	Yes	3 18.8%	1 5.9%	1 5.3%	0 0.0%		
Municipality/ metropolis has solid waste management strategy	No	3 18.8%	5 29.4%	5 26.3%	7 38.9%	-0.139	0.251
	Yes	13 82.3%	12 70.6%	14 73.7%	11 62.1%		
Solid waste management strategy is implemented	No	8 50.0%	10 58.8%	5 26.3%	12 66.7%	-0.042	0.732
	Yes	8 50.0%	7 41.2%	14 73.7%	6 33.3%		
Data on solid waste is collected	No	4 25.0%	2 11.8%	3 15.8%	10 55.6%	-0.252	0.035
	Yes	12 75.0%	15 88.2%	16 84.2%	8 44.4%		

Source: Field Survey, 2022 (N=68) M=Manually, E-Electronically, B-Both

Table 4.11 Cont'd: Local institutional adequacy

Statements	Responses	Municipality/Metropolis				Rho	P-value
		Sagnarigu	Tamale	Bolgatanga	Wa		
Mode of solid waste data collection	M	8 50.0%	8 50.0%	14 77.8%	15 100.0%	-0.452	0.000
	E	0 0.0%	0 0.0%	3 16.7%	0 0.0%		
	B	8 50.0%	8 50.0%	1 5.6%	0 0.0%		
Solid waste service providers are effectively supervised and monitored	No	6 37.5%	8 47.1%	11 57.9%	15 83.3%	-0.334	0.005
	Yes	10 62.5%	9 52.9%	8 42.1%	3 16.7%		
Municipal Assembly has bye-laws on sanitation	No	3 18.8%	3 17.6%	4 22.1%	1 5.6%	0.113	0.350
	Yes	13 82.3%	14 82.4%	15 78.9%	17 94.4%		
Sanitization programmes and bye-laws are implemented	No	8 50.0%	11 64.7%	4 22.1%	12 66.7%	-0.015	0.900
	Yes	8 50.0%	6 35.3%	15 78.9%	6 33.3%		
Bye-laws are gazetted	No	4 25.0%	4 23.5%	7 36.8%	14 77.8%	-0.395	0.001
	Yes	12 75.0%	13 76.5%	12 63.2%	4 22.2%		
Copies of bye-laws are available and accessible	No	5 32.3%	12 70.6%	9 47.4%	16 88.9%	-0.332	0.005
	Yes	11 68.8%	5 29.4%	10 52.6%	2 12.1%		

Source: Field Survey, 2022 (N=68) M=Manually, E-Electronically, B-Both

4.6 Overall performance on institutional indicators in solid waste governance

This study further assessed the arithmetic scale scores for the overall performance of the institutional governance indicators (Table 4.28). The results show that stakeholder inclusion in waste management was generally low in the

study areas. In addition, variation in views of respondents on stakeholder inclusivity was significant across all municipalities and metropolis (rho = -0.397, p-value = 0.001 (Table 4.280). Financial arrangements for solid waste management were generally considered unsustainable in the municipalities and metropolis. Despite the occurrence of some policy gaps, national and local institutional capacity was largely ranked very high by respondents. Statistically, variation in views on governance of respondents among municipalities and metropolis were significant (rho = -0.311, p-value = 0.009) (Table 4.28).

Table 4.22.1: Performance of institutional governance in solid waste management

Theme	Scale	Municipality. Metropolis				Rho	P-value
		Sagnarigu	Tamale	Bolgatanga	Wa		
Stakeholder inclusivity	Low	8 50.0%	8 47.1%	12 63.2%	18 100.0%	-0.397	0.001
	High	8 50.0%	9 52.9%	7 36.8%	0 0.0%		
Sustainable financial arrangement	Low	14 87.5%	15 88.2%	15 78.9%	16 88.9%	0.015	0.904
	High	2 12.5%	2 11.8%	4 22.1%	2 12.1%		
National policy and institutional adequacy	Low	9 56.3%	7 43.8%	11 68.8%	12 70.6%	-0.156	0.213
	High	7 43.8%	9 56.3%	5 32.3%	5 29.4%		
Local institutional adequacy	Low	5 32.3%	9 52.9%	7 36.8%	15 83.3%	-0.311	0.009
	High	11 68.8%	8 47.1%	12 63.2%	3 16.7%		

Source: Field survey (N=68)

Table 4.22: Independent T-test for equality of means on performance indicators of solid waste governance

Indicators	Comparison Between	t	Df	95% Confidence Interval of the Difference		p-value
				Lower	Upper	
Stakeholder inclusivity	Selected study areas	3.513	68	0.39356	1.42890	0.001
	Respondent category	2.115	68	-0.15296	0.54064	0.269
Adequacy of financial arrangement	Selected study areas	-0.131	68	-0.81315	0.71315	0.896
	Respondent category	0.916	68	-0.25514	0.68847	0.363
National policy and institutional adequacy	Selected study areas	1.257	63	-0.21190	0.92985	0.214
	Respondent category	0.285	63	-0.30873	0.41129	0.777
Adequacy of local institutional capacity	Selected study areas	2.682	68	0.17483	2.19119	0.009
	Respondent category	1.724	68	-0.04428	0.60638	0.089

Source: Field Survey, 2022

Note: Results reported for equal variances assumed

The level of significance in perception between being adequate or inadequate of the governance indicators was established through an independent T-test (Table 4.22). The results showed that stakeholder inclusion (being it adequate or inadequate), was significantly different among the four study municipalities and metropolis. Also, there was a statistically significant difference in mean of stakeholder inclusion between the selected study areas (municipalities and metropolis) on the adequacy of local institutional capacity. In terms of the factors examined, however, there was no significant difference between the two respondent groups of local institutional capacity being adequate or inadequate

(p-value > 0.05). However, Sagnarigu and Bolgatanga Municipalities affirmed adequacy of local institutional capacity while Tamale metropolis and Wa Municipality expressed contrary opinion **(**Table 4.22**).**

4.4.1 Compliance analysis to principles of solid waste management policies

The adoption of the public-private-partnerships policy in waste infrastructure reflects the government's desire to provide quality, cost effective and timely public infrastructure and services. This decision also indicates the government's commitment to the requisite legal and regulatory framework, clear financial and administrative framework for eliminating bottlenecks in public-private-partnerships arrangements (MOFEP, 2011, PPP Act, 2020, Act 1039).

Results of the study revealed four Public-Private Partnership (PPP) agreements; Sanitation Improvement Package (SIP), Waste and Sanitation Module (WSM), Door to Door Waste Collection Franchise (DDCF) and Landfill Management (FLM). The key policy principles government and the private sector were expected to comply with in the partnership arrangement were value for money, accountability, transparency, competition, stakeholder consultation, and clear objectives and targets. Others included affordability, efficient risk allocation, fairness, local content and safeguarding of public interest and consumer rights.

In terms of overall performance on compliance, the results suggested that service agreements were largely rated low in terms overall conformance to PPP principles (Table 4.23). The results showed SIP, DDCF, WSM agreements were generally ranked slightly above average in terms of compliance of processes

and services to all waste governance principles in study municipalities. Compliance of PPP models to the principle of competitiveness was rated very low (≥2.5). LFM, on the other hand, generally ranked below average in compliance with all the principles except the principle of local content. The implication of the results points to lapses in the design structure of PPPs, weak procurement processes, poor supervision, monitoring and evaluation of private partners by the public agencies.

Table 4.23: Results of compliance of PPP agreements with the principles of Ghana's PPP policy

Principle	Service Agreement	N	Mean	Std. Deviation	Std. Error
Value for money	SIP	68	7.00	0.816	0.408
	DDCF	68	7.25	0.957	0.479
	WSM	68	6.25	0.500	0.250
	LFM	68	3.75	1.500	0.750
Accountability	SIP	68	5.50	0.577	0.289
	DDCF	68	6.50	0.577	0.289
	WSM	68	6.00	0.816	0.408
	LFM	68	3.00	0.816	0.408
Competitiveness	SIP	68	2.00	0.816	0.408
	DDCF	68	2.50	1.732	0.866
	WSM	68	2.25	0.500	0.250
	LFM	68	2.00	0.816	0.408
Stakeholder consultation	SIP	68	6.50	0.577	0.289
	DDCF	68	6.25	0.957	0.479
	WSM	68	7.75	0.957	0.479
	LFM	68	5.00	0.816	0.408
Affordability	SIP	68	7.25	0.500	0.250
	DDCF	68	5.25	1.500	0.750
	WSM	68	6.00	0.816	0.408
	LFM	68	5.00	0.816	0.408
Local content	SIP	68	8.00	0.816	0.408
	DDCF	68	7.25	0.500	0.250
	WSM	68	6.00	1.414	0.707
	LFM	68	8.00	0.816	0.408

Source: Field Survey, 2022 N=68

Table 4.23 Cont'd: Results of compliance of PPP agreements with the principles Ghana's PPP policy

Principle	Service Agreement	N	Mean	Std. Deviation	Std. Error
Clear objectives and targets	SIP	68	6.25	0.957	0.479
	DDCF	68	6.75	1.258	0.629
	WSM	68	6.25	0.500	0.250
	LFM	68	4.75	0.957	0.479
Clear roles and responsibilities of partners	SIP	68	6.50	0.577	0.289
	DDCF	68	6.25	0.500	0.250
	WSM	68	7.00	0.816	0.408
	LFM	68	4.50	0.577	0.289
Period of agreement	SIP	68	4.00	0.000	0.000
	DDCF	68	4.50	1.000	0.500
	WSM	68	2.50	1.000	0.500
	LFM	68	4.00	0.000	0.000
General performance	SIP	68	6.75	0.957	0.479
	DDCF	68	7.25	1.258	0.629
	WSM	68	6.00	0.816	0.408
	LFM	68	2.25	0.957	0.479

Source: Field Survey, 2022 N=68

These findings of low compliance were at variance with the view that very high compliance to the principles and standards in PPP policy was necessary for successful waste governance and service delivery. Lapses in compliance to principles of PPPs could reduce the outcome of privatization as Massoud and El-Fadel (2012) concluded that PPPs would only yield the best results in the context of competition, accountability, performance monitoring and evaluation.

Many have also raised issues about the use of funds that is paid by government for waste collection services. Stakeholders believed there was no adequate value for money for waste collection services, breeding corruption. In an explanation, the Metropolitan Director of Waste Management Department at the Tamale Metropolitan Assembly said:

"The current solid waste collection contracts were based on number of collection containers and trucks. This was not the best way to structure an agreement. The contract should have been based on the quantity of waste hauled, with the cost per ton of waste explicitly stated in the contract."

Findings on respondents' perception about the competitiveness of the processes for selecting private partners for waste collection contracts was very low. These perceptions confirmed the reality on the ground as the study found that all the four PPP contracts in all the four study municipalities were managed by one company (Zoomlion Ghana Limited). These findings were not in sync with best practices for solid waste contracting. Cointreau-Levine (1994) and Obirih-Opareh and Post (2002) emphasized this point by concluding that efficiency of private sector participation can be improved by building in keen competitive mechanisms to avoid monopoly.

Analysis of variance (ANOVA) **(**Table 4.24) was conducted to determine the level of significance of respondents' perception between and within municipalities. The model fitness of analysis of variance was tested using the Levene's statistical test (Appendix VI), which showed no significance of homogeneity thus far.

Table 4.24: ANOVA between and within municipalities on compliance of indicators to PPP principles

ANOVA	Comparison	Sum of Squares	Mean Square	F	p-value
Value for money	Between municipalities	30.688	10.229	10.020	0.001
	Within municipalities	12.250	1.021		
Accountability	Between municipalities	29.000	9.667	19.333	0.000
	Within municipalities	6.000	0.500		
Competitiveness	Between municipalities	0.688	0.229	0.200	0.894
	Within municipalities	13.750	2.146		
Stakeholder consultation	Between municipalities	15.250	5.083	7.176	0.005
	Within municipalities	8.500	0.708		
Affordability	Between municipalities	12.250	4.083	4.261	0.029
	Within municipalities	11.500	0.958		
Local content	Between municipalities	10.688	3.563	3.977	0.035
	Within municipalities	10.750	0.896		
Clear objectives and targets	Between municipalities	9.000	3.000	3.273	0.059
	Within municipalities	11.000	0.917		
Clear roles and responsibilities of partners	Between municipalities	14.188	4.729	11.947	0.001
	Within municipalities	4.750	0.396		
General performance	Between municipalities	61.688	20.563	20.143	0.000
	Within municipalities	12.250	1.021		

Source: Field survey, 2022 (N=68)

The findings showed that there was a significant statistical difference between and within municipalities on ensuring value for money, accountability, stakeholder consultation, local content, clear roles and responsibilities of partners and improving upon the general performance at 95% confidence interval (Table 4.24).

4.7 The spatial distribution of waste containers

This section is devoted to answering research question four and objective four, which sought to assess the geospatial distribution of solid waste collection containers in the selected localities. The distribution of waste containers affects service quality, equity and efficiency of collection in the study municipalities. Though clustered pattern may reduce cost in terms of distance travelled by trucks and fuel consumption, it reduces service equity.

4.7.1 Distribution of Household Waste Bins (HWBs)

Figure 4.1 shows the spatial distribution of household waste bins in the selected study areas of Northern Ghana. The distribution of HWBs was more clustered in Wa Municipality and Tamale Metropolis than Bolgatanga and Sagnarigu Municipalities. This pattern of distribution of collection and disposal points has cost and efficiency implications such as distance travelled, amount of fuel used and time spent in collection and disposal. Sulemana et al. (2018) emphasized that cost-effective waste collection systems consider distance travelled, fuel consumed and quantity of waste generated when making decisions. In an interview with the Regional Manager of Zoomlion, Upper East Region, he said: *'where the waste bins are clustered, there is lower fuel consumption by trucks in servicing more bins than areas where bins were scattered".* In corroborating this view, the Zoomlion regional managers for Upper West and Northern Regions added that efficiency could be improved by concentrating the distribution of waste bins in operational zones (demarcated suburbs for waste collection services).

Door to door waste collection is an emerging waste collection system in urban areas in Ghana that is linked to the ability of residents to pay. Consequently, the distribution of household waste bins was limited to medium and high-class residential areas in the study areas (Figure 4.1). This observation is affirmed by Odonkor et al. (2020) who observed that home refuse collection was mainly in high class residential areas in large municipalities in Ghana.

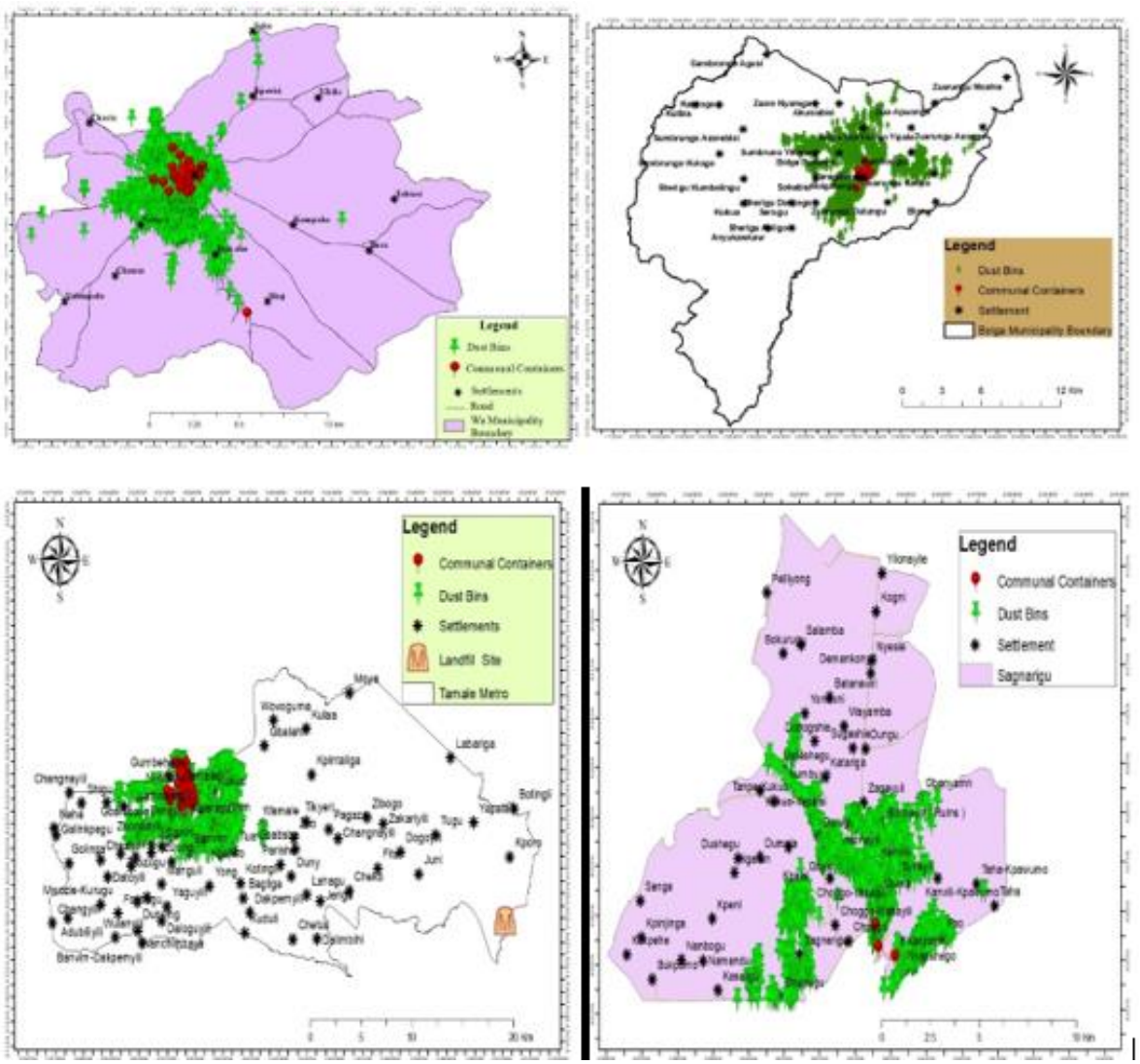

Figure 4.1: Geospatial distribution of waste collection containers in the municipalities and metropolis

In terms of quality of collection, it was observed that some HWBs were overflowing with waste, an indication of irregular services. Mpofu (2013) and Bello et al. (2016) noted that frequency of household waste collection was higher in the inner city and high-income residential areas than suburban and low-income residential areas. Observations made in the study areas affirmed this assertion, where overflow of HWBs were more frequent in low-class residential areas than high-class residential areas in the municipalities and metropolis. Through an interview, an Environmental Health Officer at Sagnarigu Municipal Assembly said,

"A lot of houses do not have waste bins. Those who have the waste bins are not well serviced. Therefore, it does not encourage others to take the waste bins".

4.7.2 Distribution and spatial analysis of Communal Containers (CCs)

Distribution of CCs was concentrated within the Central Business District (CBD) in the municipalities and metropolis, consisting of the markets, lorry parks and poorly planned clustered residential areas around the CBD **(**Figure 4.1). This observation was in line with the findings of Odonkor et al. (2020), who stated that communal container collection points were few and restricted to the city centre, making them inaccessible to residential households in large urban districts of Ghana. Additionally, Fuseini et al. (2020), in a study in the Ejisu Municipality of Ghana, concluded that CCs distributions were concentrated in the northern part of the municipality where commercial activities were high. Elsewhere in Africa, studies by Naibbi and Umar (2017) indicated that CCs were concentrated in the central part of Kano compared to the peri-urban areas; and it was discovered that there was more indiscriminate

dumping in the peri-urban areas than the city centre of Katsina in Nigeria, due to limited waste collection containers in the peri-urban areas (Danbuzu et al., 2014).

The occurrence of indiscriminate dumping, unauthorized and overflowing waste containers are shown in Figure 4.2. The appreciable number of container sites littered with refuse was an indication of possible irregular lifting of containers (Table 4.25).

Figure 4.2: Littered container sites and overflowed CCs in Tamale Metropolis and Wa Municipality

Analysis showed variations in the quality of communal collection services in the study areas. A total of 26 and 18 sites during the wet and dry seasons were respectively assessed. This resulted in the spillage of refuse at container sites (Figure 4.2). In giving reasons that accounted for the differences in frequency of lifting of containers between wet and dry seasons, the operations manager of Zoomlion in Bolgatanga stated that: *"There are some challenges experienced in the wet season. Challenges such as vehicle getting stacked due to bad roads and difficulty in dumping due to bad dumpsite environments, negatively affect the servicing of containers in the wet season"*.

The littered container sites identified were not only caused by irregular lifting but also, the poor attitudes of residents. Some of them indiscriminately dump refuse. In an interview with a container site attendant in Tamale Metropolis, he lamented:

"The container is not lifted regularly, but that is not the only cause of the dirty nature of the site. When even the container is empty, residents still dump on the ground. Every day I clean this site. By the next day, the place is dirty again. Sometimes children are sent here to dump refuse but they end up dumping on the ground because they are not tall enough to reach the top of the container. When I am around, I help. But when I am not, they just throw the waste on the floor near the container." (Interview: Container Site Attendant, Tamale Metropolis, July 2021)

Littering of container sites and burning of refuse in containers (Table 4.25**)** in the dry season posed public health and fire risk to surrounding residents. In

general, the percentage of littered sites (20%) is higher in the wet season than the dry season (14%). In comparing the Municipalities, Tamale (22%) and Sagnarigu (23%) have the highest percentages of littered container sites than Wa (17%) and Bolagatanga (14%). The source of the fire in containers came from hot ashes poured into container by residents.

Table 4.25: Status of container sites in study areas over a two-month period in wet and dry seasons

Study area	Container sites	Wet season (July - August 2021)		Dry season (January –February 2021)		
		Number of littered sites	% of littered sites	Number of littered sites	% of littered sites	Number of containers burnt
Tamale	58	13	22.4	9	15.5	13
Wa	30	5	16.7	3	16.7	6
Bolgatanga	22	3	13.6	2	9.1	7
Sagnarigu	22	5	22.7	4	18.2	9
Total	**132**	**26**	**19.7**	**18**	**13.6**	**35 (26.5%)**

The limited number and limited accessibility to CCs in the peripheral communities resulted in indiscriminate waste dumping. The Assembly member for Charia, a peripheral community in the Wa Municipality, said: *"We have always advocated for waste containers in this community to no avail. Since residents do not have waste containers, they dump waste behind their houses".* (Interview: An Assembly Member, Wa Municipality, July 2021)

The geospatial distribution analysis of the CCs in the municipalities was analysed using the average Nearest Neighbour Index (NNI) analysis technique

and the results on this are presented in Tables 4.33, 4.34 and 4.35. As explained by the ESRI (n.d) and Fuseini et al. (2021), the Nearest Neighbour Index (NNI) is the ratio of the observed mean distance to the expected mean distance. In a random distribution, the expected distance is the average distance between neighbouring points in the distribution (Environmental Systems Research Institute (ESRI, n.d).

4.8.3 Distribution of CCs in municipalities

The distribution of communal containers in the municipalities and metropolis was spatially mapped as shown in figures 4.3, 4.5 & 4.7. The normal distribution curves are also shown in figure 4.4, 4.6 & 4.8. The bigger black container in the insert map indicated all the CCs in the municipalities and metropolis at a smaller spatial scale of 1:250,000. This was the basis for the calculation of the average nearest neighbour index, expected and actual distances in Tables 4.26. 4.27 & 4.28.

From the normal distribution curve presented in Figure 4.4 and with a nearest neighbour ratio of 2.14, a z-score of 2.10, and a p-value of 0.27, it was observed that the communal containers in the Bolgatanga Municipality were randomly distributed. From this distribution, the observed mean distance was 191.99 meters and the expected mean distance was 168.47 meters (Table 4.26). The implication of this result is that holding all other factors constant, residents will have to travel 191.99 meters to the nearest containers to dump their waste. The z-score indicates there is a 2.10 meters deviation above the mean distance with the p-value indicating that communal containers in the Bolgatanga Municipality are randomly dispersed. Also, given the z-score of 2.10 in Table 4.26, the

distribution pattern could be said to be random. These findings are at variance with results by Fuseini et al. (2021), where distribution pattern of CCs in Ejisu Municipality in the Ashanti Region of Ghana was found to be clustered around highly commercialized areas of the town.

From the results, the observed mean distance between the communal containers in the Tamale area was 108.31 meters and the expected mean distance was 223.71 meters. The nearest neighbour ratio, the z-score, and the p-value computed are presented in Table 4.27.

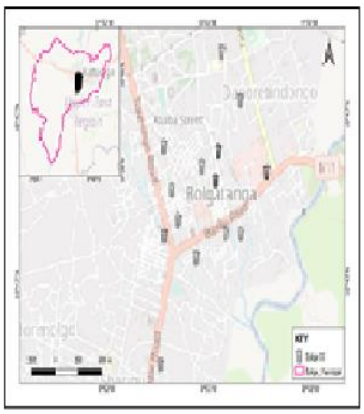

Figure 4.3: Map showing distribution of CCs in Bolgatanga

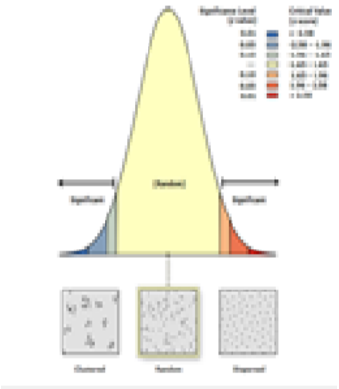

Figure 4.4: Probability normal distribution curve of Bolgatanga CCs

Table 4.26: Average nearest neighbour distance and ratio for Bolgatanga

Observed Mean Distance	191.99 Metres
Expected Mean Distance	168.47 Metres
Nearest Neighbour Ration	2.14
z-score	2.10
p-value	0.27

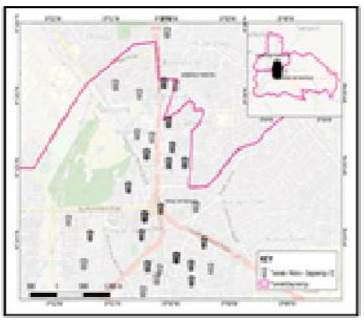

Figure 4.5: Map showing distribution of CCs in Tamale

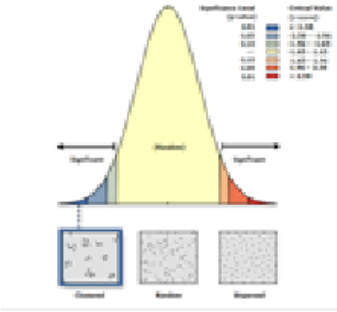

Figure 4.6: Probability normal distribution curve of Tamale CCs

Table 4.27: Average nearest neighbour distance and ratio for Tamale

Observed Mean Distance	108.31 Metres
Expected Mean Distance	223.71 Metres
Nearest Neighbour Ration	1.48
z-score	-6.77
p-value	0.00

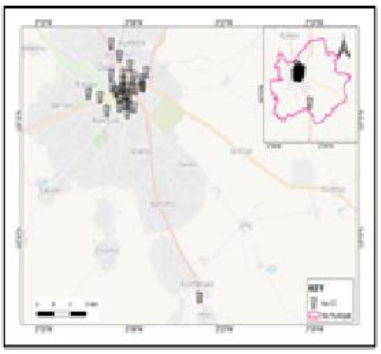

Figure 4.7: Map showing distribution of CCs in Wa

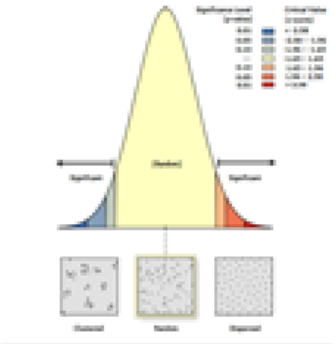

Figure 4.8: Probability normal distribution curve of Wa CCs

Table 4.28: Average nearest neighbour distance and ratio for Wa

Observed Mean Distance	191.99 Metres
Expected Mean Distance	168.47 Metres
Nearest Neighbour Ration	2.14
z-score	2.10
p-value	0.27

Source: Field Survey, 2022

The value of the nearest neighbour in the Tamale area implied a clustered pattern of the distribution of communal containers in the area (Figure 4.5), with the z-score implying a 6.77 meters deviation below the mean centre of the distribution and the p-value indicating that there was a less than 1% likelihood that this clustered pattern of communal containers within the CBD area in Tamale could be the result of random chance. These findings conformed to the distribution pattern of containers in Ejisu Municipality in the Ashanti Region of Ghana, where distribution of CCs was clustered at the commercial area of the town (Fuseini et al., 2021). Naibbi and Umar (2017) also reported of CC clustering in commercial areas in Kano, Nigeria. This Pattern of distribution is influenced by the high volume of waste generation in commercial areas and city centres.

The implication for the clustered pattern of distribution is that few residents have access to CCs for dumping waste. It also indicates that while some residents within the CBD can easily get access to CCs for dumping waste, some residents within the same CBD will have to walk long distances in order to get access to CCs for dumping waste. This might have accounted for indiscriminate dumping of waste observed in many communities within the Metropolis.

With the distribution of communal containers (CCs) in the Wa Municipality, the nearest neighbour analysis results indicated that the CCs were randomly distributed in the area. This is depicted by the probability normal graph (Figure 4.8). Table 4.28 presents the summary of the average nearest neighbour analysis of the CCs distribution in the Wa Municipality. The observed mean distance of the distribution was 631.02 meters with an expected mean distance of 587.80

meters, and a nearest neighbour ratio of 1.07 meters. This ratio indicated that the distribution of communal containers was random. The z-score implied that there was a 0.80 meters deviation above the mean centre. The p-value of 0.43 justified that the null hypothesis was valid. Given the z-score of 0.80, the pattern did not appear to be significantly different from random.

The implications for random distribution pattern is that residents within the CBD of Wa Municipality have equal access to CCs for dumping waste. The findings differed from results reported by Fuseni et al. (2021) in Ejisu and Naibbi and Umar (2017) in Kano, Nigeria. They both reported clustered distribution of waste collection containers at the city centre.

4.7.4 Waste collection

Three main formal collection systems were found in the study areas. These were public cleaning and collection, door-to-door collection and communal container collection. The public cleaning and collection and the Communal Container Collection (CCC) were operated under two modules; the Waste and Sanitation Module (WSM) and the Sanitation Improvement Package (SIP). The SIP is a public-private partnership (PPP) agreement between the private sector and Metropolitan, Municipal and District Assemblies (MMDAs) for daily solid waste collection through communal containers. SIP was the most dominant method of waste collection in the study areas. These findings are supported by the Ghana's National Solid Waste Management Strategy (2020), which reported that SIP is the largest and most crucial solid waste collection contract in Ghana. According to the reports, SIP accounts for over 70% of municipal solid waste collection in MMDAs. It is a signed contract between a single private sector

(i.e., Zoomlion Ghana Limited) and MMDAs with defined roles and responsibilities, typically for a period of four years. Under these arrangements, the private sector provides and manages an agreed number of collection vehicles, containers and sweepers for a service fee payable quarterly from earmarked funds from state institutions.

Under the Communal Container Collection (CCC) system, locating suitable sites for container placement is often a challenge. Communal containers are inefficiently distributed due to the interplay of many factors including local politics, availability of space, and community acceptance. However, an appreciable percentage of solid waste collection was through communal container collection (CCC) system, which ranged from 36.8% to 49.2%. This collection system was free for resident as it was fully financed by MMDAs. The percentage of households who had access to door-to-door waste collection services was very low (below 12.6%) for all municipalities (Table 4.29). The percentage of households who used standard waste bins (waste bins with wheels and covers) ranged from7.6% to 12.6%, falling within the low benchmark (0-49%) of Wasteaware Indicator Framework performance assessment tool (Table 4.29).

From the results in Table 4.29, the efficiency of collection ranged between 47.4% and 57.1%. This was consistent with the collection rate of 55% for Africa as reported by the World Bank in 2018. Tamale Metropolis and Sagnarigu Municipality had higher collection rates than the other study areas. This could be due to high allocation of resources for waste management in high urban areas. The number of statutory resources allocated for social services are usually

influenced by population and urbanization. MMDAs with high population and urbanization are usually allocated more resources that rural districts. In a response to a question on waste collection, the head of the Waste Management Department of the Tamale metropolis said, *"The Ministry of Local Government and Rural Development (MLGRD) allocates more resources to metropolitan areas due to high generation of waste. Collection therefore tends to be higher in urbanized MMDAs".*

The waste collection gap provides a livelihood niche for some urban poor who operate informal waste collection services for underserved urban populations.

The ratios of waste collectors to the population were 1:32, 1:26, 1:19 and 1:42 for Wa, Bolgatanga, Tamale and Sagnarigu, respectively (Table 4.29). The average ratio ranged from 1:19 to 1:42 for all municipalities and metropolis. This ratio was high and above the recommended ratio of 1:10. The implication is that workers are overwhelmed by the volume of work and tend to be ineffective. In response to the low number of staff, the regional environmental health officer (REHO) of the Upper West Region said, *"The number of staff in the department of environmental health in the Wa Municipal Assembly and other district assemblies is woefully inadequate. This situation, together with inadequate resources, makes it very difficult for officers to perform".*

Table 4.29: Status of municipal solid waste management in selected MMDAs

Aspect of physical quality	Indicator	Wa	Tamale	Bolgatanga	Sagnarigu	Standard/ Benchmark
Collection	% of solid waste collected	47.4	57.1	48.9	50.7	Low (0-49%), Low/Medium (50-60%), Medium (70-89%), Medium/High (90-98%) High (99-100%)
	% of households that have access to door to door collection	7.6	7.9	12.1	5.5	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)
	% of waste collected through communal container collection (CCC)	39.8	49.2	36.8	45.2	
	% of household using standard waste bin	7.6	7.9	12.6	5.5	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)
	Ratio of waste management and sanitation workers to population	623: 200872 1:322	1052: 374744 1:256	731: 139864 1:191	823: 341711 1: 415	1: 100

(Field Survey, 2021)

Table 4.29 Cont'd: Status of municipal solid waste management in selected MMDAs

Transport	% of enclosed collection vehicles in use	100	100	100	100	100%
	Availability of Transfer stations	No	No	No	No	Yes
	% of collected waste transported to landfill/controlled dumpsite	65	68	67	69	Low (0-49%), Low/Medium (50-69%), Medium (70-89%) Medium/High (90-98%), High (99-100%)
Treatment	Availability of functional waste processing facility	No	No	No	No	Yes
	% of waste recycled/ recovered/ treated	0.5	2.3	0.7	0.9	Low (0-9%), Low/Medium (10-24%), Medium (25-44%) Medium/High (45-64%), High (65% and above)
Disposal	Availability of engineered landfill	No	Yes	No	Yes	Yes (engineered landfill available)

% of solid waste safely disposed in landfill/ official disposal site	25	41	39	40	Low (0-49%), Low/Medium (50-60%), Medium (70-89%) Medium/High (90-98%), High (99-100%)

(Field Survey, 2021)

4.7.5 Waste disposal

The safe disposal of waste is fundamental for protecting the environment from pollution. However, waste disposal was a big problem in the study areas; with only Tamale metropolis and Sagnarigu Municipality having access to an engineered landfill. Although the Tamale landfill is engineered, it was poorly managed creating nuisance in the form of smoke, bad odour and source of flies to surrounding communities. In a response, the Assembly member for Gbalahi (community where the Tamale landfill is sited) said,

"This disposal site is causing serious health problems to us. Burning in the site engulfs the community with smoke, making it difficult to breathe. The trucks that pass through the community cause a lot of dust. In the rainy season we experience a lot of flies coming from the landfill into our homes."

Wa and Bolgatanga Municipalities disposed of waste in open dumpsites. In an earlier study, Kessman (2019) concluded that disposal by open dumping was the prevalent mode of waste disposal in Ghana. The dumpsites in the Wa and Bolgatanga Municipalities were poorly managed resulting in frequent

complaints from surrounding communities. In an interview, the Municipal Environmental Health Officer (MEHO) of the Wa Municipal Assembly said:

"Disposal has been a problem for the Assembly for many years now. The Siriyiri dumpsite, which has been used for several years, has been closed due to land litigation. The surrounding community members have been agitating for the relocation of the site and have on several occasions blocked our trucks from dumping. This year alone, we have changed three different locations as dumpsites. This is not a good practice. We need to find a permanent solution to this problem. Fortunately, the municipal assembly has partnered with Zoomlion Ghana Limited to construct a 200 metric ton waste processing plant. Construction is ongoing."

The response of the environmental health officer exemplified the state of waste disposal sites in the Wa and Bolgatanga Municipalities. Waste in open dumps creates public health risks, especially because they are often left unsegregated, untreated and uncovered (Mwesigye et al., 2012; Ogundele et al., 2018).

4.7.6 Treatment/Processing

With regards to treatment of waste, there was no formal treatment/recycling process plant in any of the study areas. The waste recovery activities seen were done by the informal sector/individuals, who engaged in this practice as a means for income and livelihood. The main materials recovered were metals, plastics, manure, and animal feed. The percentage of waste recovered (scrap metals and plastics) ranged from 0.5% in the Wa Municipality to 2.3% in the Tamale Metropolis (Table 4.29). These percentages reported might not be the true

reflection of the situation on grounds since an earlier study reported that there was a lot of informal reuse of waste as in backyard manure, and as animal feed (Weghmaan & van Niekerk, 2019). However, it was observed that waste processing/resource recovery plants were being constructed by Zoomlion in all the study areas. In an interview, the Head of the Waste Management Department (WMD) at the Tamale metropolis said, *"The Metropolitan Assembly in partnership with Zoomlion is constructing a 400 Mt/day solid waste processing plant. This plant will solve the disposal problem and help us recover resources from the waste."*

4.8. The challenges of solid waste management in municipalities

This section assesses the challenges of solid waste management in the selected localities in Northern Ghana, which is objective five of the study. The problems of solid waste management as identified by the Focus Group Discussions (FGDs) were summarized and categorized into governance, data-related, resource-related and behavioural issues (Table 4.30).

Table 4.30: Problems and suggested solutions for improving municipal solid waste management in the study areas

Key area	Problems	Solutions
Governance (Policy/legal/ political perspectives)	Poor enforcement of environmental laws Policy gaps, especially on waste data and circular economy Some environmental laws/regulations are outdated and are irrelevant in the current context Policy duplications Litigation on existing lands of dumpsite Lack of regulation on the activities of informal operators Lack of comprehensive city-wide solid waste management plans Low prioritization of solid waste management	Strict enforcement of environmental laws. Revision of policies to address gaps and current trends of the waste industry Development of policy on circular economy Regulation and formalization of the operations of informal waste collectors and scavengers Development of a single comprehensive policy on solid waste management and aligning the responsibility under one Ministry (Ministry of Sanitation and Water Resources)
Waste Data	Non-availability and or poor quality waste data Lack of comprehensive data collection system (apart from periodic population and housing census)	Develop and implement a policy on waste data collection and management Implement an electronic data collection to improve quality and credibility of data
Resources/ infrastructure	Poorly planned and layout of cities Bad road network Inadequate collection trucks and containers Inadequate waste processing facilities Inadequate staffs in waste management departments	Develop proper physical plans and ensure strict adherence Construct and maintain good roads Invest in waste management infrastructure, especially Material Recovery Facilities (MRF)

		Strengthen the sanitation levy as a source of sustainable financing for waste management
Citizens behaviour/ involvement	Poor interest of citizens in waste management issues Indiscriminate dumping of waste Regular protest over negative effects of landfill operations (Official dumpsite for Wa Municipality currently closed over citizens' protest) Poor management of disposal sites	Regular public education on waste management Close unauthorized dumpsites and gradually upgrade legally dumpsites to controlled dumping Improve upon the management of existing landfills to reduce negative effects on residents

Source: Field Survey (Focus Group Discussion)

Adequate infrastructure such as good road networks, waste processing plants, collection vehicles and landfills are very important in waste management. True to this, FGDs identified inadequate infrastructure as one the problems of waste management in the study municipalities. These findings corroborated the results by Amoah and Kosoe (2014), who asserted that poor road networks combined with few and weak collection vehicles negatively impacted solid waste collection and transportation in Ghana. Many of the roads in the municipalities and metropolis were narrow and unpaved, limiting trucks accessibility to certain areas, particularly dumpsites and slum areas. Poor roads also resulted in frequent truck breakdowns and consequently high operating costs for refuse collection operators (Hazra & Goel, 2009). In addition, poorly planned cities in terms of physical development impede the free movement of collection vehicles in the study areas.

In the opinion of discussants, Sagnarigu Municipality had better road accessibility than the three municipalities. Bolgatanga Municipality had less accessible roads, as many of the peripheral communities were not easily

accessible for waste collection services. This assertion is reflected in the service gap in Table 4.4 as Bolgatanga had a higher service gap 0.62 compared to Sagnarigu 0.51. The opinion of discussants also reflects in the distribution pattern of waste collection bins. The distribution pattern of containers in Bolgatanga are clustered, an indication of lack of accessibility to peripheral communities to provide household collection services. Distribution pattern in Sagnarigu was random, as private companies had accessibility to many of the peripheral areas to distribute waste bins and provide collection services.

Accurate waste data is fundamental for waste management planning and decisions. However, as identified by participants during the FGDs, a major setback in waste management was the lack of comprehensive, accurate, and reliable data. Accuracy on quantities of waste hauled in Tamale Metropolis and Sagnarigu Municipality were considered better than the other municipalities. The discussants gave the presence of engineered landfill with weigh bridge to record number and weight of truck as the reason for their opinion. Bolgatanga and Municipalities lack engineered landfills with weigh bridge, thereby relying on estimates to determine the quantities of waste hauled. These results are confirmed by the Africa Clean Cities Platform (2019), which highlighted that, although waste data on per capita generation, composition and quality characteristics are fundamental for proper waste management planning, many countries in Africa, including Ghana, do not have accurate data collection system in place to provide high quality waste data. The only recent formal document that attempted to compile waste management information was the 2019 Africa Solid Waste Management Data Book, which compiled waste data

through a survey (Africa Clean Cities Platform, 2019). The book compiled waste management data from 41 cities in 29 countries in Africa, covering generation rates, waste composition, socioeconomic conditions and waste management regulatory systems. The results showed that although many countries reported waste generation rates, they did not indicate the sources of their data. In addition, instead of applying empirical studies to collect data, up to 45% estimated the weight of waste generated by multiplying waste generation rate and population data.

In Ghana, the only nationwide empirical survey that characterized households' municipal solid waste was undertaken by Miezah et al. (2015). The results of the survey showed that with a per capita production of 0.47 kg and a population of 30.8 million in 2021, Ghana generated 14,476 tons of household waste (Miezah et al., 2015).

According to Kessman (2017), national reports have consistently reported a per capita generation of 1 kg of solid waste. While 0.47 kg/person/day may be considered an underestimate due to the limited scope of household solid waste data, 1 kg/person/day may just as well be a convenient estimate. The main components of household waste in Ghana are organic matter (61%) and plastics (14%) (Miezah et al., 2015). Consequently, any viable solid waste management system must address these two waste streams in order to achieve the required public health impact.

Poor Attitudes as identified by discussants of FGD, especially "use-and-throw" culture, is a serious challenge for waste management in Ghana. Discussants

generally agreed that residents in all the study municipalities exhibited poor waste disposal attitude, as many residents dispose of their solid waste indiscriminately around their houses. The negative public perception that waste collection and disposal is only the responsibility of MMDAs and waste management companies is a major problem contributing to poor waste disposal habits among citizens (Sarpong-Anane, 2015). The strong resistance by the communities to the citing of waste collection points and landfills as featured among discussants also has an impact on waste management in the study municipalities and metropolis. According to one of the discussants, complaints, agitations and unrest over the operations of the landfill and dumpsites in the municipalities and metropolis have resulted in several disruptions to solid waste operations. Incessant community resistance and demonstrations to the operations of the Wa Dumpiste led to the disruption of waste collection operations in the Wa Municipality.

The discussants also identified gaps in the main policy that governs environmental sanitation in Ghana; 2010 Environmental Sanitation Policy (ESP). According to them, although the policy has served the sector well and accounted for major improvement in the sector, there were some key gaps that have to be addressed. The policy has failed to account for major changes in trends that have taken place over the period of its implementation. The discussants suggested a review of the policy to account for new trends, especially the following:

- The new global development agenda of Sustainable Development Goals (SDGs)

- Recognizing and positioning sanitation as a human right issue as accepted by the United Nations

- Emphasizing innovations as key solutions to the current Environmental Sanitation challenges

- Highlighting on cross-cutting sector issues like climate change, circular economy, environmental sustainability, gender, children, poverty among others.

- Recognizing and highlighting the role of digital transformation in waste data collection and validation to influence public policy formulation and implementation

- The new Strategic marketing and communication of environmental sanitation service provision

- Linkages with contemporary issues related to health and environment

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides the summary of the major findings as revealed by the study. It also presents conclusions drawn from the discussion of the results obtained from the data. Finally, the chapter contains policy recommendations as well as some suggestions for future research.

5.2 Summary of major findings

The study revealed a number of findings from the analysis of data gathered from households, key informants and geographic coordinates of waste collection points in the selected municipalities in Northern Ghana. The summary of the major findings is presented according to the study objectives.

5.2.1 Assessing solid waste management service quality

Findings of the study revealed that customers' expectations for all five dimensions of service quality were not met as gap scores were all negative. Responsiveness and Reliability dimensions recorded the highest service gaps, whereas Tangibility and Empathy dimensions recorded the lowest service gaps. However, according to the findings, customers in Bolgatanga Municipality felt much better with the quality of service by providers than those in Sagnarigu Municipality, Tamale Metropolis, and Wa Municipality. The results also showed that the association between respondents' perceptions and their expectations regarding the provider's waste management service quality was statistically significant.

5.2.2 Examining the structure of solid waste governance

Findings of the study discovered inadequate involvement of key stakeholders in waste management planning and decisions, and unsustainable funding arrangement for waste management. The four main PPP arrangements for solid waste management were found to be monopolized by one company, indicating low level competition in the PPP environment of solid waste management in the study area. The findings also revealed that although solid waste policies were comprehensive, the existence of major policy gaps including a policy disconnect between national and local levels, weak institutional coordination and collaboration among relevant state agencies and stakeholders and the weak involvement of the informal sector have the potential to negatively affect solid waste governance and service delivery.

5.2.3 Efficiency analysis of solid waste collection resources

The findings showed that Wa and Bolgatanga Municipalities efficiently applied their resources three-year period (2018-2020), while Sagnarigu Municipality had inefficient operations for 2019 and 2020. In 2018, Tamale Metropolis operated inefficiently.

5.2.4 Geospatial analysis of solid waste collection containers

Findings of the study showed that patterns of distribution for the Bolgatanga and Wa Municipalities were random, while that of Tamale was clustered. The findings also showed that about half of municipal solid waste generated in the four municipalities and metropolis were collected and collection was mostly done through the CC system. It was also discovered that distribution of CCs was clustered within the CBDs of the municipalities, with no form of container

collection system for peripheral communities. Distribution pattern of containers were inefficient, resulting in inefficient collection of servicing of waste bins. Findings showed only two MMDAs (Tamale and Sagnarigu) had access to an engineered landfill for disposal of waste, while Bolgatanga and Wa used open dumpsites as means of waste disposal. The results showed there were no waste processing and resource recovery facilities in the study area therefore waste recovery activities were largely informal with no proper record keeping.

5.2.5 Challenges of solid waste management

The findings of the study identified the following as major challenges in waste management in the study area; lack of comprehensive waste data collection and management system, poor regulation of the operations of informal sector, poor harmonization of policies that guide sector operations, negative waste disposal habits of residents and weak enforcement of environmental laws (see Table 4.19 for details)

5.3 Conclusions

The study assessed the performance of municipal solid waste management systems in selected municipalities in Northern Ghana from the perspectives of governance, service quality, and efficiency of allocation and use of waste collection resources.

Firstly, the study assessed the quality of service delivered by private companies to customers and found that customers' expectations for all five service dimensions were unmet. Responsiveness and Reliability dimensions recorded the highest service gaps, whereas Tangibility and Empathy dimensions recorded

the lowest service gaps. The quality of service was evident in irregular lifting of containers resulting in spillage of refuse at container sites.

Secondly, the study assessed institutional governance of solid waste management focusing on stakeholder inclusivity, financial sustainability, national and local institutional capacity and compliance of existing PPP agreements with principles spelt out in the PPP policy framework of Ghana. There was inadequate involvement of key stakeholders in waste management planning and decisions, and unsustainable funding arrangement for waste management. The four main PPP arrangements for solid waste management identified were monopolized to one company, indicating low level of competition in the PPP space of solid waste management in the study areas.

Thirdly, the study analysed the right quantities of each resource input and output for effective and efficient waste collection. The average efficiency score for all MMDAs was 0.75, implying input resources could be reduced by 25% without impacting negatively on efficiency. There are managerial, operational and investment implications for conclusions drawn from the study. The optimal combination of assets, labour, number of trucks and waste collection bins are required to improve efficiency of waste collection.

Fourthly, the study used Nearness Neighbour Index (NNI) to analyse the spatial distribution pattern of waste collection containers in northern Ghana. Generally, the distribution pattern of waste containers was inefficient, with clustering of CCs within CBDs of municipalities and virtually no form of container collection system for peripheral communities. HWBs were generally located and used in

medium to high class residential areas in the municipalities. The inadequate and inefficient distribution pattern of containers contributed to indiscriminate dumping, especially in peripheral communities.

Lastly, the key challenges of municipal solid waste management identified were lack of comprehensive waste data collection system, poor harmonization of sector policies, negative waste disposal habits of residents and weak enforcement of environmental laws.

5.4 Recommendations

Based on the findings of the study, the following recommendations were made to improve solid waste governance, service quality and efficiency in the selected municipalities in Northern Ghana. Recommendations are in two parts; Policy and Research:

5.4.1 Policy Recommendations

- The study identified the highest service gaps in Reliability and Responsiveness dimensions of waste management service quality. To improve service quality and customer satisfaction, it is recommended that collection service providers (waste collection companies) should focus on improving business processes that affect the prompt and reliable collection of waste.
- Solid waste management service is at its embryonic stage in the municipalities. As the municipalities make progress in service delivery, the study recommends that the WMDs develop and enforce waste management operational and services standards.

- The study found out a weak institutional coordination, collaboration and synergy among relevant state agencies, where the powers of the Municipal Assemblies are usurped by the Central Government. Therefore, the study recommends re-alignment and streamlining roles and responsibilities of state actors by the Ministry of Sanitation and Water Resources to eliminate duplications, especially with relevant sector ministries and agencies. Specifically, the study recommends the de-monopolization of the sector and the decentralization of the signing and executions of waste management contracts from Ministry level to the Municipal Assembly level to ensure ownership and accountability.
- There was a weak involvement of the informal sector in solid waste governance and service delivery in the Municipalities of Wa and Bolgatanga. Considering the important role played by the informal sector, it is recommended that the Municipal Assemblies regulate the activities of the activities of the informal sector and strongly positioned position as a main player in the delivery of solid waste management services
- The Geospatial information showed inadequate and inefficient distribution of communal containers. The study therefore recommends the supply of additional containers and re-distribution of existing containers based the Municipal Assemblies based on rate of generation and equity of service to improve accessibility and efficiency of collection services
- Since municipalities have no adequate and sustainable funding for additional communal waste collection, it is recommended the Municipal Assemblies activate the polluter pays principle, especially for businesses that generate waste in the central business areas. Additionally, the sanitation levy should be

reviewed by the Ministry of Sanitation and Water Resources to anchor the sustainable financing of PPPs in the waste management sector

- Attitudes, especially "use-and-throw" culture, is a serious challenge for waste management in the municipalities. The study recommends the implementation of regular behavioural change communication programmes and activities by the Ministry of Sanitation and Water Resources. This should be complemented with sanctions for flouting sanitation by-laws of the municipalities.

5.4.2 Research Recommendations

- The main challenge that was encountered during the study was data availability, accuracy and integrity. There is the need for research into the collection and quality of waste data in Ghana and how digitization can be used to standardise waste data for quality control and assurance
- Additionally, operational and service quality standards are not well developed in waste management industry in the Municipalities. As the waste industry metamorphosises and gravitates toward maturity, there is the need for research on waste management service quality standardizations

5.4.3 Original Contribution to Knowledge

The study unveiled the actors, forces and agencies shaping municipal solid waste architecture in the study areas. The study also identify what can be aptly described as a state-sponsored monopoly, where the waste management spaces in all the four study localities are dominated by a single private waste management company. Additionally, the study broadens the scholarly understanding of how non-compliance with MSWM governance principles has

the potential to affect waste management efficiency and sustainability. The study contributed to the development of two (2) attributes for Assurance dimension and one (1) attribute for Tangibility dimension specific to waste service quality. The last contribution to knowledge is the provision of empirical evidence of solid waste collection efficiency by private companies in the selected municipalities

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Appendix I

SURVEY OF EXPECTATIONS AND PERCEPTIONS OF SOLID WASTE MANAGEMENT SERVICE IN SLECTED MUNICIPALITIES IN NORTHERN GHANA

Based on your experience with solid waste management service, on a scale of 1-5, indicate how well you are satisfied or dissatisfied with the following statement. I-Strongly dissatisfied, 2-dissatisfied, 3-neither satisfied nor dissatisfied, 4-satisfied, 5-strongly satisfied)

		My EXPECTATION (what the service should offer) is:					My PERCEPTION (what the service offered) is:				
When it comes to:		Low	----------			High	Low	----------			High
	Reliability										
1	Company provides services as promised	1	2	3	4	5	1	2	3	4	5
2	Company is dependable is handling customer service	1	2	3	4	5	1	2	3	4	5
3	Company provides service right at first time	1	2	3	4	5	1	2	3	4	5
4	Company provides service at the promised time	1	2	3	4	5	1	2	3	4	5
5	Company maintains error-free records	1	2	3	4	5	1	2	3	4	5
6	Company keeps customers informed when their service will be performed	1	2	3	4	5	1	2	3	4	5
7	Company delivers prompt service to customers	1	2	3	4	5	1	2	3	4	5
8	Company is willing to help customers	1	2	3	4	5	1	2	3	4	5
9	Company is always ready to respond to customers request	1	2	3	4	5	1	2	3	4	5
Assurance											

10	Employees instill confidence in customers	1	2	3	4	5		1	2	3	4	5
11	Employees make customers in safe in their transactions	1	2	3	4	5		1	2	3	4	5
12	Employees are consistently courteous to customers	1	2	3	4	5		1	2	3	4	5
13	Employees are knowledgeable to answer questions	1	2	3	4	5		1	2	3	4	5
14	Employees give customers individual attention	1	2	3	4	5		1	2	3	4	5
15	Employees deal with customers in a caring manner	1	2	3	4	5		1	2	3	4	5
16	Company has customers' interest at heart	1	2	3	4	5		1	2	3	4	5
17	Employees understand the need of customers	1	2	3	4	5		1	2	3	4	5
18	Company provides services at convenient business hours	1	2	3	4	5		1	2	3	4	5
19	Use modern equipment to deliver service (eg compaction trac)	1	2	3	4	5		1	2	3	4	5
20	Uses visually appealing facilities to deliver service	1	2	3	4	5		1	2	3	4	5
21	Employees of company wear neat uniform and are professional	1	2	3	4	5		1	2	3	4	5
22	Company delivers service without damaging assets of customers	1	2	3	4	5		1	2	3	4	5

23	Service is delivered without unnecessary noise and bad odour	1	2	3	4	5		1	2	3	4	5
	Reliability Importance of Service Dimensions Allocate 100 points to service dimension relative to their importance to the overall service	Reliability (..%) Responsiveness (..%) Assurance (..%) Empathy (..%) Tangibility (..%)										

Appendix II:

Questionnaire for Assessment of Solid Waste Governance

This questionnaire is part of a PhD thesis being conducted by a student of the Department of Environment and Sustainability Sciences at the University for Development Studies, Tamale on the topic,

"ASSESSING THE PERFORMANCE OF PUBLIC-PRIVATE PARTNERSHIPS IN SOLID WASTE MANAGEMENT IN SELCTED MUNICIPALITIES IN NORTHERN GHANA".

Instructions: Circle your response and provide an explanation where required

A. Stakeholder inclusivity

1. Do all sections of the town/city/electoral area receive solid waste management service? (yes/no). If no,
   why?.....
2. Are users of waste management services consulted in waste management planning in the city/town? (yes/no). If yes
   how?.....
   If no

   why……
3. Is there a complaints redressal system in place for the public? (yes/no)
4. Are stakeholder meetings organized? (yes/no). If yes, how often ? (Monthly, quarterly, half-yearly etc.)
5. How often does the sanitation sub-committee of the Assembly meet? (Monthly, Quarterly, half-yearly)
6. How often does the waste management/environmental health unit carry out public sensitization/education? Daily, monthly, quarterly …….
7. Do private partners participate in meetings of the environment and sanitation sub-committee and how? Yes /No
8. Are private partners consulted during annual budget preparation on waste management and sanitation? (yes/no)

9. Are informal waste collectors/scavengers organized into an association and their activities regulated? (yes/no)
10. Is there a standard mechanism for the determination of waste collection fees in the Assembly? Yes/No
11. Are the processes f+or contracting private waste management companies transparent? Yes/No
12. As a member of the Assembly, do have an idea of the processes involved in engaging private waste contractors. (Yes/No

B. Financial arrangement

13. Is the annual budget on waste management adequate to cover the full cost of providing waste management service? (Yes/No)
14. Estimate percentage of the total number of households both using and paying for primary waste collection services
15. As an Assembly Member, do you have full and accurate information on the cost of solid waste management within the municipality? (Yes/ No)
16. Are solid waste management service fees affordable to users? Yes/No
17. How are those who cannot afford waste management services catered for? (free service, subsidized rate,……)

C. Knowledge/national policy and institutional adequacy

18. Do you know any policies that govern solid waste management in Ghana? (yes/no)
19. Are the policies that govern solid waste management comprehensive? Yes/No
20. Are there any gaps in the policies? (yes/no). If yes mention the gaps?.....
21. Is there a national strategy for addressing solid waste management? (yes/no)
22. Are there clear guidelines for implementing the national strategy at the local level? (yes/no)
23. Is there a single institution that coordinates the implementation of solid waste management strategy? (yes/no)
24. If there is no single institution coordinates solid waste management, how effective do the institutions coordinate and collaborate? (not effective, effective, very effective)
25. Does the regulatory agency (Environmental Protection Agency) enforce legislation on solid waste management? (yes/no)

D. Adequacy of local institutional capacity

26. Is the function of solid waste management service provision concentrated in one department? (Yes/No)
27. Is the waste management department of the Assembly adequately resourced in terms of human and equipment resources to perform their function? (Yes/No)
28. Does the municipality/metropolis have a solid waste management strategy? (Yes/No)
29. If there is a solid waste management strategy for the Assembly, is it implemented? (Yes/No)
30. Are data on solid waste being collected (Yes/No)
31. If yes, how? (Manually/electronically/ both)
32. Are solid waste service providers effectively supervised and monitored? (Yes/No)

If yes,

how?.....

If no,

why……

33. Does the Municipal Assembly have bye-laws on sanitation? (Yes/No)
34. Are the bye-laws implemented (Yes/No)
35. Are the bye-laws gazette (Yes/No)
36. Do you have access to the bye-laws (Yes/No)

Thank you

Appendix III:

Interview guide on the nature/structure of solid waste management PPPs arrangement

Public Partner- Metropolitan and Municipal Assemblies

Scope and duration of PPP agreement

1. Does the Assembly have any PPP agreement with private companies) for the delivery of solid waste management services?
2. How many private companies does the Assembly have agreement with?
3. How many years are the agreements?
4. What are the roles and responsibilities of the Assembly in the agreements?
5. Does the scope in the agreement cover all relevant aspects of solid waste management? Yes/No

a. If yes why?
b. If no why?
a. If yes why?
b. If no why?

Mechanisms for monitoring, evaluation and compliance

6. Is there a monitoring and evaluation mechanisms for partners and are the mechanisms adequate?
7. Do the PPP agreement specify service levels?
8. Are the service levels complied with?
9. Are there sanctions for non-compliance with service performance levels?
10. Are the sanctions for non-compliance enforced?

a. If yes how?
b. If no why?

Bidding/procurement process

11. What were the processes leading to the selection of private partner?
12. In your opinion, did the processes comply with competitive tendering process as stipulated in the PPP Policy Framework of Ghana? Yes/No

a. If yes, why?

b. If no, why?

Sound institutions and proactive policies

13. Is there a comprehensive national law(s) in place to address solid waste management requirements? Are the laws and policies effective?
14. Is there a single institution at the national level that is charged with the responsibility of implementing, or coordinating the implementation of solid waste management strategy/policy?
15. Is there a well-organized and adequately resourced environmental regulatory agency? Does it enforce the legislation so as to ensure solid waste management is delivered in compliance with regulations?
16. Is there a recent strategy or plan in place & being implemented at the city (or regional) level for solid waste management? Is the strategy/plan effective in managing solid waste?
17. Does the MMDA have sanitation bye-laws and are they gazetted and supporting the implementation of the PPP agreement?
18. Is there a functional sub-committee on environment and sanitation and how often does it meet?

Financial sustainability

19. What is the financial arrangement with the private partner and is such arrangement favourable to the Assembly?
20. Does the MMDA determine the fees for waste collection? If so, what are the factors considered?
21. Does the Assembly have accurate and full information on the cost of waste management?
22. What percentage of the annual budget of MMDA is spent on solid waste? Is the allocation adequate to cover the full costs of providing the service?
23. Is dumping fee charged? If so, is the amount charged adequate to cover the operational cost of the dumpsite/landfill?

Stakeholder Inclusivity and participation

24. Do stakeholders participate in the solid waste management system? How do they participate?
25. Are stakeholder meetings on solid waste management organized? If they are organized, how regular are the meetings?
26. Are public education/sensitization activities on waste management organized? How regular are they organized?
27. Do private sector partners in solid waste management participate in solid waste management planning and operational sanitation sub-committee meetings at MMDA?
28. Are informal actors/scavengers organized into associations and incorporated into formal waste management system?

Challenges

29. What are the challenges and opportunities in the agreements?
30. What are your suggestion(s) for overcoming the challenges and enhancing the agreements?

b. Guide for Private Partners/Waste management companies

Scope and duration of PPP agreement

1. Does your company have any PPP agreement (s) with MMDA for solid waste management?
2. If yes, how long is the agreement?
3. What is your opinion about the length of agreement?
4. What are the roles and responsibilities of your company in the agreement(s)

Financial arrangement

5. What are the payment arrangement with the MMDA and is your company satisfied with such arrangements?
6. Does the private sector have access to capital for investment? Are the conditions for lending favarouble?

Challenges

7. What are the challenges and opportunities in the agreement(s)
8. What suggestions could you propose to overcome the challenges and enhance the opportunities in the agreement(s)

c. Focused Group Discussion Guide

1. What are the challenges of municipal solid waste management in the municipalities?

2. How can the challenges be solved to improve municipal solid waste management in the municipalities?

Appendix IV: Data for Efficiency Analysis of Solid Waste Collection

MMDA	**Tamale**			**Wa**			**Bolgatanga**			**Sagnarigu**		
Output factors	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
Quantity of waste hauled (tons)	37,699	51,045	57,059	23,270	26,870	30,372	25,885	26,640	29,301	13,444	13,208	25,799
Revenue generated'000 (GHS)	2,335	3,922	5,169	1,525	1,459	1,931	839	846	957	208	1,289	5,681

MMDA	**Tamale**			**Wa**			**Bolgatanga**			**Sagnarigu**		
Input factors	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
Total assets	2,034	1,358	685	2,472	1,864	2,499	1,379	1,245	965	43	298	648

(000) GHS												
No of trucks deployed	4	9	9	4	5	6	3	3	3	2	3	3
Number of dustbins serviced	3,645	5,962	7,006	2,790	3,165	3,773	3,494	3,525	4,039	1,934	1,893	4,029
Number of clients serviced	3,561	5,789	6,981	1,073	1,413	1,289	1,088	1,313	1,638	1,847	1,751	2,931
Number of staff	51	79	77	76	76	76	71	71	71	55	55	55

Appendix V: CCR models DMUs for 2018 and 2020 operational years

2018 operational year:

DEA CCR model for a given DMU was formulated as follows:

Target DMU (Max θ) $= v_1 y_{1o} + v_2 y_{2o} + \cdots + v_r y_{ro}$

s.t. $u_1 x_{1o} + u_2 x_{2o} + \cdots + u_m x_{mo} = 1$

$v_1 y_{1i} + v_2 y_{2i} + \cdots + v_r y_{ri} \leq u_1 x_{1i} + u_2 x_{2i} + \cdots + u_m x_{mi}$, $\quad i = 1, \ldots, n$
$u_1, u_2, \ldots., u_m \geq 0$

$v_1, v_2, \ldots., u_r \geq 0.$

y_r= amount of output r

v_r= weight assigned to output r

x_i= amount of input i

u_i= weight assigned to input i

The linear programming (LP) formulated out of the data for 2018 operational year are as followed:

Max: DMU1 (Tamale) = $37699v_1 + 23354v_2$;

Subject to: $2034u_1 + 4u_2 + 3645u_3 + 3561u_4 + 51u_5 = 1$;

$37699v_1 + 23354v_2 - (2034u_1 + 4u_2 + 3645u_3 + 3561u_4 + 51u_5) \leq 0$;

$23270v_1 + 1525v_2 - (2472u_1 + 4u_2 + 2790u_3 + 1073u_4 + 76u_5) \leq 0$

$25885v_1 + 839v_2 - (1379u_1 + 3u_2 + 3494u_3 + 1088u_4 + 71u_5) \leq 0$;

$3444v_1 + 208v_2 - (43u_1 + 2u_2 + 1934u_3 + 1847u_4 + 55u_5) \leq 0$;

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Max: DMU2 (Wa) = $23270v_1 + 1525v_2$;

Subject to: $2472u_1 + 4u_2 + 2790u_3 + 1073u_4 + 76u_5 = 1$;

$37699v_1 + 23354v_2 - (2034u_1 + 4u_2 + 3645u_3 + 3561u_4 + 51u_5) \leq 0$;

$23270v_1 + 1525v_2 - (2472u_1 + 4u_2 + 2790u_3 + 1073u_4 + 76u_5) \leq 0$

$25885v_1 + 839v_2 - (1379u_1 + 3u_2 + 3494u_3 + 1088u_4 + 71u_5) \leq 0$;

$3444v_1 + 208v_2 - (43u_1 + 2u_2 + 1934u_3 + 1847u_4 + 55u_5) \leq 0$;

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Max: DMU3 (Bolgatanga) = $25885v_1 + 839v_2$;

Subject to: $1379u_1 + 3u_2 + 3494u_3 + 1088u_4 + 71u_5 = 1$;

$37699v_1 + 23354v_2 - (2034u_1 + 4u_2 + 3645u_3 + 3561u_4 + 51u_5) \leq 0$;

$23270v_1 + 1525v_2 - (2472u_1 + 4u_2 + 2790u_3 + 1073u_4 + 76u_5) \leq 0$

$25885v_1 + 839v_2 - (1379u_1 + 3u_2 + 3494u_3 + 1088u_4 + 71u_5) \leq 0$;

$3444v_1 + 208v_2 - (43u_1 + 2u_2 + 1934u_3 + 1847u_4 + 55u_5) \leq 0$;

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Max: DMU4 (Sagnarigu) = $3444v_1 + 208v_2$;

Subject to: $1379u_1 + 3u_2 + 3494u_3 + 1088u_4 + 71u_5 = 1$;

$37699v_1 + 23354v_2 - (2034u_1 + 4u_2 + 3645u_3 + 3561u_4 + 51u_5) \leq 0$;

$23270v_1 + 1525v_2 - (2472u_1 + 4u_2 + 2790u_3 + 1073u_4 + 76u_5) \leq 0$

$25885v_1 + 839v_2 - (1379u_1 + 3u_2 + 3494u_3 + 1088u_4 + 71u_5) \leq 0$;

$3444v_1 + 208v_2 - (43u_1 + 2u_2 + 1934u_3 + 1847u_4 + 55u_5) \leq 0$;

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

2020 operational year:

DEA CCR model for a given DMU in 2020 was formulated as follows:

Target DMU (Max θ) $= v_1 y_{1o} + v_2 y_{2o} + \cdots + v_r y_{ro}$

s.t. $u_1 x_{1o} + u_2 x_{2o} + \cdots + u_m x_{mo} = 1$

$v_1 y_{1i} + v_2 y_{2i} + \cdots + v_r y_{ri} \leq u_1 x_{1i} + u_2 x_{2i} + \cdots + u_m x_{mi}$, $\quad i = 1, \ldots, n$
$u_1, u_2, \ldots., u_m \quad \geq 0$

$v_1, v_2, \ldots., u_r \quad \geq 0.$

y_r= amount of output r

v_r= weight assigned to output r

x_i= amount of input i

u_i= weight assigned to input i

The Linear Programming (LP) formulated out of the data:

Max: DMU1 (Tamale) = $57059v_1 + 5169v_2$;

Subject to: $685u_1 + 9u_2 + 7006 + 6981u_4 + 77u_5 = 1$;

$57059v_1 + 5169v_2 - (685u_1 + 9u_2 + 7006 + 6981u_4 + 77u_5) \leq 0$;

$30372v_1 + 1931v_2 - (2499u_1 + 6u_2 + 3773u_3 + 1289u_4 + 76u_5) \leq 0$

$29301v_1 + 957v_2 - (965u_1 + 3u_2 + 4029u_3 + 1638u_4 + 71u_5) \leq 0$;

$25799v_1 + 5681v_2 - (648u_1 + 3u_2 + 4029u_3 + 2931u_4 + 55u_5) \leq 0$;

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Max: DMU2 (Wa) = $30372v_1 + 1931v_2$;

Subject to: $2499u_1 + 6u_2 + 3773u_3 + 1289u_4 + 76u_5 = 1$;

$57059v_1 + 5169v_2 - (685u_1 + 9u_2 + 7006 + 6981u_4 + 77u_5) \leq 0$;

$30372v_1 + 1931v_2 - (2499u_1 + 6u_2 + 3773u_3 + 1289u_4 + 76u_5) \leq 0$

$29301v_1 + 957v_2 - (965u_1 + 3u_2 + 4029u_3 + 1638u_4 + 71u_5) \leq 0;$

$25799v_1 + 5681v_2 - (648u_1 + 3u_2 + 4029u_3 + 2931u_4 + 55u_5) \leq 0;$

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Max: DMU3 (Bolgatanga) = $29301v_1 + 957v_2;$

Subject to: $965u_1 + 3u_2 + 4029u_3 + 1638u_4 + 71u_5 = 1;$

$57059v_1 + 5169v_2 - (685u_1 + 9u_2 + 7006 + 6981u_4 + 77u_5) \leq 0;$

$30372v_1 + 1931v_2 - (2499u_1 + 6u_2 + 3773u_3 + 1289u_4 + 76u_5) \leq 0$

$29301v_1 + 957v_2 - (965u_1 + 3u_2 + 4029u_3 + 1638u_4 + 71u_5) \leq 0;$

$25799v_1 + 5681v_2 - (648u_1 + 3u_2 + 4029u_3 + 2931u_4 + 55u_5) \leq 0;$

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Max: DMU4 (Sagnarigu) = $25799v_1 + 5681v_2;$

Subject to: $648u_1 + 3u_2 + 4029u_3 + 2931u_4 + 55u_5 = 1;$

$57059v_1 + 5169v_2 - (685u_1 + 9u_2 + 7006 + 6981u_4 + 77u_5) \leq 0;$

$30372v_1 + 1931v_2 - (2499u_1 + 6u_2 + 3773u_3 + 1289u_4 + 76u_5) \leq 0$

$29301v_1 + 957v_2 - (965u_1 + 3u_2 + 4029u_3 + 1638u_4 + 71u_5) \leq 0;$

$25799v_1 + 5681v_2 - (648u_1 + 3u_2 + 4029u_3 + 2931u_4 + 55u_5) \leq 0;$

$$v_1, v_2, u_1, u_2, u_3, u_4, u_5 \geq 0$$

Appendix VI: Test of Homogeneity of Variances

Performance Indicators	Levene Statistic	df1	df2	p-value
Value for money	3.286	67	4556	0.058
Accountability	0.000	67	4556	1.000
Competitiveness	1.557	67	4556	0.251
Stakeholder consultation	0.500	67	4556	0.689
Affordability	1.419	67	4556	0.285
Local content	0.881	67	4556	0.479
Clear objectives and targets	0.783	67	4556	0.526
Clear roles and responsibilities of partners	0.158	67	4556	0.923
Period of agreement	6.000	67	4556	0.010
General performance	0.322	67	4556	0.809

Source: Field Survey, 2022 (N=68)