IMPACT OF ENVIRONMENTAL RESOURCE MANAGEMENT ON THE OPERATIONS OF MICRO, SMALL AND MEDIUM ENTERPRISES IN LANGATA, NAIROBI

by

KAGO KARURI

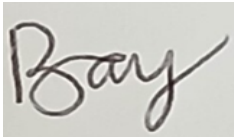
A Thesis submitted in partial fulfilment of the requirements for the award of the degree of Master of Environment and Natural Resource Management in the department of Environment and Natural Resource Management and the school of Science and Technology of Africa Nazarene University

2026

DECLARATION

I declare that this document and the research that they describe are my original work and that they have not been presented in any other university for academic work.

Name: Kago Karuri (110062952)

Student signature  Date **15/04/2026**

This research was conducted under our supervision and is submitted with our approval as university supervisors.

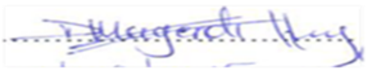
Supervisor name: **Dr. David Mugendi (PhD)**

Department of Zoology

College of Physical and Applied Sciences

Jomo Kenyatta University of Agriculture and Technology (JKUAT)

P.O. Box 62000 – 00200 Nairobi, Kenya

University supervisor signature…  … Date 30th April, 2026...

Supervisor name: **Dr. Sharon Jones (PhD)**

University supervisor signature…  …… Date…29th April, 2026………**Africa Nazarene University**

P.O BOX 53067 00200 Nairobi, Kenya.

EXAMINERS' SIGNATURES

We have examined this document and the research has met or exceeded the requirement for the degree sought, in addition, the candidate has sufficiently defended the material presented to merit the awarding of the degree of (the name of the degree being awarded.

Dr. Micky Mwamuye

Internal examiner – (Typed name)

2nd May, 2026

Internal examiner signature | Date (dd/mm/yyyy)

Dr Christine Majale

External examiner – (Typed name)

1st June, 2026

External examiner signature | Date (dd/mm/yyyy)

Notes: (Pass, Pass with Distinction)

DEDICATION

This work is dedicated to my family and friends for their unwavering belief and support throughout this academic journey. It is equally dedicated to my supervisors, Dr. David K. Mugendi and Dr. Sharon M. Jones, whose invaluable guidance and support made this thesis possible.

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I express my sincere gratitude to my supervisors, Dr. David Mugendi and Dr. Sharon Jones, for their invaluable guidance, insightful feedback, and unwavering support throughout this research. I am also deeply grateful of the faculty and staff of Africa Nazarene University, particularly the Department of Environment and Natural Resource Management for providing a supportive academic environment and vital resources necessary to complete this study. Finally, I extend my appreciation to all the researchers, and professionals whose foundational work in sustainable business practices guided the framework of this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Micro, Small, and Medium Enterprises (MSMEs) in Langata Constituency operate within a highly volatile urban ecosystem characterized by severe resource constraints, including irregular municipal water supply, escalating electricity tariffs, frequent power grid outages, and inadequate solid waste management infrastructure. This study investigated the operational and financial implications of the water-energy-waste nexus among localized commercial operators, focusing specifically on how resource consumption, energy efficiency, and material recovery practices influence overall business performance. Theoretically anchored upon the Resource-Based View (RBV) framework, the research positioned sustainable utility optimization as a core internal strategic asset capable of driving operational resilience and distinct cost advantages. The study adopted a mixed-methods research design, deploying concurrent triangulation to systematically merge qualitative key informant insights with qualitative field data collected from a high-integrity sample of seventy-five (75) actively operating manufacturing, service, and trading MSMEs clustered within the diverse administrative wards of Langata. Primary data collection was executed utilizing structured questionnaires, field observations, and semi-structured interviews. Quantitative analysis was conducted in R-Studio using descriptive metrics, Spearman's Rank Correlation, and Multiple Linear Regression (MLR) modelling, while qualitative themes were processed via thematic analysis. The empirical findings revealed complex, asymmetric relationships within the urban resource nexus. Multiple Linear Regression analysis established that a unit increase in structural water sustainability practices significantly reduced monthly expenditures by KES 26.72, underscoring the immediate financial return of efficiency technologies. Conversely, Spearman's correlation tests demonstrated a weak positive correlation (rho = 0.1427) between enterprise sustainability scores and monthly electrical bills, highlighting that baseline technological inefficiencies and fixed tariff structures frequently overshadow isolated conservation behaviors. Within the waste sector, MLR modelling proved that enterprise sustainability scores ($p = 0.939$), weekly waste volumes (bags disposed; $p = 0.340$), and industry sector classifications exerted no statistically significant influence on localized waste disposal costs (overall model P – value = 0.7881). This anomaly is driven by institutional market rigidities, specifically the prevalence of flat-rate monthly private collection fees that fail to reward source segregation or volume minimization. Qualitative data synthesized from field observations indicated that immediate cost-saving utility reductions serve as the primary catalyst for micro-scale conservation, while rigid, non-negotiable flat-rate disposal fees act as a structural hinderance to effective material recovery. Current enterprise sustainability frameworks remain profoundly inadequate relative to rapidly accelerating urban consumption trends, and local regulatory compliance remains fundamentally reactive rather than driven by Corporate Social Responsibility (CSR). Consequently, physical resource scarcity forces vulnerable operators to depend on highly inflated, informal private water markets and expensive generator fuels. The study concluded that while natural resource management among Kenyan urban MSMEs is currently driven strictly by short-term economic survival, structured efficiency can be leveraged as a transformative business strategy to secure long-term operational resilience.

DEFINITION / OPERATIONAL TERMS

Sustainable Business Model Innovation (SBMI): a model that changes how a firm operates to create positive impacts or reduce negative consequences for the environment and society.

System Average Interruption Duration Index (SAIDI): measures the total duration of power outages experienced by a customer over a given period.

System Average Interruption Frequency Index (SAIFI): measures how often a customer experiences power outages.

Total Productive Maintenance (TPM): a proactive maintenance approach that aims to maximize equipment efficiency and prevent breakdowns.

Resource-based View (RBV): a theory indicating that possessing essential resources enables a firm to create competitive advantage and enhance performance.

Business Models for Circular Economy (BMCE): a strategic framework that moves from the basic linear economic model to the circular economic model.

R – Studio: a free, open-source statistical software and programming language used for statistical data analysis.

ABBREVIATIONS / ACRONYMS

BMCE: Business Models for Circular Economy

CSR: Corporate Social Responsibility

DRC: Democratic Republic of Congo

EMCA: Environmental Management and Co-ordination Act

EMIs: Easy Monthly Installments

EPRA: Energy and Petroleum Regulation Authority

FERFA: Foreign Exchange Rate Fluctuation Adjustment

GDP: Gross Domestic Product

GHGs: Greenhouse Gas emissions

GWh: Gigawatt Hours

INFA: Inflation Adjustment

KR – 20: Kuder-Richardson 20 (KR-20)

KWH: Kilowatt Hours

LED: Light-Emitting Diode

LPG: Liquid Petroleum Gas

MLR: Multiple Linear Regression

MSMEs: Micro, Small and Medium Enterprises

MSW: Municipal Solid Waste

MWh: Megawatt Hours

NACOSTI: National Council for Science Technology and Innovation

NCWSC: Nairobi City Water and Sewerage Company Limited

RBV: Resource-based View

SDGs: Sustainable Development Goals

SME: Medium, small and micro enterprises

SMEs: Small and Medium enterprises

SSF: Security Support Facility

SWM: Sustainable Waste Management

TWh: Terawatt Hours

UNSDGs: United Nations Sustainable Development Goals

VAT: Value Added Tax

WM: Waste Management

CHAPTER ONE

INTRODUCTION AND BACKGROUND INFORMATION

1.1 Introduction

This chapter outlines the background of the study and statement of the problem, as well as the purpose, objectives and research questions of the study, the study's significance, scope, delimitations, limitations, assumptions, theoretical framework and conceptual framework.

1.2 Background of the Study

The sustainable management of critical resource inputs such as water and energy, alongside the mitigation of operational waste has become critical for business operations globally, particularly for micro, small and medium enterprises (MSMEs**)** that have limited resources and narrow profit margins. Environmental pressures, rising utility costs, and stricter regulatory demands have increased MSMEs necessity to adopt greener business practices, yet their response capacity varies depending on policy support, financing options, access to technology, and awareness.

MSMEs are categorized differently across countries. In the United States, micro-enterprises have 1–10 employees, small enterprises 11–50, and medium enterprises 50–250 employees (Liberto, 2024). In Kenya, the Micro and Small Enterprises Act (2012) defines micro-enterprises as firms with fewer than 10 employees and an annual turnover below Ksh 500,000. Small enterprises have 10–49 employees with a turnover between Ksh 500,000 and Ksh 5 million, while medium enterprises employ 51–100 people and generate Ksh 5–800 million annually. Despite varying classifications, MSMEs collectively play a significant economic role by contributing to GDP, job creation, innovation, entrepreneurship, and regional development. As sustainability pressures intensify, the green business concept has gained prominence. Green enterprises refer to companies that operate in a manner that causes minimal harm to the environment (Safdie, 2024). Most MSMEs recognise the importance of sustainability, their ability to transition into green operations remains constrained by financial, informational, and infrastructural challenges, especially in developing economies.

In China, water scarcity has prompted government intervention through policy shifts such as introducing a water tax for high-stress provinces, raising operational costs, and increasing compliance due to tax authority enforcement (Zhou, 2024).

Similarly in Europe, MSMEs are both vulnerable users and emerging innovators. Water-related risks such as droughts, floods, and operational disruptions, affect sectors like construction, food processing, and textiles (Brieger, 2025). However, MSMEs adapt by developing technologies in greywater reuse, smart monitoring, and precision irrigation. In energy use, 12% of MSMEs generate renewable energy onsite and 23% purchase it (European Commission, 2024), though high administrative costs and regulatory procedures remain a barrier. Waste management policies under the European Green Deal and Circular Economy Action Plan encourage MSMEs to adopt circular economy practices. Proposed incentives include reduced VAT for repair services and repair bonuses (Brieger, 2023).

Additionally, in the United States, MSMEs face increasing water-use restrictions in drought-prone states such as California, affecting high water consuming businesses (Dumont, 2025). The country generates over 12% of the world’s municipal solid waste, with 62% of it ending up in landfills or incineration (Trash in America, 2025). Energy costs are projected to rise due to market dynamics, increasing the cost of doing business and disrupting supply chains (DNE, 2025). Policy responses include bans on single-use plastics and shifting recycling responsibility to manufacturers.

In contrast, MSMEs in India contribute nearly 30% to national GDP, yet struggle with rising energy costs that account for 10–20% of revenues (Miller et al., 2025). Reliance on costly diesel or grid power reduces profitability, though accessible financing options for solar installations, such as collateral-free EMIs, are becoming increasingly available.

Common global challenges related to high utility costs, inadequate infrastructure, lack of information, and insufficient financing mechanisms are on the rise. These factors are critical for MSME competitiveness and survival.

Transitionally, in Africa, rapid urbanisation, limited infrastructure, and informal business systems intensify pressure on water, energy, and waste management. Water shortages cause businesses to purchase water from vendors at inflated prices of up to 400% (Nkatha, 2024). Ageing infrastructure, leakages, and poorly maintained distribution systems further increase losses and reduce water quality. Clear regulation and enforcement would improve industrial water use in urban centres. Energy demand has risen significantly due to population growth and increased business activity. Industry and residential sectors account for over 70% of electricity consumption, while the commercial and public service sectors show accelerating demand (IEA, 2022). In Nigeria, energy supply fluctuations significantly affected MSME productivity, where urban enterprises consumed more electricity than rural ones and experienced frequent power interruptions (Ajibola et al., 2021).

Additionally, solid waste management presents a growing challenge. Africa's urban population is expanding at 3.6% annually, with waste generation expected to rise from 174 million tonnes in 2016 to 516 million tonnes by 2050 (Yamauchi, 2022). Only about 55% of waste is collected, with the rest disposed through informal dumping. Although individual MSMEs generate relatively small amounts of waste, their collective footprint poses significant environmental risks, especially in manufacturing sectors.

Specifically, Kenya hosts 1.56 million registered MSMEs and over 5 million unregistered enterprises, contributing an estimated 33.8% of national GDP (Kathambi & Obiero, 2021). However, MSMEs face persistent challenges related to water access, energy reliability, and waste disposal. Water stress has been shown to increase operational costs and business competition (Mulwa et al., 2021), while many firms cope by sourcing water from multiple providers when shortages occur (Ochungo, 2020). Energy access has contributed to economic diversification and job creation, particularly in areas where electricity was previously unavailable. The electrification of coastal regions, for example, led to the establishment of woodworking and metal fabrication industries (Ndolo, 2021). However, unreliable power supply and frequent outages negatively affect MSME productivity, with smaller firms being less equipped to integrate backup systems compared to larger corporations. Evidence shows that electricity availability strongly correlates with MSME growth, output volume, and efficiency (Ndolo, 2021).

Nationally, solid waste management systems remain severely constrained; Nairobi generates 2,000–2,500 tons of waste daily with marginal structural recycling (Fieconsult, 2023). Within Langata Constituency, 59% of residential occupants classify unallocated waste as a critical environmental threat (Odanga, 2020), while local manufacturing MSMEs dump substantial volumes without active material recovery (Mumin, 2018). Crucially, localized empirical research remains highly fragmented. Prior studies isolate these environmental variables: Koech (2024), examined water stress in Nairobi, without ward focus; Ombuor (2016) studied illegal electricity tapping; and Odanga (2020) focused on residential waste management, excluding MSME operations. Consequently, a stark empirical gap persists regarding how Langata's MSMEs navigate the compounding cost, reliability and regulatory constraints of the unified water-energy-waste nexus.

1.3 Statement of the Problem

In Langata, water stress has negatively affected operational costs by forcing smaller MSMEs to source water from alternative sources at inflated rates, while unreliable power supply and frequent grid outages directly affect business efficiency (Mulwa et al., 2021; Ndolo, 2021). Furthermore, urban commercial centers such as Langata generate substantial amounts of solid waste, yet infrastructure for recycling and resource recovery is limited (Fieconsult, 2023).

Existing literature has largely addressed these critical variables in isolation such as Koech (2024) examined urban water stress across Nairobi without providing ward specific assessments; Ombuor (2016) focused on electricity tapping in Kibera slum: and Odanga (2020) evaluated residential waste management in Langata although excluded MSMEs in the study.

Langata Constituency lacks integrated empirical evidence showcasing how Langata's MSMEs simultaneously manage the combined pressures of water scarcity, rising energy costs and commercial waste disposal. By capturing these variables in isolation, it fails to present the true operational reality of the combined effects each variable has on the other.

Therefore, this study seeks to fill this gap by providing a combined assessment of the influence water, energy and solid waste management has on MSME operations in Langata Constituency. The study then provides empirical evidence necessary to design targeted policies, enhance urban MSME resilience, and promote green business practices in Nairobi's rapidly evolving landscape.

1.4 Purpose of the study

The purpose of this study was to assess how water, energy, and solid waste management influences the operations of MSMEs in Langata Constituency. Specifically, the study examined water management strategies and their effects on performance, evaluated energy utilization patterns and their operational implications, and analysed the efficacy of existing solid waste practices. Ultimately, this research proposes sustainable, nexus-driven strategies to enhance MSME resource resilience and productivity.

1.5 Objectives of the Study

1.5.1 General Objective

1. The study's general objective was to assess the influence of water, energy and waste management systems on MSME operations in Langata Constituency and propose sustainable resource management strategies for MSMEs in the Constituency.

1.5.2 Specific Objectives

1. To investigate water management strategies and their impacts on MSME operations in Langata Constituency.
2. To evaluate the various forms of energy usage and their impacts on MSME operations in Langata Constituency.
3. To assess the efficacy of solid waste management techniques used by MSMEs in Langata Constituency.

1.6 Research Questions

1. How do water management strategies influence MSME operations in Langata Constituency?
2. What effect does energy usage have on MSME operations in Langata Constituency?
3. How effective are the current waste management techniques used by MSMEs in Langata Constituency?

1.7 Significance of the Study

Sustainable management of water, energy, and waste has become a critical determinant of MSME survival, particularly in rapidly urbanising areas such as Langata Constituency. MSMEs operate with limited resources and are highly vulnerable to fluctuating utility costs, poor infrastructure, and environmental pressures. Yet, there is limited empirical evidence on how these three environmental factors collectively affect MSME performance in Langata. Without such knowledge, businesses may continue to operate inefficiently, policymakers may design ineffective interventions, and environmental degradation may intensify over time. This study therefore addresses a significant knowledge and policy gap by examining how water availability, energy usage, and waste management influence MSME sustainability in Langata Constituency.

MSMEs will directly benefit from this study by gaining practical insights into environmentally sustainable practices that can reduce operational costs, improve efficiency, and enhance business resilience. Adopting green strategies is likely to increase profitability while reducing their ecological footprint, thereby giving them a competitive advantage in a market where sustainability is increasingly demanded by consumers and regulators.

Policymakers and government agencies will gain evidence-based guidance for formulating targeted policies that address MSME-specific environmental challenges. Well-informed policy interventions could improve utility reliability, enhance infrastructure, and promote resource-efficient technologies, ultimately supporting inclusive economic growth while reducing environmental stress in urban areas.

Researchers and academia will benefit from the study by gaining access to empirical data from a relatively under-researched area, thereby expanding the existing body of knowledge on MSME environmental management within the Kenyan urban context. This study also identifies emerging research gaps that future scholars can explore, particularly in the field of green entrepreneurship and urban sustainability.

The local community and wider society stand to benefit indirectly from improved MSME environmental practices. As MSMEs adopt cleaner and more efficient water, energy, and waste systems, there will likely be reduced pollution, improved public health, increased resource availability, and a cleaner urban environment contributing to broader environmental sustainability in Kenya. If this study were not conducted, MSMEs may continue facing operational inefficiencies, policy interventions may remain poorly targeted, and environmental degradation could intensify. Therefore, the study is both timely and essential in guiding sustainable MSME development in Langata Constituency and advancing Kenya’s transition toward a greener economy.

1.8 Scope of the Study

The study was done in Kenya, Nairobi County, Langata Constituency where the target population consisted of various MSMEs in different sectors and the variables that were assessed per sector are depicted by table 1.1 below. The study was conducted in Langata constituency and was conducted in three of the five different wards of the constituency namely; Mugumoini (126.4 km^2), Karen (48 km^2) and Nairobi West (6.9 km^2).

1.8.1 Description of MSME Industry Categorization

Table 1.1: *MSME industries and business types in Langata Constituency*

MSME Industry	Business Types	Resource (Water/Energy)	Waste Type
Retail Shop	General Shops, Hardware, Bookshop, Minimarts, Candy Mart, Package Distributor, Packaging	Energy & Water	Organic Inorganic
Personal Care	Salons, Barbershops, Beauty & Cosmetics, Dry Cleaners, Laundromat	Energy & Water	Inorganic
Food Retail	Restaurants, Butcheries, Bakeries, Juice/Water Vendors, Groceries, Fast Food	Energy & Water	Organic & Biodegradable matter.
Health	Pharmacies, Chemists, Optical Shops	Energy & Water	Inorganic
Automotive	Garages, Auto Spares, Auto Paint, Locksmiths, Dealer Shops	Energy & Water	Hazardous
Professional & Agency	Banks, M-Pesa, Driving Schools, Study Abroad Consultation	Energy & Water	Organic Inorganic
Retail Fashion	Clothing Businesses, Fashion & Design, Uniform Retail, Bata Shoes	Energy & Water	Inorganic
ICT & Services	Cyber Cafes, Electronics Shops, Phone/Electronics Repair, Telkom Shop	Energy & Water	Inorganic / Hazardous

The study categorized MSMEs into eight distinct industry groups based on their primary economic activity, water consumption profiles, energy consumption profiles and waste profiles as seen in table 1.1 to ensure MSMEs with similar resource profiles are analyzed together. While the scope initially targeted the broad layout of registered MSMEs across all commercial activities in Langata, the final operational scope focused heavily on resource dependent sectors where water, energy and waste footprints were directly measurable. Sectors with incomplete resource metrics such as the automotive and professional agencies were excluded during data filtration to preserve statistical validity.

1.9 Limitations of the Study

The willingness of MSME owners to partake in the study was a disadvantage as there was a general mistrust from some MSME owners who assumed that the researcher was a government official. This was addressed by displaying the student identification card that ensured that the information they provided was strictly used for educational purposes.

Despite the high business density within the constituency, the fast-paced nature of the MSMEs was a challenge. The limitation was addressed through a Drop-and-Pick Method where the questionnaires were dropped off at the business premises and later picked after twenty-four (24) to fourth eight (48) hours to allow informants to complete the questionnaire during off-peak hours.

1.10 Delimitation(s) of the Study

The study did not take into account other contributing factors that led to MSME failure such as poor financial accounting, marketing, sales, human resource management, access to finance and others. The study focused on the environmental factors that contribute to MSME failure.

In alignment with the Africa Nazarene University institutional framework, the study excluded alcoholic outlets as they contrary to the University’s mission that upholds character, competence, and community.

1.11 Assumptions of the Study

The study assumed that sampled operators provided accurate, transparent information regarding utility bills and operational challenges. Logistically, it was assumed that all distributed instruments would be returned completely filled; this assumption was debunked, as field constraints necessitated extensive data cleaning, yielding a high-integrity final sample of 75 MSMEs.

Lastly, it was assumed that sustainable environmental practices had a positive effect on MSME operations while a lack of sustainable practices produced a negative effect. This assumption was largely debunked by empirical evidence. The study found that sustainable environmental practices had a marginal effect on water by reducing the price by only KES 26.72 while on energy, sustainable measures were a reactive measure to high energy usage, and on solid waste management, there was a negligible effect on sustainability practices on operational performance due to fixed cost pricing models.

1.12 Theoretical Framework

1.12.1 Resource-based view (RBV) theory

The resource-based view (RBV) of the firm suggests that possessing essential resources enables a firm to create competitive advantage and enhance performance (Chahal et al., 2020). The theory is significant as it shows the benefit of using resources in a sustainable manner. MSMEs that use resources sustainably will be better placed than those who misuse resources such as water, energy and unsustainable waste management. In this study, RBV is applied to position sustainable water conservation systems and alternative renewable energy setups (such as solar) as internal strategic assets. MSMEs that systematically optimize this resource inputs isolate themselves from erratic external municipal utility failures, reduce operational downtime, and minimize utility outlays, securing a clear cost advantage.

1.12.2 Business Models for Circular Economy (BMCE)

The business models for circular economy (BMCE) is a strategic framework that moves from the basic linear economic model that focuses on raw material extraction, product manufacturing, and eventually disposal (Colombo et al., 2021). BMCE emphasizes the closed loop system where businesses implement the maximization of resources through keeping resources in use for longer durations, maximizing resource value, recovery and regenerating products and materials at the end of their life cycle. This includes the reduction of raw materials, reusing of products with minimal processing, refurbishing (turning old products into new condition) and recovery turning waste back into raw materials. MSMEs in Langata would greatly benefit from the BMCE model as it would reduce their carbon footprint through reducing, reusing, refurbishing and recycling practices.

1.13 Conceptual Framework

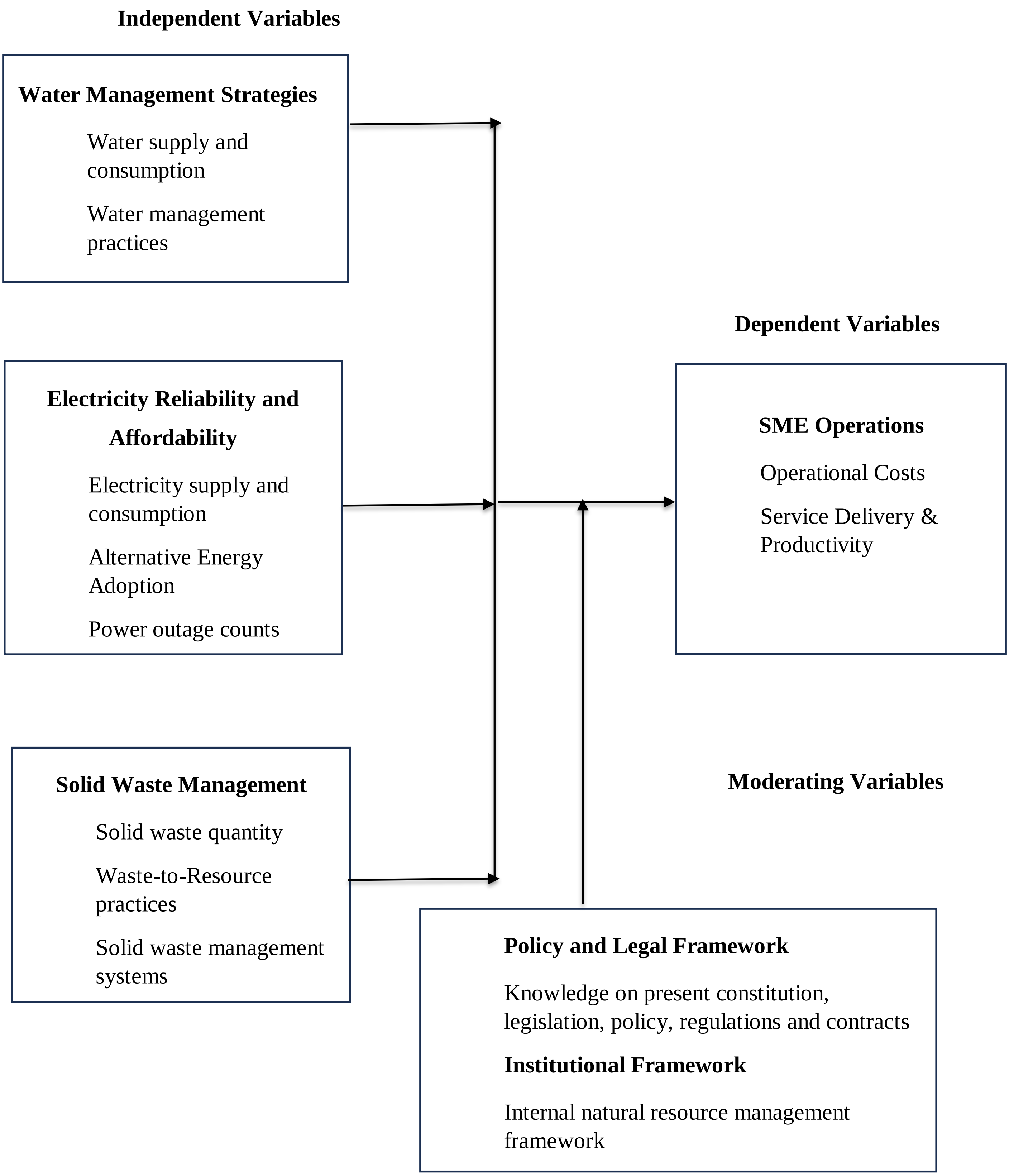

Fig 1.1: Conceptual Framework for Sustainable Water, Energy, and Waste Management among MSMEs in Langata Constituency, Nairobi.

Table 1.2: *Conceptual framework variables and measures*

Variable Type	Variable	Measures
Independent Variables	**Water Management Strategies**	**Quantity:** Cubic meters used per month / units / Water tankers used per week / Jerry cans per week **Price:** Cost of water **Conservation:** Presence of water saving technology
	Electricity Reliability and Affordability	**Quantity:** KWh used per month / units **Price:** Cost of electricity **Reliability:** Frequency count of power outages **Conservation:** Presence of energy saving technology or alternative energy
	Solid Waste Management	**Quantity:** Bags per week disposed **Price:** Cost of collection/disposal per month **Management:** Presence of recycling, recovery, substitution, segregation
Moderating Variables	**Policy and Legal Framework**	Knowledge of present constitution, legislation, policy, regulations and contracts
	Institutional Framework	Presence of internal natural resource management framework
Dependent Variables	**Operational Costs**	High or low water & energy bills, positive or negative impact on businesses
	Business Sustainability & Compliance	Use of water recycling or energy saving technology Presence of waste recycling

The conceptual framework shows the integrated relationship between environmental utility management and the operational performance of MSMEs in Langata Constituency. Rather than viewing these variables in isolation, the framework structures them as a combined resource nexus, heavily anchored to the Resource-Based View (RBV) and Business Models for Circular Economy (BMCE) Theories in Section 1.12.

The inclusion of water and energy management systems within the framework is directly driven by the RBV theory where it dictates that an MSMEs survival and competitiveness is directly linked to its ability to optimize critical internal resources. By implementing water conservation systems and alternative energy such as solar, MSMEs transform unpredictable external utilities into stable internal assets. This buffers MSMEs from municipal water shortages, grid outages, high utility bills and reduces their operational downtime which enhances MSME sustainability.

Solid waste management is operationalized through the BMCE framework that advocates for closed-loop resource recovery. However, the framework identifies a local hurdle where fixed cost pricing models implemented by private collectors in Langata is dominant. While sustainable waste management such as segregation and minimization mitigate environmental pollution, their capacity to lower operational costs is heavily constrained by fixed cost pricing models.

Finally, Policy, Legal, and Institutional Frameworks act as moderating variables that dictate compliance costs and enforcement boundaries which shape the independent variables such as operational costs and MSME sustainability and compliance.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature relevant to the water, energy and waste management systems that enhance MSME sustainability in Langata Constituency.

2.2 Review of the Literature

This section synthesises global, regional, national and local literature around the three key environmental factors affecting MSMEs; water management strategies, electricity reliability and affordability, and, the efficacy of solid waste management systems.

2.2.1 Water Management Strategies and its impact on MSME Operations

Water serves as a fundamental production input across diverse commercial sectors. While global frameworks emphasize resource conservation due to escalating urban demand and climate variability (National Geographic, 2022), sub-Saharan African cities face acute structural unreliability (Livingston, 2021).

Global and Regional Context

Many African cities experience unreliable water supply due to infrastructure limitations and rapid urbanization (Livingston, 2021). In Africa, MSMEs frequently face water rationing, forcing them to adjust operating hours or suspend activities. Dependence on informal water markets is common, leading to higher costs and inconsistent quality. The continent accounts for about 18% of the world's population and is projected to almost double by 2050 (Worldometer, 2024). In Africa, Tanzania is the highest water abstractor in the region at 5.2 billion m^3 followed by Kenya with 4.0 billion m^3 of water abstracted annually (Bennett, 2025). Studies in Sub-Saharan Africa highlight that water insecurity disproportionately affects small businesses compared to large firms. At least 13 African countries are already critically water insecure (Ighobor, 2023).

Water scarcity leads to production delays, reduced output, and increased operational costs. Water shortages have led many households and businesses to rely on water vendors and tankers, often at highly inflated prices—sometimes up to 400% higher than standard tariffs (Nkatha, 2024). Poorly maintained and ageing infrastructure, including leaky pipes and inadequately maintained distribution networks, further exacerbates losses, lowers water quality, and undermines reliability. Nkatha (2024) shows that such weaknesses discourage investment, reduce economic productivity, and ultimately affect employment and service delivery. While that study focuses primarily on agriculture, the same structural issues directly affect urban MSMEs that rely on predictable, affordable water supply.

MSMEs in water-stressed regions often rely on alternative sources such as private vendors and groundwater, increasing business expenses. Globally, water stress affects business location decisions, investment patterns, and operating costs. Regions with unreliable or poor-quality water supply tend to attract fewer investors, reducing job opportunities and slowing economic development. For MSMEs, which operate with limited financial cushions, water scarcity and quality problems can cause reduced production, higher costs, and even business closure.

Water Management in Kenya and Nairobi

In Kenya, water is recognised as a key driver of economic progress, environmental sustainability and social development. However, urban areas in Kenya experience intermittent water supply, with MSMEs relying on water vendors, boreholes, and storage systems. Water stress and unreliable supply have been reported to adversely affect businesses by increasing competition over scarce resources and creating potential conflict (Mulwa et al., 2021).

Water scarcity in Kenya is influenced by weak regulations and outdated infrastructure. Kathambi et al., (2021) illustrates that in Nairobi, water efficiency contributed to maximizing MSME sustainable water consumption as well as production. Kathambi et al., (2021) added that, data information, regulatory frameworks, financing and innovative governance enables MSMEs to innovatively recycle, re-use their waste water and efficiently manage their water resources. Kathambi et al., (2021) adds that water infrastructure is a factor affecting water and sanitation aspects for MSMEs within Nairobi by increasing water supply and treatment costs.

More recent studies, Koech (2024) highlights that Nairobi City Water and Sewerage Company (NCWSC) supplies approximately 525,000 m^3 of water per day, but an estimated 300,000 m^3 is lost through leakages and illegal connections. Informal settlements such as Kibera, which neighbours Langata, are notorious for illegal tapping. In response, NCWSC has concreted sections of the main pipeline serving Langata, Highrise, Ngei and parts of Kibera (Koech, 2024). These systemic losses and illegal abstractions contribute to unreliable water supply in adjacent areas, including Langata Constituency, where MSMEs must cope with inconsistent availability and potential contamination.

The Sustainable Development Goals (SDGs) further frame water as a sustainability priority. SDG 6.4 aims to increase water-use efficiency and ensure sustainable withdrawals across all sectors, while SDG 6.1 targets universal and equitable access to safe and affordable drinking water by 2030. These targets are directly relevant for MSMEs in Langata, especially food-related businesses. Illegal connections and contaminated pipelines pose public health risks and force some enterprises to treat water before use, increasing production costs (Owino, 2021).

Water, MSMEs and Sustainability

Efficient water use and conservation practices have been linked to improved operational sustainability and cost reduction. Kathambi and Obiero (2021) note that Kenya has approximately 1.56 million licensed MSMEs and 5.85 million unregistered enterprises, together contributing 33.8% of GDP. They emphasise that good water management practices—such as prompt leakage repair, closing taps after use, staff sensitisation, and adoption of water-efficient technologies—are essential for balancing production and environmental sustainability. Poor water accessibility and unreliable supply reduce MSME returns on investment (ROI) by increasing operational costs, while poor water quality forces some businesses to invest in pre-treatment, further eroding profit margins. Their study recognises that in many developing countries, water management is often driven by demand rather than availability, leading to lax practices when water is abundant and strict measures when it becomes scarce. This dynamic, cyclical behaviour can undermine sustainable consumption and production. They recommend that MSMEs adopt water-efficient models, reuse and recycle water where possible, and better understand their consumption patterns to improve risk management and sustainability (Kathambi & Obiero, 2021). Although they touch on examples from both Kenya and Botswana, the study does not provide detailed, location-specific analysis of how MSMEs in particular urban constituencies, such as Langata, cope with water scarcity, intermittent supply and rising costs.

Water Supply and Costs in Langata Constituency

Langata Constituency comprises five wards: Karen, Nairobi West, Mugumoini, South C and Nyayo Highrise. Their population, household and area distribution are shown in Table 2.1.

Table 2.1: *Population, Household and Area Distribution by Ward (Langata Constituency)*

Ward Name	Population No.	Household No.	Area Km²
Karen	24,507	9,467	48
Nairobi West	33,372	8,311	6.9
Mugumoini	47,037	12,867	126.4
South C	47,207	13,637	15.1
Nyayo Highrise	24,191	8,374	0.4
Total	176,314	2,656	196.8

Source: Ochungo (2020)

Ochungo (2020) examined water supply security in drought-exposed Langata Sub-County and found that Nairobi depends heavily on the Aberdare ecosystem for about 95% of its water, with Ndakaini Dam storing most of this supply. Despite a high rate of piped water coverage (98%), Nairobi still experiences high water stress, with Langata identified as one of the most affected constituencies. Langata residents often rely on municipal water from NCWSC but must supplement this with water from boreholes and private tankers due to inconsistent supply.

Over the years, increased drilling of boreholes has lowered the water table, with boreholes commissioned between 1982 and 2017 reaching progressively greater depths (Ochungo, 2020). Households incur substantial additional costs when they purchase tanker water to supplement utility supply, with some wards paying significantly more than others. The study also found that the total cost borne by residents (combining utility bills, bottled water and tanker water) could be up to 258% higher than their official monthly payments to NCWSC. Residents cope by diversifying water sources. Although this work focuses on households, intermittent supply, reliance on expensive alternatives, and high total costs also apply to

MSMEs operating in Langata. For the current study, water tariffs are also relevant, as they allow conversion of monetary expenditure into consumption volumes for analysis.

Table 2.2: *Nairobi Water and Sewerage Company Water Tariffs 2025*

Consumption Block (m^3)	Tariff per m^3 (Ksh)	Total Price in Ksh
1 – 6	45	270
7 – 20	57	1,340
21 – 50	70	3,500
51 – 100	76	7,600
101 – 300	78	23,400
Above 300	80	24,000

Source: Nairobi City Water and Sewerage Company (2025)

2.2.2 Energy Usage and Its Impact on MSME Operations

Energy is essential for MSME productivity, influencing production efficiency and service delivery. Energy is a key input in modern business operations, affecting production processes, service delivery, storage (e.g. refrigeration) and communication. Unreliable electricity supply results in downtime, equipment damage, and reduced output. Reliable and affordable electricity enables MSMEs to improve productivity, product quality and service consistency; conversely, frequent outages, low voltage and high costs undermine their performance.

Global and Regional Energy Context

MSMEs globally adopt alternative energy sources such as diesel generators and renewable energy systems. Fossil fuels (coal and gas) still generate the majority of electricity, although renewable sources now account for around 30% of global generation. Hydro, wind, solar, nuclear and other low-carbon sources are gradually increasing their share as countries pursue decarbonisation goals (Ember, 2025; Motyka et al., 2024). Energy efficiency measures are associated with reduced costs and improved competitiveness.

Many African countries face energy access challenges, including unreliable electricity supply and high tariffs. Despite comprising around 18% of the world’s population, African countries account for only about 3% of global electricity demand. Per capita, electricity consumption remains low: Africa's average is around 0.63 MWh per person, compared to the global average of 3.43 Megawatt-hours (MWh), and Kenya's average is even lower at about 0.19 MWh per person (IEA, 2022). The main electricity-consuming sectors in Africa are industry (37%), residential (36%), and commercial/public services, which have experienced substantial growth in demand due to expanding economic activity (IEA, 2022).

Africa's electricity generation mix is dominated by natural gas, coal and hydro, with smaller shares from oil, wind, nuclear and other renewables. Limited generation capacity, ageing transmission infrastructure and financial constraints contribute to frequent outages and high system losses, which in turn affect business operations.

Electricity in Kenya and Nairobi

MSMEs often rely on backup generators, increasing operational costs and environmental impact. Kenya's total energy generation between July 2023 and June 2024 was approximately 13,684.63 GWh. Geothermal power accounts for the largest share of installed capacity (around 26%), followed by hydro (24%), thermal (17%), solar (12%) and wind (12%), with smaller contributions from other sources (Energy and Petroleum Regulatory Authority [EPRA], 2024). Small commercial enterprises consumed about 1,715.54 Giga Watt hours (GWh), representing 16.38% of total electricity use. Nairobi is the largest consumer of electrical energy, accounting for about 43.7% of national consumption.

However, grid instability remains a critical operational bottleneck. Total national system losses hit 23.47% of total purchased energy, significantly exceeding the 18.5% regulatory benchmark (EPRA, 2024). Reliability metrics also lag behind national standards, with the Customer Average Interruption Duration Index (CAIDI) averaging 2.53 hours per month and the System Average Interruption Duration Index (SAIDI) at 10.14 hours. The System Average Interruption Frequency Index (SAIFI) stood at 3.96 interruptions per customer, higher than the target of 2.15 (EPRA, 2024). These figures indicate frequent and sometimes prolonged power interruptions, which directly affect MSMEs that depend on electricity for their day-to-day operations. Renewable energy adoption (e.g., solar) is increasing but remains limited due to high initial costs.

Kenya Power and Lighting Company (KPLC) tariffs for small commercial enterprises are presented in Table 4.

Table 2.3: *Cost of Electricity for Small Commercial Enterprises (2023/2024)*

Customer Category	Voltage at Connection	Energy Limit (kWh/month)	Base Tariff (2023/2024)	Approx. Monthly Cost (Ksh)
Small Commercial	240V / 415V	0–30	12.24 Ksh/kWh	372
		30–100	16.36 Ksh/kWh	1,224
		>100	20 Ksh/kWh	2,000

Source: Kenya Power Tariffs 2023/2024

In addition to base tariffs, customers pay various additional charges (e.g. fuel cost adjustments, forex adjustment, inflation, levies and taxes). This means the effective cost per kWh is significantly higher than the nominal tariff. For example, in 2024, customers paying Ksh 500 or Ksh 5,000 for electricity tokens received a relatively small number of units, illustrating the high effective cost of electricity (Nyanchama & Simwa, 2024). High and fluctuating energy costs can erode MSME profitability, especially for energy-intensive business types.

Electricity, Informal Connections and MSMEs

Illegal electrical connections are common in informal settlements neighboring Langata, such as Kibera. Ombuor (2016) notes that extensive illegal tapping through improvised wiring not only increases technical and commercial losses but also poses safety risks (e.g. fires) and discourages utility staff from entering these areas. These losses ultimately feed back into higher system costs, which may be transferred to customers through tariffs.

MSMEs in Kenya face high electricity costs and frequent power outages, affecting productivity. For MSMEs, especially those that rely on continuous power for refrigeration, food processing, salons, barbershops, and ICT services, frequent outages and voltage fluctuations result in product spoilage, equipment damage and lost sales. Such shocks can be particularly severe for smaller firms lacking capital for backup generators or solar installations.

Empirical Evidence from Other Countries

Studies from other contexts reinforce the importance of reliable electricity for MSME performance. Ajibola et al. (2021), in a study of Nigerian MSMEs, found that a one-unit increase in electricity supply resulted in a 3.9% improvement in business performance, while a one-unit increase in alternative power supply (e.g. generators, solar) led to a 3.7% improvement. The study concluded that both grid supply and alternative sources significantly influence MSME productivity and recommended that MSMEs adopt alternative power options to mitigate outages.

Ndolo (2021), studying Kenyan MSMEs, reports that electricity access promotes job creation and livelihood diversification in previously unserved areas, citing examples from the Kenyan coast where electrification enabled the growth of woodworking, metal fabrication and other small industries. The study found that electricity availability positively influences MSME production volume and quality, while outages adversely affect output, efficiency and growth prospects. Larger firms are often better able to cope through generators and diversified energy strategies, making smaller enterprises more vulnerable.

2.2.3 Solid Waste Management and MSME Operations

MSMEs generate various types of waste, including organic, plastic, and hazardous materials. Global municipal solid waste generation stands at 2.01 billion tonnes annually, and is projected to expand to 3.40 billion tonnes by 2030, with over half systematically landfilled or openly dumped due to poor recovery frameworks (Filipenco, 2024).

Global and Regional Trends

In Africa, urban population growth is among the fastest in the world, at around 3.6% annually. Waste generation in the region is projected to increase from 174 million tonnes per year in 2016 to 516 million tonnes by 2050, yet average collection coverage stands at only about 55%, with the remainder often disposed of through open dumping or uncontrolled burning (Yamauchi, 2022). Waste management systems in many African cities are underdeveloped, with limited infrastructure and services. Additionally, limited financial and institutional capacities, weak enforcement of regulations and low public awareness all hinder effective waste management.

Waste Management in Kenya and Nairobi

Kenya is estimated to generate between 3,000 and 4,000 tonnes of waste per day, with Nairobi contributing approximately 2,000–2,500 tonnes daily due to its high population density and urbanisation levels (Alliance of Bioversity International and CIAT, 2024). Most of this waste (70–80%) is organic, with the remainder consisting of plastics, metals, glass and other inorganics. Only about 10% of waste reaches designated disposal sites (Fieconsult, 2023).

Dandora dumpsite, located in Nairobi, is one of the largest dumpsites in Africa. It covers about 30 acres and has been officially full since 1996, yet continues to receive approximately 850 tonnes of waste daily. Poor design and management, and the proximity of settlements, have resulted in significant environmental and health risks (Fieconsult, 2023).

MSMEs, particularly in manufacturing, food service, retail and services, contribute to this waste stream. Mumin (2018) found that MSMEs in manufacturing generate substantial quantities of waste with limited recycling, reuse or by-product use. Such unrecycled waste ends up in landfills or open dumps, exacerbating pollution and resource inefficiency. Informal waste management practices are common, leading to environmental and health concerns. At the same time, Fieconsult (2023) notes that gaps in waste management create opportunities for private sector participation and youth employment in collection, sorting and recycling, with an estimated 200,000 jobs in Kenya linked to waste-related activities (Oluoko-Odingo & Mutisya, 2019).

Waste Management in Langata Constituency

MSMEs often face challenges in accessing formal waste collection systems. Odanga (2020) assessed household willingness to pay for waste separation services in Langata Constituency. The study found that 59% of respondents considered uncollected waste and poor waste management a serious environmental problem, and 26% cited it as the most serious issue, ahead of inadequate water supply and poor sanitation. Residents typically pay between Ksh 185 and 800 per month for waste collection, depending on their residential area. About 68% expressed willingness to pay an additional fee for a three-way separation service, with a mean willingness to pay Ksh 356. High waste disposal costs discourage proper waste handling among MSMEs.

These results suggest that residents recognize the importance of improved waste management and are open to participating in more sustainable systems. However, the study focuses on households and does not examine MSMEs, which also generate considerable waste and influence neighborhood environmental quality.

Waste Management Practices and MSME Performance

Literature on MSMEs indicates that many small enterprises have at least some awareness of green practices that reduce waste and enhance recycling (Šebestová & Sroka, 2020). Lean and green approaches—including waste minimization, reuse, recycling and remanufacturing—can improve environmental performance and operational efficiency (Derhab & Elkhwesky, 2022). Tools such as 5S, Six Sigma and Total Productive Maintenance (TPM) support cleaner, safer and more organized workplaces, helping to reduce non-value-added activities, detect leaks, and improve resource utilization (Labedz & Murdock, 2024; Kovach, 2024; Vorne Industries Inc., n.d.).

Waste management in Kenyan urban areas is largely managed by county governments and private collectors. Derhab and Elkhwesky (2022) show that MSMEs adopting waste minimization and cleaner production practices often experience cost savings, improved operational performance and better financial outcomes due to reduced waste handling costs, lower input use and enhanced process efficiency. They also highlight the role of information technology in connecting MSMEs with recyclers, waste buyers and reuse initiatives, sometimes through simple platforms such as messaging groups. However, other studies have found that waste reduction is not always a high priority for MSMEs, and many small firms do not consistently implement reuse, composting or separation strategies (Toke & Kalpande, 2022; Kasseeah, 2020).

MSMEs often rely on basic disposal methods due to cost constraints and limited awareness. Ineffective waste management affects business operations, compliance, and environmental quality. Effective waste management is not only an environmental issue but also a business opportunity. It can lead to cost savings, new product lines (through upcycling or recycling), and a more attractive business environment. For MSMEs in sectors such as restaurants, food production and hospitality, visible cleanliness and proper waste handling also influence customer perceptions and competitiveness. Yet, most empirical work in Kenya has focused on households and municipal systems rather than on MSMEs' own waste management strategies, especially at the constituency level. Additionally, there are limited studies evaluating the effectiveness of waste management practices on MSME performance in Langata Constituency

2.2.4 Summary of the Review of Literature and Research Gaps

The reviewed literature demonstrates that water availability and quality, electricity reliability and affordability, and solid waste management are critical factors influencing MSME operations and sustainability. Globally and regionally, studies highlight how water scarcity, energy insecurity and inadequate waste systems increase costs, disrupt production and reduce competitiveness. In Kenya, existing research confirms that MSMEs contribute substantially to GDP and employment but face challenges related to unreliable utility services and environmental management. However, several gaps remain.

Environmental sustainability as an MSME challenge

Mulae (2022) describes challenges facing Kenyan MSMEs—such as access to credit, markets, infrastructure and logistics—but gives limited attention to environmental sustainability (water, energy and waste) as a core operational constraint.

Water use studies focused on households, not MSMEs

Ochungo (2020) examined water supply security in Langata Sub-County but concentrated on residential responses and coping strategies while failed to account for commercial users.

Waste management studies centred on households

Odanga (2020) evaluated household willingness to pay for waste separation in Langata and found strong support for improved solid waste systems. The study, however, did not include MSMEs, and therefore does not provide a full picture of waste generation and management practices in the constituency.

Fragmented treatment of water, energy and waste

Existing studies tend to address water, energy and waste separately, often within specific sectors (e.g. agriculture, households, or manufacturing), rather than examining their combined influence on MSME operations at a local scale. This limits the understanding of how these factors interact to shape MSME sustainability.

The proposed study responds to these gaps by focusing specifically on MSMEs in Langata Constituency and by examining the combined influence of water management, electricity reliability and affordability, and solid waste management practices on MSME operations and sustainability. By doing so, it aims to generate evidence that can inform MSME-level strategies, policy interventions, and broader efforts towards green business practices in urban Kenya.

2.3.1 Matrix Showing the Research Gaps

Table 2.4: *Summary of Reviewed Studies and Knowledge Gaps*

Author & Year	Title of the Study	Focus Area	Key Findings	Knowledge Gap
Ochungo (2020)	Water Supply Security in a Drought-Exposed Langata Sub-County	Water	Identified water supply security risks and household reliance on expensive alternatives.	Focused on residential dwellings and did not address how MSMEs in Langata adapt their operations to water scarcity.
Kathambi & Obiero (2021)	Unseen Barriers: Water Risks to Sustainable Production in Kenyan MSMEs	Water	Identified broad water-related risks affecting sustainable production for small firms.	Provided a national view therefore lacks the localized focus.
Ajibola et al. (2021)	Sustainable Energy Management Practices and MSME Performance in Nigeria	Energy	Found that energy efficiency and renewable energy adoption significantly boost MSME competitiveness.	Provides a West African regional context which does not account for the specific tariff issues unique to Nairobi.
Odanga (2020)	Valuing Urban Environmental Quality Improvement Through Household Willingness to Pay	Waste	Investigated households "willingness to pay" for waste separation in Langata.	Excluded MSMEs, leaving a gap in understanding MSME waste management in the same area.
Ndolo (2021)	Influence of Green Supply Chain Management Practices on Performance of Manufacturing MSMEs in Nairobi	Management	Highlighted that green purchasing and eco-design improve business performance.	Focused on Manufacturing therefore left a gap on the other MSME industries that dominate the Langata business landscape.

Author & Year	**Title of the Study**	**Focus Area**	**Key Findings**	**Knowledge Gap**
Owino (2021)	Determinants of Waste Management Practices among Small and Medium Enterprises in Nairobi	Waste	Identified that cost and lack of awareness are the main barriers to proper waste disposal.	Provides a city-wide view therefore lacks constituency or ward level focus.
Author & Year	Title of the Study	Focus Area	Key Findings	Knowledge Gap
Toke & Kalpande (2022)	Barriers to Sustainable Practices in MSMEs: A Systematic Review	Sustainability	Reviewed global barriers like lack of finance and technical knowledge in MSMEs.	A Theoretical review which lacks empirical evidence from East African urban business environments such as Langata.
Mulae (2022)	The Micro and Small Medium Enterprises Development in Kenya	Finance	Found that MSMEs face challenges such as access to affordable credit, market access, infrastructure and logistics.	Did not examine how environmental sustainability (water, energy and waste) constrains MSME performance.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This section contains the Research Design, Research Site/Economic Activities/Area Population, Study Area Map, Target Population, Study Sample, Sampling Procedure, Study Sample Size, Pilot Testing of Research Instruments, Instrument Reliability and Instrument Validity.

3.2 Research Design

The study implemented a mixed method research design. Environmental issues are often complex and multi-faceted (United Nations Environment Programme- UNEP, 2016). Hence a concurrent triangulation design was used to merge qualitative and quantitative data simultaneously to address the research questions and triangulate the findings to increase the validity and reliability of the results. Quantitative and qualitative methods used aimed to provided valuable insights into attitudes, beliefs, and behaviors of individual MSME owners.

Quantitative data was collected for variables relating to water, electricity and waste. Qualitative data included categorical data obtained from interviews with MSME owners and observations relating to the surrounding environments of MSMEs and premises fixtures.

3.3 Research Site

The study was conducted in Langata constituency which contains five wards of Langata subcounty namely; Mugumoini (126.4 Km^2), Karen (48 Km^2), South C (6.9 Km^2), Nairobi West (6.9 Km^2), and Nyayo Highrise (0.4 Km^2), (Kenya National Bureau of Statistics [KNBS], 2019). The study focused on the wards of Mugumoini, Karen and Nairobi West (see Appendix 16) to capture maximum variation in economic activity, spatial density, and environmental utility infrastructure. The study excluded South C and Nyayo Highrise as their MSME profiles heavily replicate the MSME profiles captured in Nairobi West.

Mugumoini Ward (126.4 Km^2; Population; 47,037) (KNBS, 2019), presents a mixed-density profile spanning both formal and informal MSME activities, including small-scale manufacturing, open-air markets, transport hubs, and artisan workshops. Major commercial nodes include Freedom Heights, Langata Mall and Galleria Shopping Mall.

Karen Ward (48 Km^2; Population; 24,507) (KNBS, 2019), presents a high-income, low-density profile that consists of high-end hospitality, private schools, professional consultancies, commercial hubs, and agribusiness/horticulture (Nairobi City County, 2023). Major commercial nodes include The Waterfront Karen, Crossroads Karen, Karen, The Hub Karen.

Nairobi West Ward (6.9 Km^2; Population; 33,372) (KNBS, 2019), presents a dense commercial profile that consists of economic sectors such as the entertainment and hospitality sector, retail shops, and car washes (Nairobi City County, 2023). The main business centres in Nairobi West include; Gandhi Avenue, Bukani Road, Birongo Square, Mai Mahiu Road, Magharibi Place, and T-Mall.

3.4 Target Population

The target population of this study included MSMEs within Langata constituency. According to records held at the Nairobi City County offices, Langata Constituency had 1,712 registered MSMEs (Omolo, 2019). These registered MSMEs formed the population from which the study sample was drawn.

3.5 Study Sample

3.5.1 Sampling Procedure

The study adopted a proportional stratified random sampling technique to ensure accurate reflection of the MSMEs within Langata. Strata were identified based on the three wards of Langata which represent different spatial and business-densities: Mugumoini (mixed density), Karen (low density) and Nairobi West (high density).

Nested purposive sampling was used for the qualitative data to provide context specific depth. This provided the identification of extreme, typical and contrasting case insights on the resource management of MSMEs in the study area. After stratification, systematic sampling was done to identify specific respondents. The researcher used a random walk method, starting from major geographical land marks such as T-Mall, Galleria Mall, and The Hub Karen). From these central hubs, every 5th MSME encountered along the pre-mapped business hubs and street clusters was selected to receive a questionnaire which also reduced researcher bias and improve spatial coverage in the study area. Where a selected MSME declined to participate in the study, the researcher moved to the next 5th unit. Nested purposive sampling was used for the qualitative component to select five MSMEs per ward to provide extreme, typical and contrasting case insights of MSME experiences in Langata Constituency.

Despite the high business density in Nairobi West, there was a high non – response rate and exclusions from this ward, due to the fast-paced nature of the ward where key informants did not have adequate time to participate. A low response rate was recorded despite using the drop and pick method. To ensure data integrity, post-hoc cleaning yielded a final analytical sample of 75 questionnaires. While the low response rate in Nairobi West and the exclusion of incomplete sectors introduce localized selection bias, descriptive validity is maintained. Consequently, generalizability is limited specifically to resource-dependent urban MSMEs rather than the constituency's entire multi-sector business population.

3.5.2 Study Sample Size

The target population for this study consisted of 1,712 MSMEs registered at the Nairobi City County offices (Omolo, 2019). The sample size for the quantitative component of the study was determined using Yamane's simplified formula (1967), at a 95% confidence interval (margin of error = 0.05): (Yamane, 1967):

$$\mathbf{n} = N/ 1 + (N * e^2)$$

Where:

- n = sample size
- N = target population (1712)
- e = level of precision (0.05)

$$\mathbf{n} = 1712 / 1 + 1712 * (0.0025)$$

$$\mathbf{n} = 1712 / 1+ (1712 * 0.0025)$$

$$\mathbf{n} = 1712 / 1 + 4.2825$$

$$\mathbf{n} = 1712 / 5.2825$$

$$\mathbf{n} = 324 \text{ MSMEs}$$

Yamane's simplified formula yielded a study sample size of 324 MSMEs. However, the sample size was adjusted to realistic fieldwork expectations using a two-stage sampling design framework. The first stage established the ideal statistical requirement of 324 MSMEs while the second stage applied a pragmatic operational filter in accordance with the university's research guidelines, which explicitly state that availability of resources and time are critical factors to be considered when deciding on the final sample size.

Due to logistical boundaries, time constraints, and the fast-paced nature of the commercial hubs, the operational field distribution was set at a logistically viable maximum target of 105 questionnaires. To maintain scientific objectivity and spatial fairness the 105 questionnaires were distributed using the proportional allocation formula (n_h = Weight x n) based on the relative human population weights of the three wards according to the data provided by the Kenya National Bureau of Statistics (KNBS, 2019).

Out of a combined target ward population of 104,916 residents, the proportional weights (Wh) and systematic questionnaire allocations (nh) were calculated using the following mathematical sequence:

Mugumoini

Mugumoini Weight = (47,037/104,916) X 100 = 44.83% = 45%

Mugumoini Allocation = 45% X 105 = 47.25 = 47 questionnaires

Karen

Karen Weight = (24,507/104,916) X 100 = 23.36% = 25% (Normalized sample)

Karen Allocation = 25% X 105 = 26.25 = 26 questionnaires

Nairobi West

Nairobi West Weight= (33,372/104,916) X 100 = 31.81% = 30% (Normalized sample)

Nairobi West Allocation = 30% X 105 = 31.50 = 32 questionnaires

Following the systematic field allocation detailed above, the actual breakdown of data collection outcomes, response rates, and final valid analytical returns per ward is shown in table 3.1 below.

Table 3.1: *Sample size summary table*

Ward	Target Pop (Nh)	% of Total Pop	Distributed (n)	Final Valid Sample (n)	Realized Proportion
Mugumoini	770	45.00%	47	41	54.70%
Karen	428	25.00%	26	19	25.30%
Nairobi West	514	30.00%	32	15	20.00%
Total	1,712	100%	105	75	100%

Initially, the study targeted a sample size of 324 MSMEs based on Yamane's formula. However, due to the field constraints and rigorous data cleaning processes, a final high integrity sample of 75 MSMEs was achieved. This represented a response rate of 71.4% from the 105 distributed questionnaires. A purposive decision by the researcher was made to reduce 90 of the retrieved questionnaires to 75 questionnaires to exclude the automotive and professional & agency industries as they did not have adequate data on water and waste management variables for data analysis.

Although the final count for Nairobi West (n = 15) fell below the threshold of 30%, the researcher maintained a focus on data quality. The exclusions made ensured a high-quality data set that accurately reflected the operational realities of resource dependent MSMEs in the study area.

Out of the 105 distributed questionnaires, 15 were not retrieved due to lack of follow up access leaving 90 retrieved questionnaires. During the subsequent data cleaning and inspection phase, an additional 15 questionnaires from the automotive and professional & agency sectors were excluded due to incomplete data regarding water and waste variables. This rigorous filtering process yielded a final, high-integrity analytical sample of 75 fully completed questionnaires.

3.6 Data Collection

3.6.1 Data Collection Instruments and Material

Self-administered questionnaires consisting of both closed-ended and open-ended questions were used to collect data filled by MSME owners and employees with the relevant information required for the study (see Appendix 4 for the questionnaire). In- person interviews were conducted after the completion of questionnaire filling which recorded data that was still fresh in the minds of respondents. In addition, field observations of MSME surrounding environments and premises fixtures were recorded to enhance data verification.

Table 3.2: *Study objective and data collection methods summary table*

Study Objective	Description	Data Collection Methods
Objective 1	To investigate water management strategies and their impacts on MSME operations in Langata Constituency.	Self-administered questionnaires and in – person interviews targeting key informants; MSME owners, managers & employees. field observations.
Objective 2	To evaluate the forms of energy used by MSMEs and their impacts on operational performance in Langata Constituency.	Self-administered questionnaires and in – person interviews targeting key informants; MSME owners, managers & employees. field observations.
Objective 3	To assess the effectiveness of solid waste management practices adopted by MSMEs in Langata Constituency.	Self-administered questionnaires and in – person interviews targeting key informants; MSME owners, managers & employees. field observations.

The distribution of sampled MSMEs by ward and industry is shown by table 3.3 below. There is a diverse industrial distribution covering eight distinct sectors where the most prevalent sectors were the food retail (n = 16) and the personal care (n = 14). The study aimed for proportional allocation of MSMEs per ward, the final distribution shows Mugumoini (Langata) had the highest participation rate (Total n = 41), followed by Karen (Total n = 19) and Nairobi West (Total n = 15).

Table 3.3: *Distribution of Sampled MSMEs by Ward and Industry*

Industry	Langata	Karen	Nairobi West	Total
Food Retail	10	5	1	16
Personal Care	7	4	3	14
ICT / Electronics	8	0	5	13
Health / Medical	7	4	1	12
Retail – Shop	4	3	4	11
Retail – Fashion	5	3	1	9
Total (n)	**41**	**19**	**15**	**75**

3.6.2 Pilot Testing of Research Instruments

A pilot test was conducted with five MSMEs across Langata and Karen to assess the clarity and applicability. To maintain data integrity these pilot participants were excluded from the final analyzed sample (n = 75). observational mapping identified specific hesitation points where respondents required clarification on technical environmental terms.

Based on the pilot results, the questionnaire layout was refined using categorical checkboxes to reduce the completion time from 15 minutes down to under 10 minutes, minimizing respondent fatigue. Additionally, because informants struggled to estimate resource usage in cm^3 or KWh, expenditure was integrated as a functional proxy for consumption. Technical phrasing like "solid waste segregation" was simplified to everyday language, and employee count metrics were added to Part One to ensure accurate firm classification under the MSE Act (2012).

3.6.3 Instrument Reliability

Instrument reliability was the level in which the instrument produced consistent results after repeated trials. The study utilized the test-retest method during the pilot phase where two weeks after the initial pilot, three out of the five respondents were asked to recomplete the questionnaire. The responses provided were then compared for consistency and yielded a high degree of stability in the data.

The internal reliability of this dichotomous index was processed in R-Studio (relying on the psych package) through the Kuder-Richardson 20 (KR-20) coefficient, defined mathematically as:

$$KR_{20} = k/k\text{-}1\ (1- \sum pq/\sigma\text{^}^2)$$

Waste recycling was deleted from the internal consistency coefficient as it showed zero variance which means that all MSMEs responded to the question identically which then ensured mathematical validity. The coefficient result was 0.338 and this was attributed to the heterogeneity of MSME operations. The low alpha reflects the diverse and independent nature of resource management strategies among MSMEs within Langata.

3.6.4 Instrument Validity

Content validity was ensured by aligning the questionnaire and interview guides to the three specific objectives of the study ensuring that each research variable was adequately addressed. The instruments underwent expert review by the university supervisors to ensure that key indicators such as KWh for energy and cost of water were meaningful inferences of MSME resource management.

Furthermore, construct validity was realised by operationalizing study variables into measurable indicators. Finally, face validity was established during the pilot phase of the study to ensure the instrument was simple and clear for respondents who had varying educational levels.

Table 3.4: *Instrument validity summary table*

Validity Type	**Method of Achievement**
Content validity	Supervisor review and objectives alignment.
Construct validity	Used standardized environmental units e.g. KWh and m^3.
Face validity	Pilot testing of 5 non-sampled MSMEs.

3.6.5 Data Collection Procedures

Data was collected using a structured questionnaire with both open-ended and closed-ended questions to capture data on electricity use, water consumption, and solid waste management among MSMEs in Langata constituency. The questionnaire was self-administered to key informants: MSME owners, managers and or employees, who were directly involved in the daily running of the businesses. The researcher personally visited each business premises to collect data and in cases where respondents needed clarification, the researcher guided them through the question and recorded their response. Each questionnaire took approximately five to ten minutes to complete.

The language used in the questionnaire was English, for respondents who had difficulty understanding English, Kiswahili was used to communicate to the respondent what the questions were asking. Pilot testing was done before the commencement of data collection which refined the data collection instrument.

The researcher made it clear that the participation of the respondent was entirely voluntary and the respondent's information would be completely confidential. The researcher displayed their school identification as well as their NACOSTI permit to the respondent to validate the data collection. Data collected was checked for completeness and stored securely for data analysis.

3.7 Data Processing and Analysis

Data was processed and analyzed using a dual track process which accounted for both the numerical and categorical data of the respondents. Numerical data was cleaned to exclude unusable questionnaires due to lack of thematic data. Descriptive statistical techniques were then used to determine the measures of central tendency as well as the standard deviation to identify the characteristics and profile of the study sample. Inferential statistics were used such as Multiple linear Regression (MLR) and Correlation tests to determine the various associations between the independent variables (water, electricity and waste) to identify the positive or negative relationships to the dependent variable (MSME operations). Statistical predictive modeling (R-Studio) was used to clean and convert categorical data into binary codes to obtain frequency counts and percentages of categorical data responses. R-Studio was used to visualize data using charts, tables, pie charts, heatmaps and graphs.

Table 3.5: *Summary of data Analysis*

Research Question	**Independent Variable**	**Dependent Variable**	**Statistical Analysis**
Q1. Water Management	Consumption (m^3), monthly unit price.	Total water bills, perceived operational impact	Descriptive statistics, Multiple linear regression (MLR).
Q2. Energy Usage	Monthly consumption (KWh), monthly unit price.	Total energy bills, perceived operational impact.	Descriptive statistics, Spearman's Rank Correlation.
Q3. Waste Management	Weekly volume (bags), collection cost, disposal method.	Presence of MSW segregation, waste re-use, in-house recycling.	Descriptive statistics, Multiple linear regression (MLR).

3.8 Legal and Ethical Considerations

Institutional authorization was secured through a research permit from the National Commission for Science, Technology and Innovation (NACOSTI) alongside university ethical clearance. Informed consent was obtained from all participants prior to data collection, emphasizing voluntary participation without financial incentives. To ensure data privacy, all respondent identifiers were kept strictly confidential. Academic integrity was maintained by systematically citing and attributing all external ideas, processes, and literature to their respective creators, with final findings disseminated responsibly to relevant stakeholders.

CHAPTER FOUR

DATA ANALYSIS AND FINDINGS

4.1 Introduction

This chapter presents the empirical results and interpretations of the field data collected across Langata Constituency, modelling the operational impacts of the water, energy and solid waste nexus among local MSMEs. Field data was processed in Microsoft Excel and systematically analyzed using R Programming Language, utilizing the ggplot2 library for high-resolution diagnostic plotting.

4.2 Characteristics of the Respondents

4.2.1 Response Rate

Table 4.1: *Distribution of Response Rate*

Variable	Frequency (n)	Percentage (%)
Total Questionnaires Distributed	105	100%
Non-Returned Questionnaires	15	14.3
Total Questionnaires Returned	90	85.7
Excluded: Missing/Unusable Data	15	14.3
Final Usable Sample (N)	75	71.4

The operational step-down from the initial sampling target to the final high-integrity analytical dataset is structurally mapped in Table 4.1. As illustrated in Figure 4.1, the final usable response rate of 71.4% sits comfortably above.

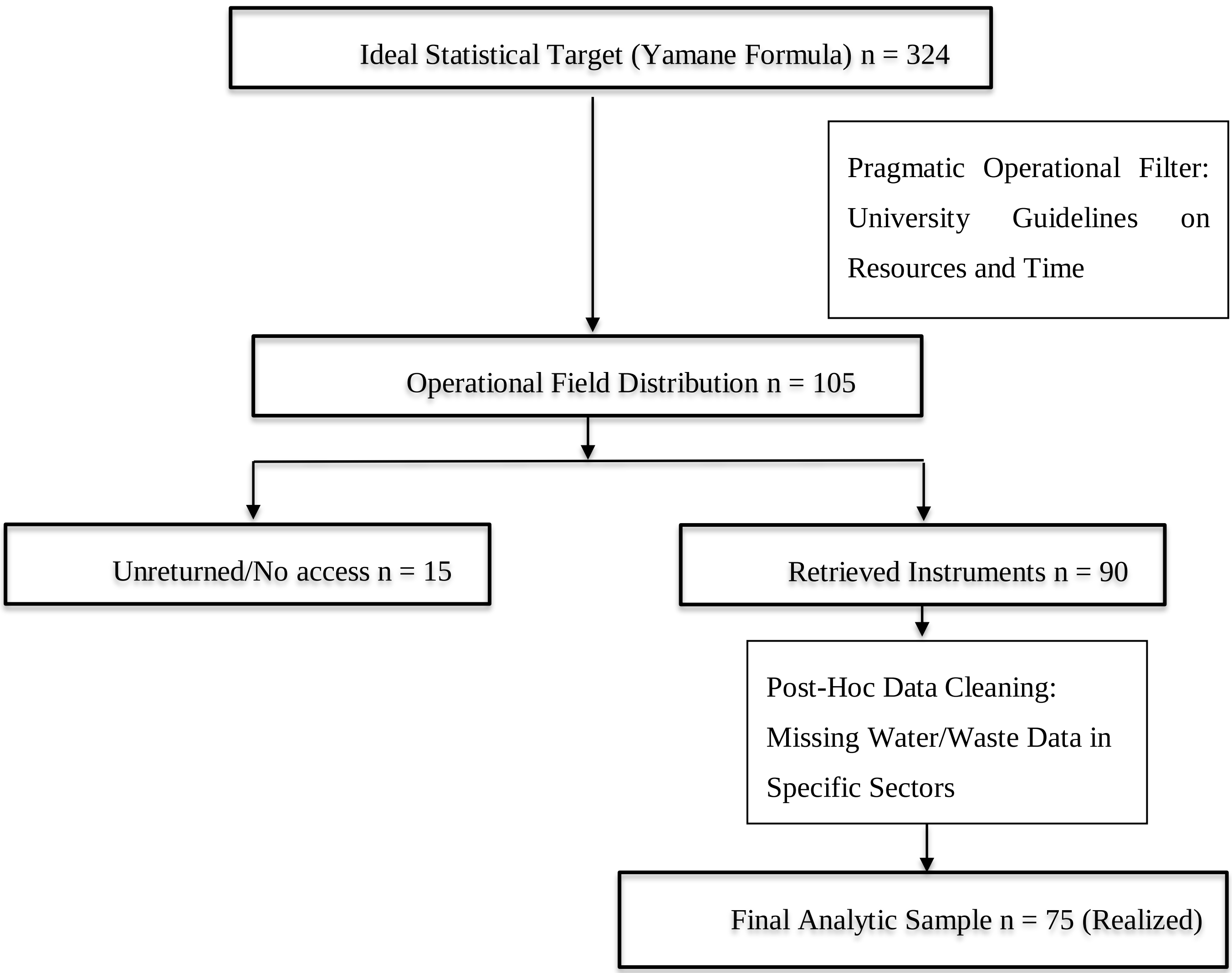

Fig 4.1: *Sample Flow Diagram*

However, the limitations mentioned in section 1.9 of the study contributed to lower samples being collected. In particular, the rapid pace of MSME operations and a general mistrust of the researcher, where key informants assumed that the researcher was a government official affected the study. The researcher countered the mistrust by displaying the university identification, the university introductory letter as well as the NACOSTI research license, while ensuring absolute anonymity to the respondents. The fast-paced business environment limitation was countered using a "drop and pick later" method that allowed the researcher to drop off the questionnaires during slow morning hours and collect them during off-peak hours to avoid business disruptions.

4.2.2 Demographics

4.2.2.1 Distribution of Business Size (N=75) and Employee Range

Table 4.2: *Distribution of Business Size (N=75) and Employee Range*

Category	Employee Range	Frequency (n)	Percentage (%)
Micro	1 – 9 Employees	71	94.67%
Small	10 – 49 Employees	4	5.33%
Medium	50 – 99 Employees	0	0.00%
Total		75	100%

Table 4.2 shows that the study found that 71 enterprises (94.67%) were classified as micro-enterprises according to the MSE Act (2012). The remaining 4 enterprises (5.53%) were classified as small enterprises, with employees ranging from 10 to 15. No medium-sized enterprises were identified in this specific usable sample, which enhanced the study's focus on micro and small enterprises within Langata constituency.

4.2.2.2 Business Age

Table 4.3: *Business Age*

Operational Longevity	Frequency (n)	Percentage (%)
0 to 6 months	3	4.10%
6 months to 1 year	11	15.10%
1.5 to 2 years	13	17.80%
2 to 3 years	11	15.10%
More than 3 years	35	47.90%
Total	73	100.00%

Table 4.3 above provides a detailed overview of the business age. The MSMEs show different maturity levels, ranging from start-ups (4.1% operating for less than 6 months) to long-term enterprises with over 15 years of market presence. The majority of the firms (47.9%) fall into the over 3 years category, indicating a substantial level of business continuity within the study area.

4.2.2.3 Respondents and Socio-Economic Characteristics

The respondents in the study were key informants mainly MSME owners, managers, and employees. Out of the 75 usable respondents, all indicated their gender. Female respondents accounted for 39 (52%), while male respondents consisted of 36 (48%) of the participants in the study." Out of the 75 usable respondents, all indicated their age.

4.3 SME Operations

4.3.1 Operational Costs

Table 4.4: *Total and Mean MSME Operational Costs*

Resource Category	Total Consumption (KWh)	Total Cost (KES)	Mean Consumption (m^3)	Mean Cost (KES)	% of Total Burden (%)
Electricity	10328.9	KES 182,865.60	169.33	KES 3,047.76	54.4
Water	1906.4	KES 117,337.00	40.46	KES 1,952.28	34.8
Waste Management		KES 23,010.00		KES 605.53	10.8
Total Combined		**KES 323,212.60**		**KES 5,605.57**	100

Table 4.4 above indicates the total and mean operational costs of MSMEs in Langata. Operational costs are the monthly costs of keeping the business operational without including other costs such as labour, capital, stock and others. The expenditure matrix reveals that electrical power tariffs impose the heaviest operational penalty on small firms (54.4%), while combined utility outlays (electricity and water) lock up 89.2% of the aggregate monthly overhead burden. Waste costs may be more of a burden than water costs to micro enterprises who use limited amounts of water although a small enterprise would indicate that water costs would be more of a utility burden than waste costs. The MSME size has a significant influence on energy, water and waste costs.

4.3.2 Business Sustainability & Compliance

Table 4.5 below shows the business sustainability and compliance which were measured using the maturity level of the individual business by selecting five criteria that showcased sustainable practices which included; the presence of energy saving equipment, presence of alternative energy sources within the business, presence of water saving technology, water harvesting practices and the presence of waste recycling within the business. The scores were determined using low, moderate and high maturity levels. Those who conducted four (4) to five (5) sustainable practices were classified under the high maturity level, those that had two (2) to three (3) practices were considered to have a moderate maturity level and those that practiced only one (1) or none (0) were considered as the low maturity level.

Table 4.5: *Business Sustainability & Compliance*

SME Sustainability Maturity Profiles

Distribution based on implemented practices

Scoring System	Maturity Level	Frequency (n)	Percentage (%)
Low: 0 to 1 sustainability practices	Low	51	68.0
Moderate: 2 to 3 sustainability practices	Moderate	23	30.7
High: 4 to 5 sustainability practices	High	1	1.3
Total	**NA**	**75**	**100.0**

Source: Field Survey Data (2026)

The largest portion within the constituency fell under the low maturity level with 51 MSMEs practicing 0 to 1 sustainability practices and this accounted for 68% of the respondents who responded to all the five questions. The moderate category consisted of 23 MSMEs who practiced 2 to 3 sustainability practices accounting for 30.7% while the high maturity level consisted of only 1 MSME which accounted for 1.3%. The constituency shows a pattern of low to moderate sustainability and compliance.

In regards to this study water saving technology included; modern toilets, taps, piping, smart water flow meters, low-flow faucet aerators and foot-pedal controlled faucets that reduce the overall water consumption. In addition, energy saving equipment included; LED bulbs, sensor lights and battery powered appliances that reduced overall energy consumption.

4.4. Objective One: Water Management Strategies and MSME Operations

This section presents the data analysis, presentation, and interpretation of findings for the first research objective, which aimed to investigate how water management strategies affect MSME operations in Langata Constituency.

4.4.1 Descriptive Results for Water Management

The study first established the baseline descriptive characteristics of water usage, source dependency, consumption volumes, and sustainability practices across the sampled MSMEs.

All the surveyed industries were overly dependent on the city council to meet their water needs in the constituency with the retail shop industry as the highest at 80% reliance on city council water. The health industry is the largest user of borehole water amongst the industries in the constituency accounting for 33%. Food retail is the largest user of water tanker services at 29%. ICT is the largest user of hand cart water services at 23% and also the largest user of rain water at 8% as seen below in Fig 4.1.

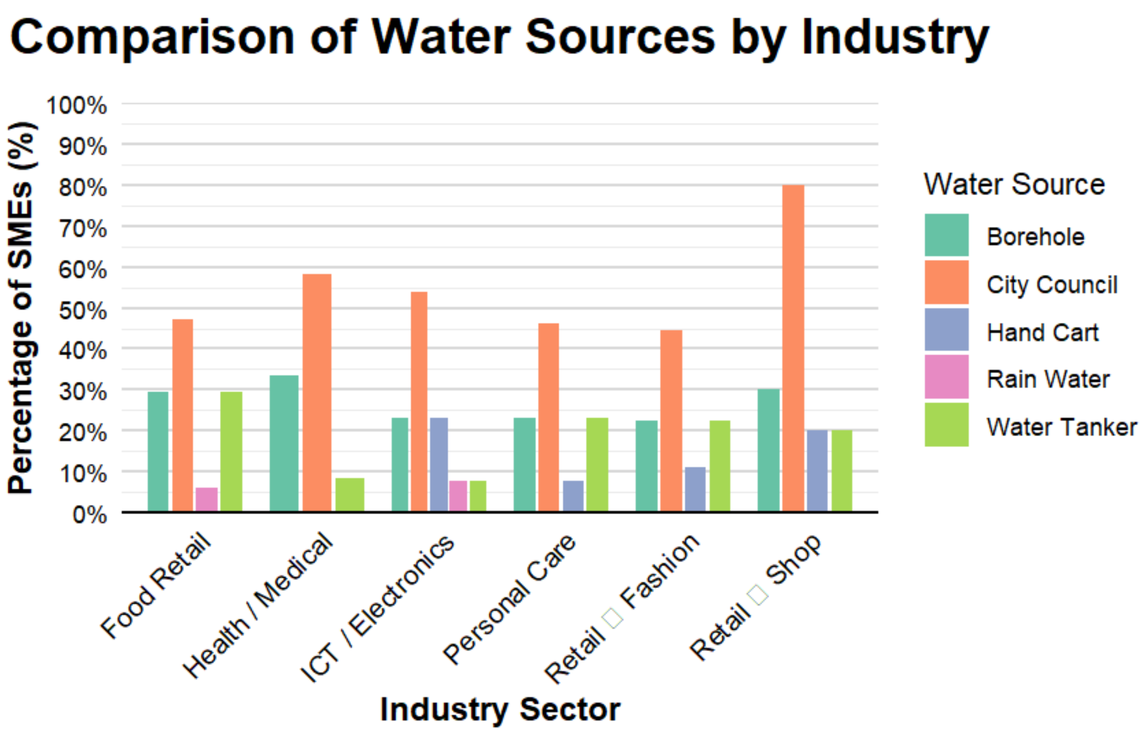

Fig 4.2: *Water Sources by Industry*

Mugumoini is the largest consumer of water 1,457m^3 within the constituency representing 64.4% and recorded a low water harvesting rate of 18.4% and the lowest water-saving technology rate at 22.2%.Karen Ward had a low water consumption (331m^3) compared to the constituency's water consumption of 1,222m^3 paired with a high water-saving technology adoption of (32.8%).

Nairobi West had the lowest consumption rate 119m$^{3.}$ The following data is presented in appendices 7 & 8.

In terms of specific industry footprints, the personal care sector is the largest single water consumer, utilizing 386 m^3 per month (Mean =43 m^3, SD = 36.6 m^3), followed closely by the food retail at 309 m^3 per month (Mean = 34 m^3, SD = 24.4 m^3). The lowest consumption levels were recorded in the ICT industry, which consumed 97 m^3 monthly, (Mean = 14 m^3, SD = 14.3 m^3).

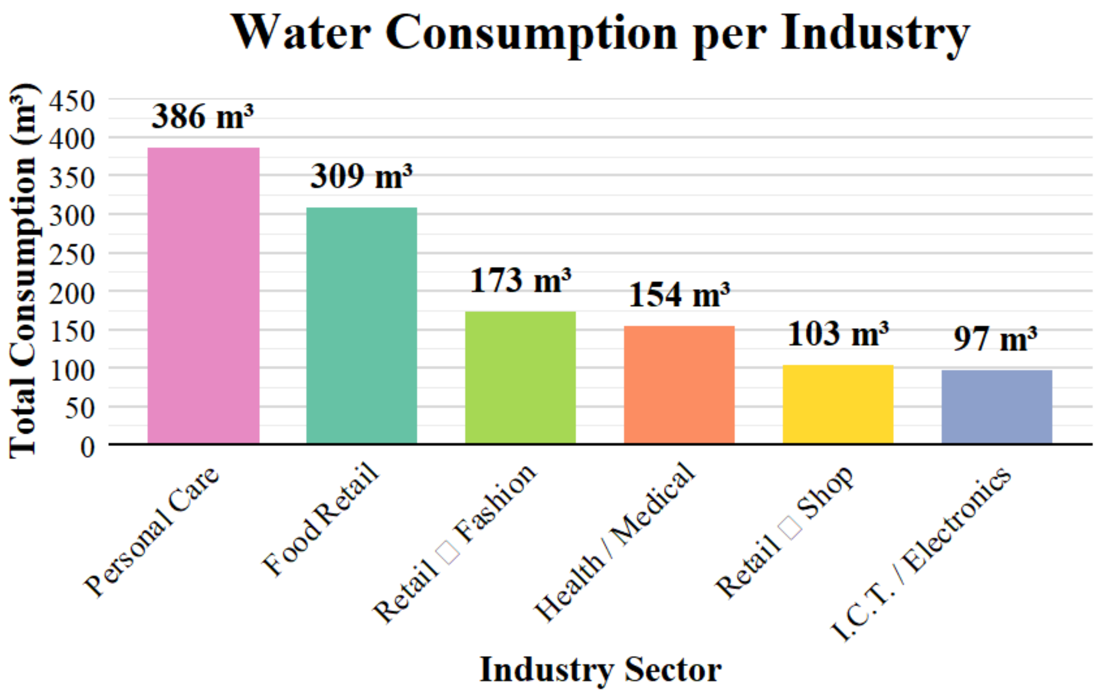

Fig 4.3: *Water Consumption by Industry*

On sustainability metrics, the retail fashion (77.7%) and retail shop (70%) industries measure their consumption the most, while ICT is the lowest at 33.3%. Food retail (53.3%) and the personal care (45.5%) have the highest implementation of water saving technology. The industries that needed supplementary water for their businesses were the personal care industry (54.5%), retail fashion (44.4%), food and retail (40%) and the retail shop (40%).

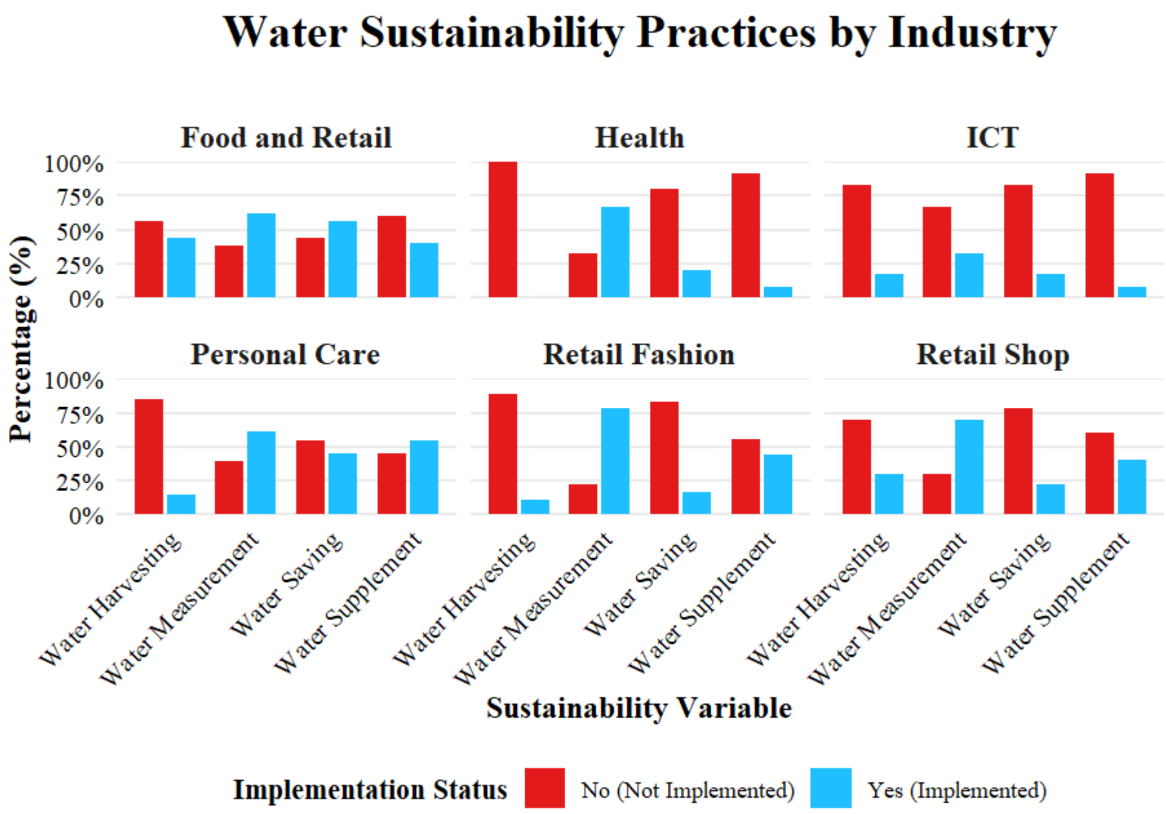

Fig 4.4: Water Sustainability Practices by Industry

The impact of water saving is highly felt by the industries that do have water saving technology such as the food retail (53%) and personal care (46%). Contrastingly, in the retail fashion industry needed to supplement their water needs (44.4%) while had low water saving technology (16.7%) and low water harvesting (11.1%).

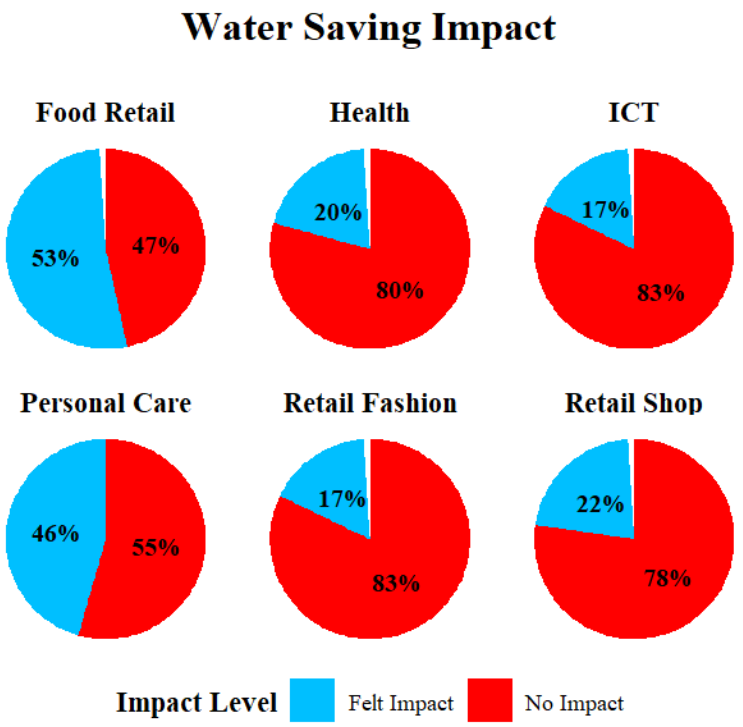

Fig 4.5: Water Saving Impact by Industry

Although the study initially intended to compare the eight industry sectors listed in the scope, the number of usable responses retrieved during data cleaning for the automotive (n = 6) and professional agency (n = 5) sectors were too small to support statistically meaningful comparisons. To protect model integrity, these two sectors were excluded post hoc, leaving a high-integrity, resource-dependent final sample of 75 MSMEs.

4.4.2 Relationship Tested and Statistical Method

To determine the precise nature of the relationship between proactive water conservation and firm performance, the study tested the relationship between independent water sustainability scores/industry types and the dependent variable of monthly MSME water costs (bills).

The statistical method applied was Multiple Linear Regression modeling executed in R-Studio. This method was selected to isolate the predictive variance of adopting green practices while simultaneously controlling for the baseline consumption differences inherent to different industry sectors.

4.4.3 Statistical Output and Plain-Language Interpretation

The empirical results of the regression model are summarized directly from the R-Studio output in Table 4.2 below.

Table 4.6: *Statistical Output on Water*

Variable / Predictor	Coefficient (β)	Standard Error (SE)	95% Confidence Interval (CI)	t-statistic	p-value
(Intercept / Retail Shop)	1,457.40	781.32	[-124.30, 3,039.10]	1.865	0.0699
Sustainability Score	-26.72	260.09	[-553.24, 499.80]	-0.103	0.9187
Retail - Fashion	-428.03	891.74	[-2,233.26, 1,377.20]	-0.48	0.634
Food Retail	535.49	882.08	[-1,250.19, 2,321.17]	0.607	0.5474
Health / Medical	-394.69	887.34	[-2,191.02, 1,401.64]	-0.445	0.659
ICT / Electronics	-843.93	916.05	[-2,698.38, 1,010.52]	-0.921	0.3627
Personal Care	741.5	865.45	[-1,010.51, 2,493.51]	0.857	0.3969

Model Fit Summary:

Multiple R^2: 0.1397, **Adjusted R^2:** 0.003861

F-statistic: 1.028 on 6 and 38DF (p-value = 0.4221)

The regression output yields a negative coefficient (-KES 26.72), confirming that every sustainable conservation practice adopted by an MSME shaves approximately KES 26.72 off their monthly water bill. However, with a p-value of 0.918, this savings is not statistically significant. the financial benefits of a business going green are currently completely overshadowed by industry-specific demands. Ultimately, a cost reduction of only KES 26.72 per practice is too small a financial motivator for a struggling MSME to go green.

4.5 Objective Two: Energy Management and MSME Operations

This section presents the data analysis presentation, and interpretation of findings for the second research objective, which aimed to investigate how electricity reliability and affordability affect MSME operations in Langata Constituency.

4.5.1 Descriptive Results for Energy Usage

The study first established the baseline descriptive characteristics of electricity source dependency, consumption volume rates, and energy saving practices across the sampled MSMEs.

The descriptive data reveals that all industries are overly dependent on the national grid to meet their energy needs which indicates high vulnerability to energy supply fluctuations or rapid price increase. Specifically, food retail and retail fashion indicate a 100% reliance on the national grid followed by ICT at 91.67%, personal care at 85.71%, health at 83.3%, and the retail shop at 80%. Solar energy systems are low, with adoptions concentrated almost exclusively within the retail shop industry (20%), while other alternative sources are limited to standalone fuel generators and small battery setups.

Spatially, Mugumoini is the largest consumer of energy (6,122KWh) within the constituency compared to the total energy consumption of 10,329KWh. However, Mugumoini recorded the lowest alternative energy adoption rate at 15% and the highest urgent demand for supplementary power (34.1%). Karen ward had an energy consumption of (2,240KWh) a high-energy saving adoption rate of 71.4% but still required supplementary energy at 50%. Nairobi West had an energy consumption of (1,968Kwh) where 53.3% used energy saving equipment and 80% of them did not need to supplement their energy supply. The underlying distributions are presented in appendices 5 & 6.

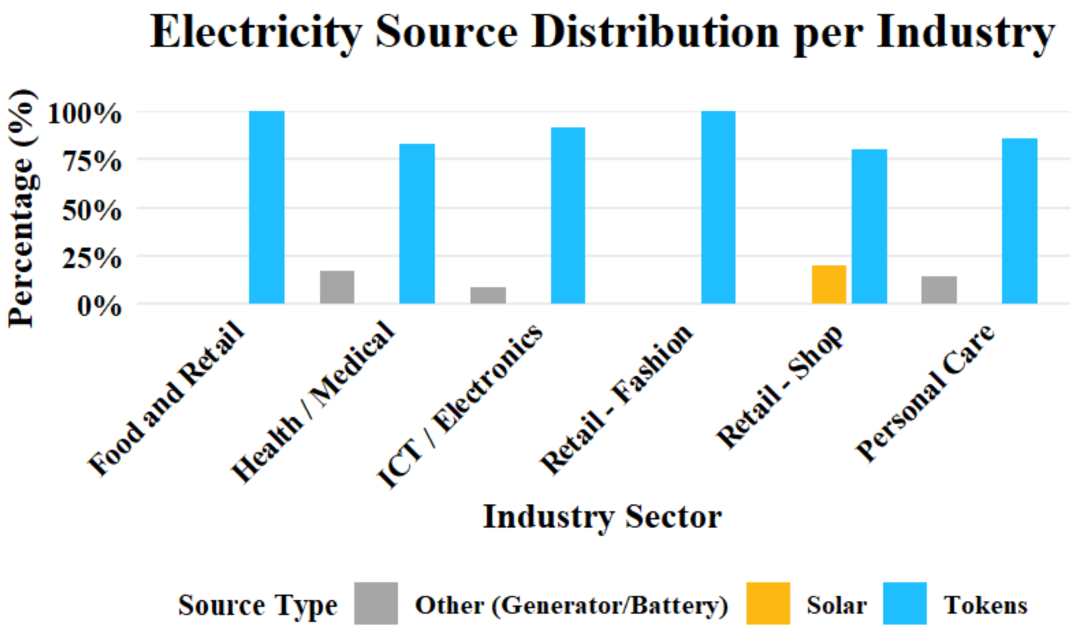

Fig 4.6: Electricity Source by Industry

Volumetrically, the ICT industry recorded the highest monthly energy consumption at 2,379 KWh (Mean = 183 KWh, Median = 163 KWh, SD = 118.3 KWh), followed closely by personal care at 2,063 KWh (Mean =188 KWh, Median = 196 KWh, SD = 140.8 Kwh) and food retail at 1,996 Kwh (Mean = 181 Kwh, Median = 130 Kwh, SD = 104.6 Kwh). The health sector consumed 1,905 Kwh (Mean = 190 Kwh, SD = 231.2 Kwh). The lowest consumption profiles were in the retail shop at 1,144 Kwh and retail fashion at 841 KWh per month.

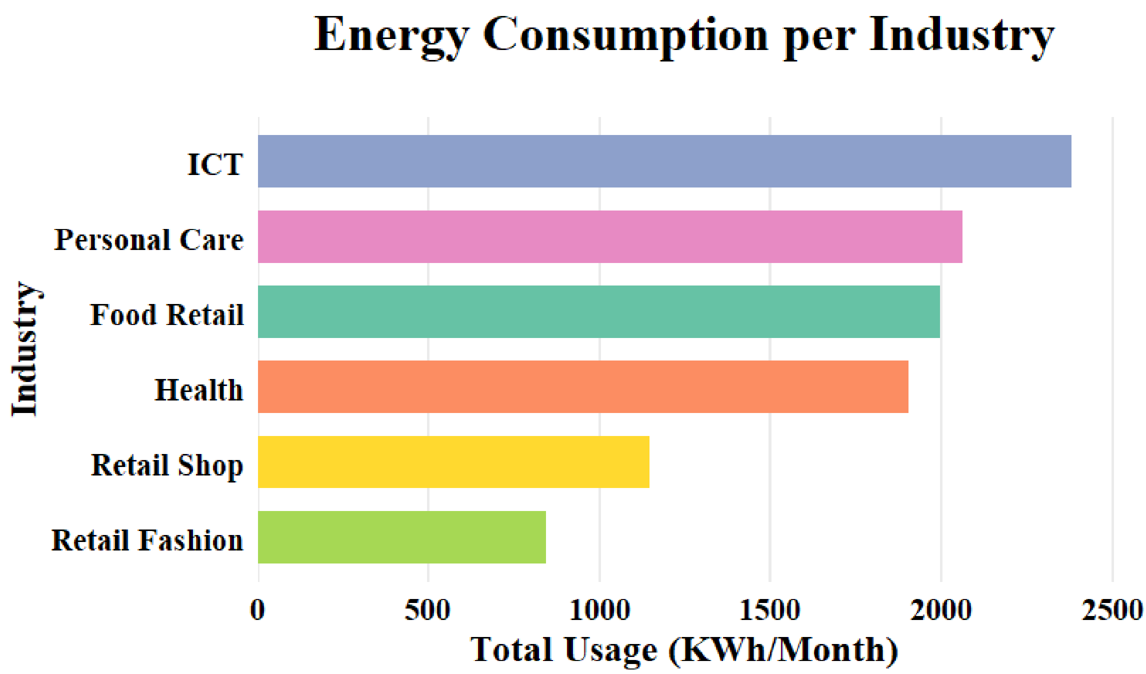

Fig 4.7: Energy Consumption by Industry

The sustainability measure such as alternative energy adoption remained low within the food retail (13.3%), retail fashion (11.1%), and the health (8.3%). In contrast, the ICT (43%), personal care (43%), and the retail shop (33%) sectors demonstrated higher alternative energy adoption rates.

Resource tracking is consistently practiced across the industries led by the retail fashion (100%) and retail shop (90%), with personal care at the lowest (71.4%). Demands for supplementary power were highest in the food retail (50%), personal care (42.9%), and health (33.3%). The health industry leads on energy saving equipment installation with (60%), followed by ICT and retail fashion at 50% each, while retail shop lags behind at 37.5%.

Notably, despite 50% of food retail firms require supplementary power, 87% do not utilize any alternative energy configurations.

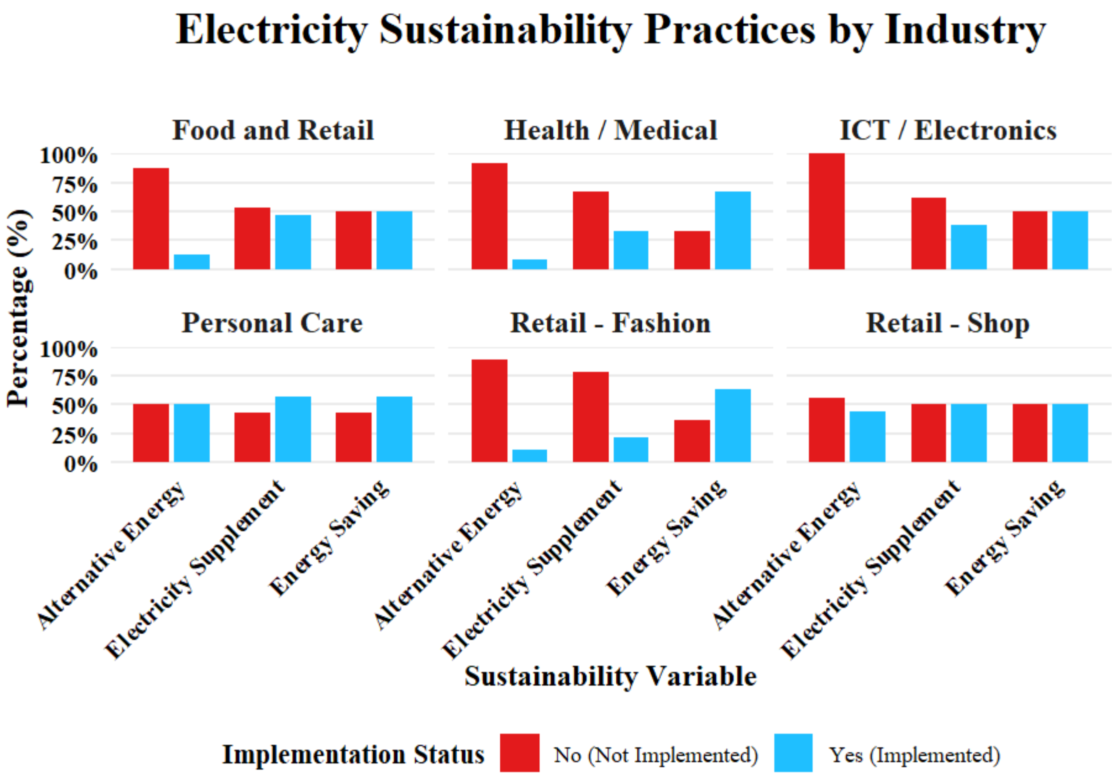

Fig 4.8: Energy Sustainability Practices by Industry

4.5.2 Relationship Tested and Statistical Method

To determine the exact operational impact of green energy choices, the study tested the relationship between the independent energy sustainability scores and the dependent variable of monthly MSME electricity bills.

The Spearman's rank correlation (r_s) modelling through R-Studio was utilized. The non-parametric method was selected to measure the strength and direction of the relationship between the sustainability scores and energy bills.

4.5.3 Statistical Output and Plain-Language Interpretation

The Spearman's rank correlation test yielded a weak positive correlation coefficient of 0.277 between the sustainability scores and energy costs. The correlation model demonstrated that this relationship was not statistically significant ($p = 0.277$, where $p > 0.05$) depicted by table 4.7 below.

Table 4.7: *Statistical Output on Electricity*

Test Metric / Variable Relationship	Statistical Value / Estimate	S-Statistic	p-value	Statistical Significance Baseline
Sustainability Score vs. Monthly Electricity Cost	+0.1427 (rho)	30,855	0.2768	Non-Significant ($p > 0.05$)

In plain language the results above suggest that the current sustainability practices are inadequate to create a significant reduction in the total energy consumption compared to the energy intensive activities of individual MSMEs. It would be assumed that sustainability practices would lead to a reduction in electricity costs although the correlation test proves that a high sustainability score does not indicate a reduction in electrical bills but shows that the sustainability measures put in place are reactive rather than proactive. The energy reduction initiatives need to transit from minor cost reduction measures to actual significant energy reduction which will lead to industry specific recommendations.

4.6. Objective Three: Solid Waste Management Techniques and MSME Operations

This section presents the data analysis, presentation, and interpretation of findings for the third research objective, which sought to assess the efficacy of solid waste management techniques used by MSMEs in Langata Constituency.

4.6.1 Descriptive Results for Solid Waste Management

To establish a standardized baseline for quantifying the solid waste generation, waste volume was measured using a standard 50-kilogram (kg) capacity bag over a period of one week (7 days).

The descriptive results show that in the category of more than a bag (>50kg/week) of waste disposed, the retail shop (50 %) generates the most volume of waste while personal care (9.1%) generates the least within the category. The trend in the one bag category (50kg/week), shows that health (58.3%) generates the highest volume in this category while ICT (50%) and personal care (45.45%) generate the most volume of waste in the less than a bag category (<50kg/week).

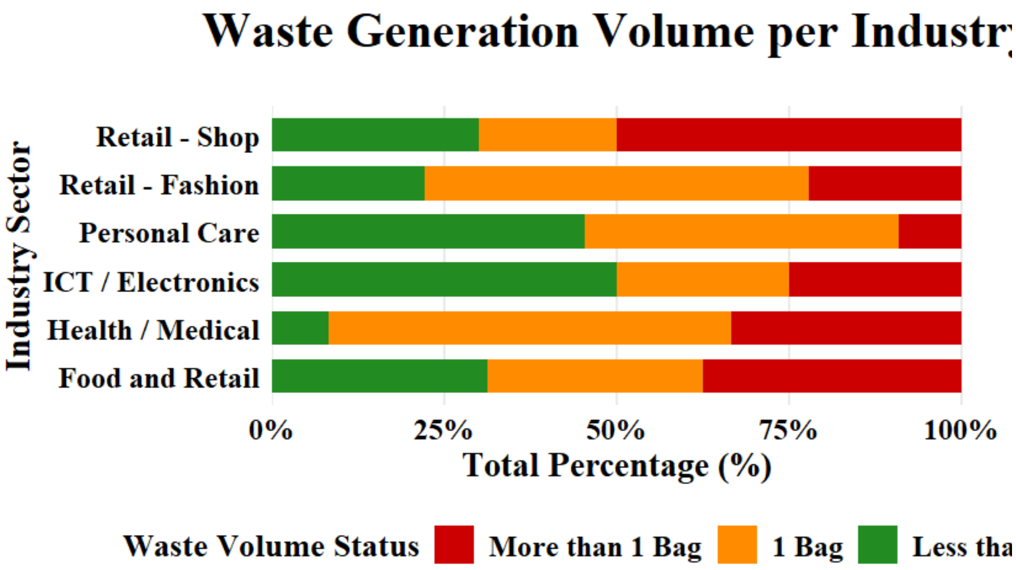

Fig 4.9: Waste Volume by Industry

Financial tracking shows that the retail fashion (26.5%), food retail (24.5%), and health (24.3%) industries bear the highest relative waste disposal within the constituency. Conversely, the personal care (8.7%), retail shop (8.5%), and ICT (7.6%) sectors pay significantly lower rates.

Spatially, Mugumoini is the largest waste producer accounting to 56% of the total waste generated in the constituency. In the category of the less than a bag of waste disposed, Karen ward generates the lowest (1%) and produces the least waste volume in the constituency at 20%. In the more than a bag of waste disposed Nairobi west produces the least amount of waste at 3%.

Waste recycling participation is extremely low in all the three wards with only Mugumoini accounting for 2.5% of recycled waste. Although different industries generate distinct waste streams, empirical field observations confirmed that alternative circular practices such as reusing, repurposing, or refurbishing materials were not present, with conventional disposal as the dominating response across all sectors. This shows overreliance on waste disposal mechanisms both within the industries and wards which exposes untapped potential for in house recycling or recycling partnerships between waste recyclers and individual MSMEs. The following data is presented in appendices 9, 10 & 11.

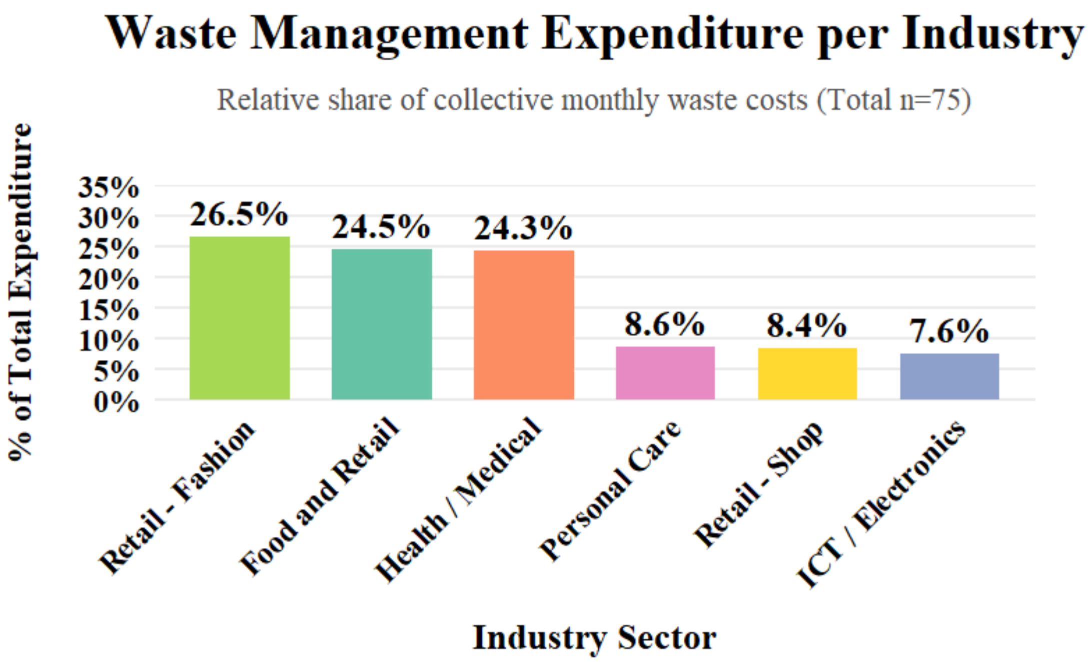

Fig 4.10: Waste Disposal Cost by Industry

4.6.2 Relationship Tested and Statistical Method

To evaluate the operational and financial impact of local waste management choices, the study tested the relationship between the independent variables (sustainability scores, weekly waste volumes, and specific industry classifications) and the dependent variable of monthly MSME waste disposal costs (bills).

The statistical method used was Multiple Linear Regression Modelling executed in R-Studio. This method was selected to identify whether an MSMEs green waste practices or waste volumes directly influence their waste costs.

4.6.3 Statistical Output and Plain-Language Interpretation

The multiple linear regression model revealed that sustainability scores ($p = 0.939$), waste volumes ($p = 0.340$), and specific industry types do not statistically influence waste disposal costs of an MSME ($p = 0.7881$ for the overall model layout). The model also generated a negative adjusted R-squared value of -0.098 shown in table 4.8 below.

Table 4.8: *Statistical Output on Waste*

Variable / Predictor	Coefficient (β)	Standard Error (SE)	95% Confidence Interval (CI)	t-statistic	p-value
(Intercept / Retail Shop)	-38.03	650.36	[-1,370.23, 1,294.17]	-0.058	0.954
Sustainability Score	11.43	147.48	[-290.67, 313.53]	0.077	0.939
Waste Volume (Ordinal)	198.35	204.38	[-220.30, 617.00]	0.97	0.34
Retail - Fashion	461.96	498.26	[-558.68, 1,482.60]	0.927	0.362
Food Retail	504.26	528.14	[-577.59, 1,586.11]	0.955	0.348
Health / Medical	305.29	495.2	[-709.08, 1,319.66]	0.616	0.543
ICT / Electronics	-77.49	529.92	[-1,162.98, 1,008.00]	-0.146	0.885
Personal Care	94.66	546.89	[-1,025.59, 1,214.91]	0.173	0.864

Model Fit Summary:

Multiple R^2: 0.1211, **Adjusted R^2:** -0.09858

F-statistic: 0.5514 on 7 and 28DF (p-value = 0.7881)

In plain language, these statistical outputs prove that the amount of waste an MSME produces, and whether that business tries to be green, has absolutely zero impact on its monthly waste bill. This complete lack of statistical significance as well as the negative R-squared value, shows that the waste costs are completely influenced by external factors.

Specifically, private waste collectors use flat-rate fixed pricing model (averaging KES 605.53). This means that the smallest MSMEs producing significantly lower waste volumes are penalized by paying the same amount as the others in a similar category generating higher volumes of waste.

This shows that the current sustainability measures are inadequate as the fixed cost pricing acts as a barrier to circular economy. The current pricing framework discourages waste segregation, resource substitution, re-use and recycling as it promotes disposal rather than sustainable waste management (SWM) and is based on fixed cost pricing rather than price by volume.

4.7 Chapter Summary: Comprehensive Resource Intensity Matrix

To synthesize the combined operational footprint of the three environmental variables, the study compiled a multi-variable statistical heatmap. The matrix below (Fig 4.10) utilizes standardized Z-scores to map the energy use, water consumption, and waste disposal costs by sector.

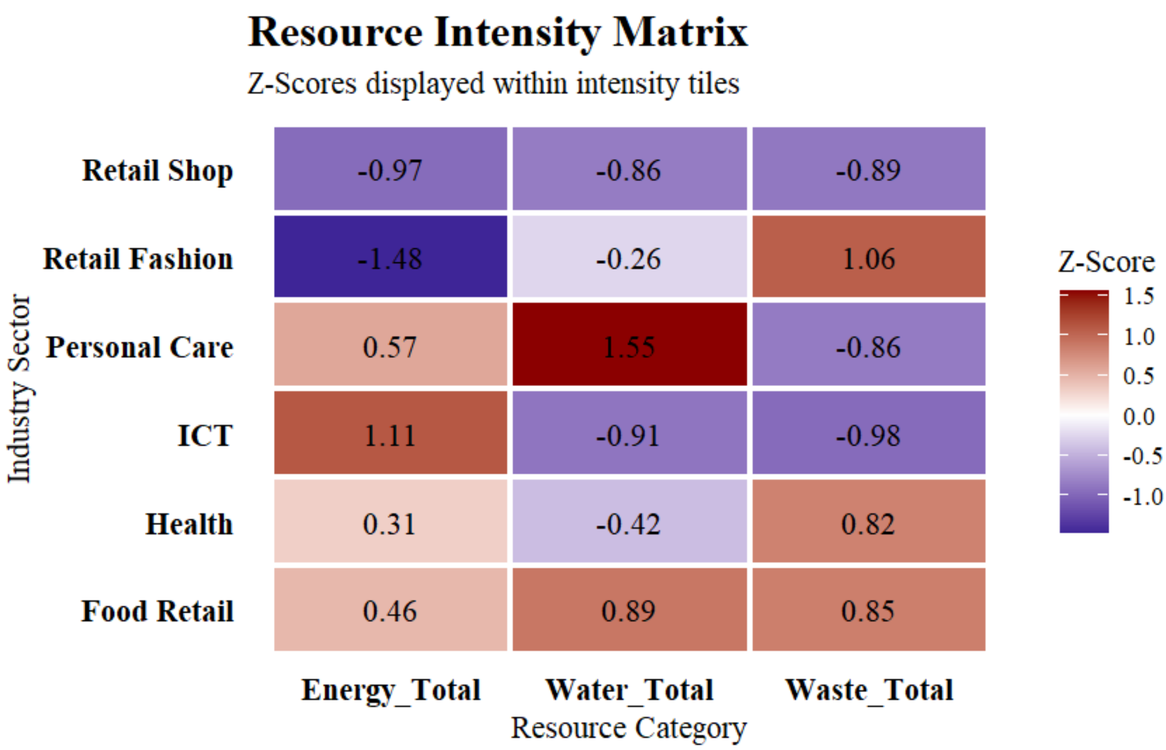

Fig 4.11: *Resource Intensity Matrix*

Matrix Interpretation:

The retail shop industry shows low resource intensity across all three variables (Z_E = -0.97, Z_W = -0.86, Z_{Waste} = - 0.89), meaning the industry consumes lower energy, less water and pays less for waste disposal compared to the constituency's totals. The retail fashion industry shows the lowest overall energy consumption (Z_E = -1.48) and moderate water needs (Z_W = -0.26), yet suffers from the highest relative waste disposal costs (Z_{Waste} = + 1.06) due to the flat-rate pricing model.

The personal care industry shows high energy and water consumption (Z_E = +1.55, Z_W = +0.57) due to heavy reliance on water heating and styling equipment, while maintaining low waste costs (Z_{Waste} = - 0.86).

The ICT industry shows the highest overall energy consumption (Z_E = +1.11) due to continuous server and hardware uptime demands, but requires almost no water (Z_W = -0.91) or waste handling overheads (Z_{Waste} = - 0.98).

The health industry shows stable, elevated consumption trends with high energy consumption (Z_E = +0.31) due to continuous clinical equipment demands, a moderate water consumption profile (Z_W = -0.42), and a significantly high waste disposal cost (Z_{Waste} = + 0.82).

The food retail industry shows the most critical sustainability risk, recording high intensities across all three variables (Z_E = +0.46, Z_W = +0.89, Z_{Waste} = + 1.06).

CHAPTER FIVE

DISCUSSIONS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This chapter presents discussions, summary, conclusions, and recommendations. The section provides insight on what the purpose of the study was and discusses the findings of the research.

5.2 Discussion

5.2.1 Water Management Discussion

The data analysis in section 4.4.3 found that water management strategies in Langata are diverse within the MSME sectors and are highly influenced by the specific operations an MSME conducts based on their industry classification. An increase in one sustainability score only results in a slight cost reduction shown in the Multiple linear regression test performed. The current sustainability measures undertaken by MSMEs in Langata vary across industries and overall effectiveness. The sustainability practices do not offer a significant financial incentive to promote the current sustainability measures undertaken by MSMEs.

High water consuming industries, specifically personal care and food retail show high levels of resource monitoring and water saving tech adoption but remain dependent on expensive supplementary sources to sustain operations.

Conversely, low-intensity sectors like ICT and retail shop possess a structural advantage; their low utility footprint allows them to transition toward complete water self-resilience through localized rainwater harvesting, eliminating the reliance on municipal supply. These industries have a strategic advantage where they can fully transit from City council dependent water to self-reliant water provision through increased water harvesting practices that would eradicate the need for supplementary water services.

The results of the study agree with the findings of (Mulwa et al., 2021) where water stress and unreliable supply have been reported to adversely affect businesses. The study also found that sustainability practices are overrun by water consumption rates of MSMEs, deeming them inadequate to address the water challenges faced by MSMEs in Langata constituency.

The study found that most MSMEs rely on City council water to provide adequate water supply for their businesses while most MSMEs indicated a need for supplementary water such as the food retail, retail fashion, personal care and retail shop industries.

Kathambi et al. (, 2021) found that data information, regulatory framework, financing and innovative governance enables MSMEs to innovatively recycle, re-use their waste water and efficiently manage their water resources. Additionally, (Kathambi et al., 2021) discovered that poor water infrastructure was a major constraint to proper water management for MSMEs within Nairobi. The study agrees with (Kathambi et al., 2021) study and discovered that the adoption of water saving technology has been relatively low across the constituency with the food retail and personal care industries having the highest implementation rates for water saving technology within their businesses.

Kathambi & Obiero (2021), recommend that MSMEs adopt water-efficient models, reuse and recycle water where possible, and better understand their consumption patterns to improve risk management and sustainability. The study agrees with the recommendations of (Kathambi & Obiero, 2021) and found that there was a high rate of water resource monitoring but a low implementation of water harvesting practices. The study found that the ICT, retail fashion and personal care industries had a low rate of water harvesting while the food retail & retail shop industries had a moderate water harvesting nature within their businesses.

Ochungo (2020), found that households incur substantial additional costs when they purchase tanker water to supplement utility supply, with some wards paying significantly more than others. The study found that water accounts for 34.8% of the operational costs of an MSME where on average MSMEs pay KES 1,952.28 to meet their monthly water needs.

5.2.2 Energy Usage Discussion

The data analysis revealed that energy management in Langata for the MSME sector is highly influenced by the specific industrial operations of an MSME. Sustainability scores do not directly influence energy bills which is seen through the Spearman's Rank correlation analysis performed in section 4.5.2. Statistically, internal energy-saving scores do not drive down monthly electricity costs: instead, minor behavioral interventions are completely rendered ineffectively by heavy, grid-dependent machinery required by high-consumption sectors. Small firms deploy energy-saving equipment as a desperate, defense mechanism only after facing sudden utility billing shocks.

The personal care industry has moderately implemented the use of alternative energy sources, food retail had good resource monitoring but were overly reliant on grid power and also required supplementary power to meet their business needs. The ICT industry is highly vulnerable to power outages as they are overly dependent on the national grid to meet their business demands. To optimize their operations, MSMEs need to transition from minor cost reduction to large scale alternative energy source infrastructure. The ICT industry could implement the use of solar powered systems, efficient server racks to enhance cooling, energy management software to identify high energy consuming equipment, adjust power management settings, and, energy auditing to replace or maintain high energy consuming equipment. The low energy consuming industries such as the retail shop and retail fashion show great potential to transit from 100% reliance on the national grid to meet their energy demands to complete self-reliance through adopting green energy solutions within their businesses. By using small wattage solar systems within their businesses for lighting could shift the industry from grid reliance to self-sustainability.

The findings are essential to prompt a change from reactive monitoring to implementing actionable energy reduction measures that significantly reduce the energy footprint of specific MSME industries within the constituency. MSMEs that undertake these changes will experience a competitive advantage compared to their competitors and this can be achieved through integrating these alternative energy investments into their individual businesses reducing the overall industrial consumption.

Nyanchama & Simwa (2024) found that in 2024, customers who paid Ksh 500 or Ksh 5,000 for tokens received a relatively small number of units, illustrating the high effective cost of electricity. The study agrees with (Nyanchama & Simwa, 2024) and found that energy accounts for 54.4% of the operational costs of an MSME where on average MSMEs pay KES 3,047.76 to meet their monthly energy needs.

Ajibola et al. (2021), in a study of Nigerian MSMEs, found that a one-unit increase in electricity supply resulted in a 3.9% improvement in business performance, while a one-unit increase in alternative power supply (e.g. generators, solar) led to a 3.7% improvement. The study found that the ICT, personal care and retail shop had higher alternative energy adoption rates while only the personal care industry and retail shop industries indicated that the alternative energy sources were impactful.

5.2.3 Waste Management Discussion

The MLR test result showed that there was no influential relationship between the volume of waste generated, the industry, sustainability score and the waste disposal cost which was attributed to fixed cost pricing across the constituency. This relevant finding identifies that there are other external factors controlling the waste costs where ideally it would be assumed that the waste disposal cost would be directly proportional to the waste volume.

The analysis of solid waste management reveals a disconnect between waste generation volume, sustainability scores and waste costs. Statistically, neither a firm’s weekly waste volume nor its sustainability score exercises any predictive influence over monthly waste utility costs. This outcome directly validates the field finding that private waste collection service providers enforce a rigid, flat-rate fixed pricing model across Langata’s commercial zones. Due to the fixed pricing the MSMEs also lack motivation to reduce their waste or recycle their waste where most choose to dispose rather than manage their waste. This identifies a significant opportunity for MSME in house waste recycling within the constituency. Sorting or reducing waste streams yields zero direct financial savings for an MSME, the local business community exhibits an extremely low priority for waste recycling with 97.7% of surveyed MSMEs choosing mass disposal.

In conclusion the current pricing framework in the constituency does not reward sustainability therefore the motivation to practice sustainable waste management is relatively low. For waste management to be an integral part of MSME operations there has to be a transition from fixed pricing to priced-by-volume where sustainability incentives can then be introduced to promote sustainable waste management. Practices such as waste segregation and waste reduction would create a symbiotic relationship between waste costs, sustainability scores and reduced operational costs for MSMEs within Langata constituency. Waste management provides an opportunity for policy intervention within the waste sector.

Filipenco (2024), found that a large proportion of waste is landfilled or openly dumped, with less than half adequately recycled or recovered. The study found an extremely low waste recycling rate and a high overreliance on disposal services. This shows that there is a low interest in recycling, reusing and substituting of materials to reduce waste generation in the constituency.

Odanga (2020), found that residents typically pay between Ksh 185 and 800 per month for waste collection, depending on their residential area. The study found that most MSMEs pay KES 605.53 monthly to dispose their waste accounting to 10.8% of their operational costs. The waste costs are highly influenced by fixed pricing of waste disposal services within the constituency.

Literature on MSMEs indicates that many small enterprises have at least some awareness of green practices that reduce waste and enhance recycling (Šebestová & Sroka, 2020). The study found that although awareness on waste reduction and recycling was present, there was an extremely low implementation rate.

Derhab and Elkhwesky (2022), show that MSMEs adopting waste minimization and cleaner production practices often experience cost savings, improved operational performance and better financial outcomes due to reduced waste handling costs, lower input use and enhanced process efficiency. The study found that the effect of waste management practices on operational costs was insignificant as waste disposal prices were fixed therefore, Derhab and Elkhwesky (2022) study findings can only be utilized in a priced by volume setting for better analysis and conclusions.

However, other studies have found that waste reduction is not always a high priority for MSMEs, and many small firms do not consistently implement reuse, composting or separation strategies (Toke & Kalpande, 2022; Kasseeah, 2020). The study found that 97.7% of MSMEs do not recycle their waste indicating a low priority towards waste recycling practices.

5.3 Summary of Main Findings

This section summarizes the primary findings of the study conducted across the three selected wards of Langata Constituency. The findings focus on the relationship between natural resource management and the operational efficiency of MSMEs.

Current Resource Management Trends: The study found that most MSMEs in Langata do prioritize energy saving measures over water conservation and waste management. The energy saving measures were manly behavioural practices and energy saving equipment was implemented to reduce the immediate monthly energy costs. Cost saving was the biggest motivator to conserve natural resources in the constituency rather than environmental compliance and policy.

Waste Management Practices: A relevant finding in this area was that a large portion of MSMEs did not practice waste segregation, reduction and recycling at source but rather relied on waste disposal services as their waste management technique. Most relied on private waste pickers to handle their waste and did not prioritize composting as a sustainable waste management practice. The findings indicated that the fixed waste disposal cost is a major hinderance to effective waste management as it negatively affects the MSMEs motivation to conduct sustainable waste management.

Impact on Operational Costs: There was a clear relationship between water management strategies and MSME operational costs where sustainable practices had a slight reducing effect on water bills and operational costs while sustainability measures were only undertaken as a reactive measure to high energy costs deeming them ineffective to reduce operational costs.

Regulatory Awareness and Compliance: The research revealed a gap between the existence of environmental regulations and the actual awareness levels of MSME owners. Most respondents were reacting to costs associated with energy, water and waste rather than integrating sustainability practices as a comparative advantage to their businesses.

Resource Scarcity Challenges: The findings highlighted that water scarcity was highly mentioned within high consuming industries which led to expensive alternatives. This then significantly affected their operational costs over time.

5.4 Conclusions

Based on the research findings and the subsequent discussions, the following conclusions are made in line with the study objectives:

5.4.1 Adoption of Resource Management Practices

The research has identified that most sustainable practices are implemented as a cost cutting measure rather than corporate social responsibility (CSR). There is great potential to transform less effective sustainability measures into data driven resource management which may produce a significant reduction in water and energy consumption as well as a reduction in waste disposal volume. MSMEs are highly attracted to cost dominant differences which means that MSMEs would undertake a sustainable measure only if it has a direct significant effect on their operational costs.

5.4.2 Impact on MSME Operations

The study concludes that the way in which an MSME manages its natural resources is a good predictor of its operational resilience therefore, MSMEs should pay much needed attention to natural resources as this can enhance their business resilience when environmental shocks occur rather than passing immediate costs directly to consumers.

5.4.3 Regulatory and Institutional Influence

The study concludes that the existing regulatory framework for environmental management is not effectively reaching the MSME level in Langata. Instead of acting as a proactive catalyst that enhances the relationship between resource monitoring and sustainility, it creates structural friction. Compliance is mainly reactive driven by immediate enforcement fears and utility shocks rather than integrated into the core business framework. The systematic gap is further highlighted by a general mistrust of academic research, where MSME owners frequently combine academic research with state regulatory or tax compliance auditing. Therefore, to enhance the moderating effect, enforcement of environmental regulators should transition away from detached oversight towards supportive oversight to bridge the gap between localized institutional frameworks and firm level resource management to enhance MSME sustainability and resilience.

5.5 Recommendations

Based on the conclusions of this study, the following recommendations are made to various stakeholders to enhance environmental resource management and the operational success of MSMEs in Langata Constituency.

5.5.1 Recommendations for Objective One (Water Management)

MSME Owners and Managers

Equipment upgrade: High water consuming industries such as the personal care industry and the food retail industry should transit from basic water conservation practices to large scale water harvesting infrastructure by implementing better water saving technology such as low-flow faucet aerators, high-efficiency spray valves, recirculating shower or sink systems, and, smart water flow meters, water efficient pre-rinse spray valves, foot-pedal controlled faucets, and, high pressure, low volume cleaning systems to reduce their overall water consumption.

The moderately to low consuming industries such as the retail fashion, health, retail shop and ICT should increase water harvesting practices that eradicate their need for supplementary water services.

Internal resource auditing: Business owners and managers should conduct internal resource monitoring and in house SWM to enhance their environmental compliance and promote data driven resource management.

5.5.2 Recommendations for Objective Two (Energy Management)

MSME Owners and Managers

Equipment upgrade: The high energy consumption industries such as the ICT, food retail, personal care, and health need to invest in large scale alternative energy source infrastructure through industrial clustering to increase their purchasing ability. The ICT industry could implement the use of solar powered systems, efficient server racks to enhance cooling, energy management software to identify high energy consuming equipment, adjust power management settings, and, energy auditing to replace or maintain high energy consuming equipment.

The personal care industry could incorporate the usage of heat pump water heaters to improve their energy efficiency and smart power strips to stop power leakage when devices are on standby.

The health industry can transit to LED surgical and examination lamps, and, high efficiency sterilizers that significantly reduce the energy consumption within the respective MSMEs. Daylight sensors could also improve energy efficiency by ensuring that lights go on when a patient is present to reduce continuous power consumption.

The low energy consuming industries such as the retail shop and retail fashion could transit from 100% reliance on the national grid to complete self-reliance through the use of small wattage solar systems within their businesses for lighting purposes.

Internal resource auditing: Business owners and managers should conduct internal resource auditing to improve their energy management and environmental compliance to enhance data driven resource management.

5.5.3 Recommendations for Objective Three (Waste Management)

MSME Owners and Managers

MSMEs should practice waste segregation at source to reduce the waste that actually finds its way to landfills. Implementation of practices such as resource to recovery models would create a financial incentive for MSMEs through circular economy. MSMEs should make direct strategic partnerships with recycling companies to ensure that their waste is properly managed rather than relying on waste disposal services.

Nairobi County Government & NEMA

Enactment of Municipal Bylaws for Standardized Volume Metrics: Since the solid waste management sector in Nairobi County is highly liberalized with private sector actors pricing their services independently, the Nairobi City County Government, in coordination with NEMA, should introduce updated environmental bylaws. These regulations should encourage a shift from fixed cost pricing to price by volume models.

Institutional incentives and rebates should be deployed by the county government incentivize MSMEs that are ecologically efficient. Enterprises that provide verified proof of localized sustainability practices should be eligible for targeted single business permit discounts, reduced structural levies or seasonal tax rebates.

5.6 Areas for Further Research

The current study provides significant insights to the relationship between natural resource management and MSME operations in Langata constituency, it also has provided several areas of further research which include the following;

Longitudinal Impact Studies: Future researchers should conduct longitudinal studies to compare the financial and environmental performance of firms that are considered green and those that are not over a five-to-ten-year period to highlight the long term financial and environmental benefits of green businesses.

Impact of Green Financing on Adoption Rates: A study done to investigate whether the availability of green loans to purchase sustainable equipment would increase the sustainability energy adoption rates of MSMEs would yield significant insight onto whether this approach could act as an incentive to MSMEs within Langata and Nairobi as a whole.

Gender-Based Analysis of Environmental Management: Future research on whether sustainability practices are influenced by gender by comparing men lead businesses with women led businesses in Langata could yield essential data for policy interventions.

The Role of Digitalization in Environmental Monitoring: Further research should be done on how the implementation of digital technology for environmental monitoring can assist MSMEs efficiently measure and manage their resources in real time.

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APPENDICES

Appendix 1 - Budget

Item	Unit	Unit cost	Cost
Questionnaire printing	150	1,000Ksh	18,900Ksh
Transport	7 days	1,000Ksh	7,000Ksh
Lunch	7 days	200Ksh	6,000Ksh
Airtime	30 days	200Ksh	6,000Ksh
Printing Thesis	3	1,260Ksh	3,780Ksh
Binding	3	500Ksh	1,500Ksh
Sub Total			**43,180Ksh**
Contingency (10% of subtotal)			4380Ksh
Grand Total			**47,498Ksh**

Appendix 2 – Work Plan

ACTIVITY	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE
Proposal development								
Proposal presentation								
Field work and data collection								
Data analysis								
Thesis writing and presentation								
Thesis finalization, printing and binding								

Appendix 3 – TBL Checklist

Performance Indicator	**Score (1-5)**
1. Health, Safety & Equity	
PPE availability, fire extinguishers, and smoke alarms	
Gender equity (male-to-female ratio)	
2. Employee Training & Development	
Structured training programs and frequency	
Participation in professional development forums	
3. Community & CSR	
Participation in community forums (clean-ups, health walks)	
Contributions to local development and CSR initiatives	
4. Water & Energy Efficiency	
Water-saving tech, storage, and rainwater harvesting	
Use of solar/renewable energy and efficient appliances	
Maintenance of electrical equipment	
5. Waste & Environmental Compliance	
Waste reduction, segregation, and disposal methods	
Knowledge of and compliance with environmental laws	
Sustainability certifications/accreditations	
6. Financial & Operational Viability	
Long-term viability (years of operation, profit vs. expense)	
Sustainable sourcing and eco-friendly transport	
7. Innovation & Customer Relations	
Product diversification and new tech adoption	
Customer retention, feedback, and referrals	
TOTAL SCORE	**/65**

Appendix 4 – Research Questionnaire

PART ONE: GENERAL INFORMATION

TYPE OF BUSINESS: ....

Please tick your response.

1. Gender:

☐ Male

☐ Female

2. Age:

☐ 18-25

☐ 25-32

☐ 32 and above

3. Employee number:

☐ 1-10

☐ 10-49

☐ 50 - 100

4. Electricity (Tick the options you use)

☐ Tokens

☐ Solar

☐ Other

5. Water (Tick the options you use)

☐ City Council

☐ Borehole

☐ Water tanker

☐ Hand Cart

☐ Rain Water

6. How do you deal with your rubbish?

☐ Burning

☐ City Council

☐ Private rubbish pickers

☐ Individual rubbish picker

7. How long has the business been open?

☐ 0 to 6 months

☐ 6 months to 1 year

☐ 1.5 to 2 years

☐ 2 to 3 years

☐ More than 3 years

PART TWO: ELECTRICAL RELIABILITY & AFFORDABILITY

Please tick where appropriate.

1. How frequently do you measure your electrical usage?

☐ Daily

☐ Weekly

☐ Monthly

☐ Do not measure

2. How many token units, KW or cash do you use for electricity supply either daily, weekly or monthly?

....

3. Do you have any energy saving equipment (e.g. Led bulbs, sensor lights, battery powered appliances etc.) in the business and if yes, which ways do you save energy in the business?

....

4. Do you feel the need to supplement the electricity supply in your business?

☐ Yes ☐ No

If yes briefly explain;

………

5. Do you use any other sources of electricity to operate the business?

☐ Yes ☐ No

If yes briefly explain;

………

6. Has using the alternative energy impacted your business and in what way?

☐ Yes ☐ No

If yes briefly explain;

………

PART THREE: WATER AVAILABILITY & USE

1. How frequently do you measure your water consumption?

☐ Daily

☐ Weekly

☐ Monthly

☐ Do not measure

2. How many units or how much money do you use to purchase water either daily, weekly or monthly?

………

3. Do you have any water saving technology (e.g. modern toilets, taps, piping etc.), in the business or how do you save water in the business?

☐ Yes ☐ No

If yes briefly explain;

………

4. Do you feel the need to supplement the water supply in your business?

☐ Yes ☐ No

5. Do you practice water harvesting and or recycling, reusing and others within your business?

☐ Yes ☐ No

If yes briefly explain;

....

6. Have water saving techniques impacted your business and in what way?

☐ Yes ☐ No

If yes briefly explain;

....

PART FOUR: WASTE MANAGEMENT

7. What type of rubbish is the most common in your business?

....

8. How frequent is your rubbish thrown, burnt, collected or recycled?

☐ Daily

☐ Weekly

☐ Monthly

☐ Do not know

9. How much rubbish do you generate in a week e.g. less than a bag, 1 bag, or more than 1 bag?

....

10. How much do you pay for your rubbish to be collected either daily, weekly or monthly?

....

11. Do you do more with the rubbish you generate or is it disposed off entirely?

☐ Yes ☐ No

If yes briefly explain;

....

Appendix 5 – Cleaned Master Dataset Sample

Row ID	Industry Sector	Employees	Baseline Electricity Usage	Energy Saving Equipment	Baseline Water Cost / Units	Water Saving Tech	Most Common Waste	Rubbish Volume (Weekly)	Rubbish Cost	Business Age
1	ICT / Electronics	2	7 units per day	Yes, LED bulbs	Rent inclusive	No	Paper waste	1 bag	N/A	More than 3 years
2	Health / Medical	3	500 KES weekly	Rechargeable equipment	600 KES monthly	No	Paper	1 bag weekly	500 KES monthly	More than 3 years
3	ICT / Electronics	2	1500 KES	No	N/A	No	N/A	Less than a bag	250 KES	1.5 to 2 years
4	Food Retail	3	N/A	Yes, LED bulbs	N/A	Yes, Modern taps	Paper waste	Less than a bag	N/A	N/A
5	Food Retail	8	1500 KES monthly	No	80 KES per day	No	Organic waste	Less than a bag	20 KES daily	More than 3 years

Appendix 6 – Variable Dictionary

R Object Data Type	Measurement Unit	Description
Numeric (Continuous)	Kenyan Shilling (KES)	Monthly operational water costs. Cleaned of string suffixes and capped at < KES 20,000 to manage outliers.
Numeric (Continuous)	Kenyan Shilling (KES)	Monthly operational electricity costs; evaluated using rank-order metrics.
Numeric (Continuous)	Kenyan Shilling (KES)	Monthly operational waste management expenses. Outliers capped at < KES 10,000.
Numeric (Continuous)	Score Index	Continuous rating index assessing organizational sustainability frameworks.
Factor (Nominal)	Categorical Grouping	SME Industry Sector classification. Reference baseline / omitted category is Retail Shop.
Numeric (Ordinal)	Ordered Scale (1 to 3)	Categorized volume metric representing monthly waste volume: 1 = Less than a bag, 2 = 1 bag, 3 = More than 1 bag.

Appendix 7 – R Script / Source Code

Water Cost Linear Regression Analysis

```r
library(tidyverse)

library(janitor)

library(broom)


# 1. Data Pre-Processing & Outlier Treatment

df_water_analysis <- Statisticaltestdata %>%

  clean_names() %>%

  mutate(across(contains("costs"), ~ {

    x <- gsub("[KES, ( )]", "", .)

    x[x == "-" | x == ""] <- NA

    as.numeric(x)

  })) %>%

  mutate(sustainability_score = as.numeric(sustainability_score)) %>%

  filter(!is.na(water_costs_per_month), water_costs_per_month < 20000)


# 2. Model Execution

water_model_normal <- lm(water_costs_per_month ~ sustainability_score + industry,

                         data = df_water_analysis)

summary(water_model_normal)


# 3. Coefficients Extraction & Label Tidying

water_coeffs <- tidy(water_model_normal, conf.int = TRUE) %>%
```

```
  filter(term != "(Intercept)") %>%
  mutate(term = case_when(
    term == "sustainability_score" ~ "Sustainability Score",
    grepl("Retail.*Fashion", term)  ~ "Retail - Fashion",
    term == "industryFood Retail"     ~ "Food Retail",
    term == "industryHealth / Medical"  ~ "Health / Medical",
    term == "industryICT / Electronics" ~ "ICT / Electronics",
    term == "industryPersonal Care"     ~ "Personal Care",
    TRUE ~ term
  ))
```

Statistical Output

Call:

```
lm(formula = water_costs_per_month ~ sustainability_score + industry,
    data = df_clean %>% filter(!is.na(water_costs_per_month),
        water_costs_per_month < 20000))
```

Residuals:

```
    Min      1Q  Median      3Q     Max
-2018.9  -829.4  -320.0   433.8  4241.8
```

Coefficients:

```
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)           1457.40     781.32   1.865   0.0699 .
sustainability_score   -26.72     260.09  -0.103   0.9187
```

industryRetail - Fashion   -428.03   891.74 -0.480   0.6340

industryFood Retail   535.49   882.08   0.607   0.5474

industryHealth / Medical   -394.69   887.34 -0.445   0.6590

industryICT / Electronics   -843.93   916.05 -0.921   0.3627

industryPersonal Care   741.50   865.45   0.857   0.3969

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1546 on 38 degrees of freedom

Multiple R-squared: 0.1397, Adjusted R-squared: 0.003861

F-statistic: 1.028 on 6 and 38 DF, p-value: 0.4221

<u>Electricity Cost Non-Parametric Correlation</u>

 # Executing Spearman's Rank Correlation test for non-normal cost fields

```
elec_spearman <- cor.test(df_elec_cost$sustainability_score,
                          df_elec_cost$electricity_costs_per_month,
                          method = "spearman")
print(elec_spearman)
```

<u>Statistical Output</u>

Spearman's rank correlation rho

data: df_elec_cost$sustainability_score and df_elec_cost$electricity_costs_per_month

S = 30855, p-value = 0.2768

alternative hypothesis: true rho is not equal to 0

sample estimates:

rho

0.142684

<u>Waste Management Cost & Scale Regression</u>

library(tidyverse)

library(janitor)

library(broom)

 # 1. Processing, Factor Construction, and Sample Clustering Filter

```
df_waste_analysis <- Statisticaltestdata %>%
  clean_names() %>%
  mutate(across(contains("costs"), ~ {
    x <- gsub("[KES, ( )]", "", .)
    x[x == "-" | x == ""] <- NA
    as.numeric(x)
  })) %>%
  mutate(
    sustainability_score = as.numeric(sustainability_score),
    waste_volume_ordinal = as.numeric(waste_conversion_to_ordinal_data_month),
    industry = as.factor(industry)
  ) %>%
  filter(!is.na(waste_disposal_costs_per_month), waste_disposal_costs_per_month <
10000) %>%
  group_by(industry) %>%
  filter(n() > 1) %>%
```

```
  ungroup()

# 2. Model Execution
waste_model_volume <- lm(waste_disposal_costs_per_month ~ sustainability_score +
                         industry + waste_volume_ordinal, data = df_waste_analysis)
summary(waste_model_volume)

# 3. Label Tidying
waste_coeffs <- tidy(waste_model_volume, conf.int = TRUE) %>%
  filter(term != "(Intercept)") %>%
  mutate(term = case_when(
    term == "sustainability_score" ~ "Sustainability Score",
    term == "waste_volume_ordinal" ~ "Waste Volume (Ordinal)",
    grepl("Retail.*Fashion", term)  ~ "Retail - Fashion",
    term == "industryFood Retail"      ~ "Food Retail",
    term == "industryHealth / Medical"  ~ "Health / Medical",
    term == "industryICT / Electronics" ~ "ICT / Electronics",
    term == "industryPersonal Care"      ~ "Personal Care",
    TRUE ~ term
  ))
```

Statistical Output

Call:

```
lm(formula = waste_disposal_costs_per_month ~ sustainability_score +
    industry + waste_volume_ordinal, data = df_waste_analysis)
```

Residuals:

Min	1Q	Median	3Q	Max
-662.32	-404.41	-136.73	20.62	2135.42

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-38.03	650.36	-0.058	0.954
sustainability_score	11.43	147.48	0.077	0.939
industryRetail - Fashion	461.96	498.26	0.927	0.362
industryFood Retail	504.26	528.14	0.955	0.348
industryHealth / Medical	305.29	495.20	0.616	0.543
industryICT / Electronics	-77.49	529.92	-0.146	0.885
industryPersonal Care	94.66	546.89	0.173	0.864
waste_volume_ordinal	198.35	204.38	0.970	0.340

Residual standard error: 768.6 on 28 degrees of freedom

(2 observations deleted due to missingness)

Multiple R-squared: 0.1211, Adjusted R-squared: -0.09858

F-statistic: 0.5514 on 7 and 28 DF, p-value: 0.7881

Appendix 8 – Model-by-Model Results

Feature Matrix / Predictor	**Model 1: Water Cost (β)**	**Model 2: Electricity Cost (ρ)**	**Model 3: Waste Cost (β)**
Sustainability Score	-26.72 (260.09)	0.1427	+11.43 (147.48)
Waste Volume (Ordinal)	—	—	+198.35 (204.38)
Retail - Fashion	-428.03 (891.74)	—	+461.96 (498.26)
Food Retail	+535.49 (882.08)	—	+504.26 (528.14)
Health / Medical	-394.69 (887.34)	—	+305.29 (495.20)
ICT / Electronics	-843.93 (916.05)	—	-77.49 (529.92)
Personal Care	+741.50 (865.45)	—	+94.66 (546.89)
Intercept (Retail Shop)	1457.40^{\cdot} (781.32)	—	-38.03 (650.36)
Fitness Metrics			
Sample Size (N)	45	68	36
R^2 / Spearman's S	0.1397	S = 30,855	0.1211
Adjusted R^2	0.0039	—	-0.0986
F-Statistic / p-value	F=1.028 (p=0.4221)	p = 0.2768	F=0.5514 (p=0.7881)

Appendix 9 – Electrical Consumption by Ward

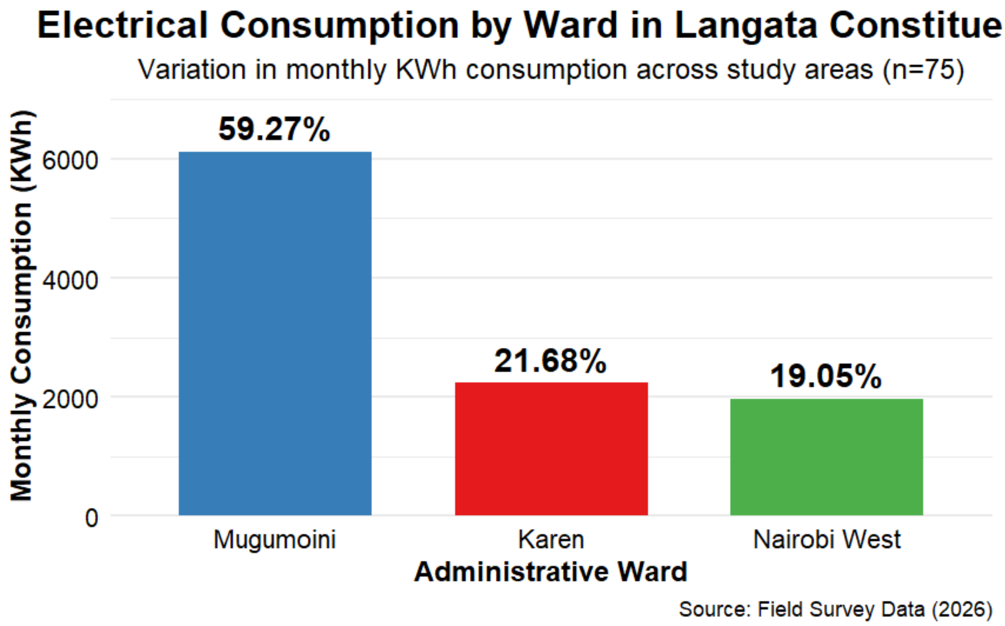


Fig 5.1: Electrical Consumption by Ward

Mugumoini: This is the largest consumer of energy within the constituency accounting more than half (59.27%) of the constituency's electrical consumption. This can be attributed to the low adoption of alternative energy sources and moderate implementation of energy saving technology and other factors such as its large area and large number of SMEs within the ward.

Karen: This is a low consumer of energy compared to the constituency consumption and this could be attributed to the high energy saving equipment adopted within the ward. The ward could further reduce their energy consumption by increasing the adoption to alternative energy sources.

Nairobi West: The ward had a low consumption profile but is slightly similar to the consumption of Karen ward yet the geographical sizes differ significantly as Nairobi West is less than half the size of Karen ward. Nairobi West ward could decrease their overall electrical consumption by adopting alternative energy sources within their businesses.

Appendix 10 – Energy Analysis Responses by Ward

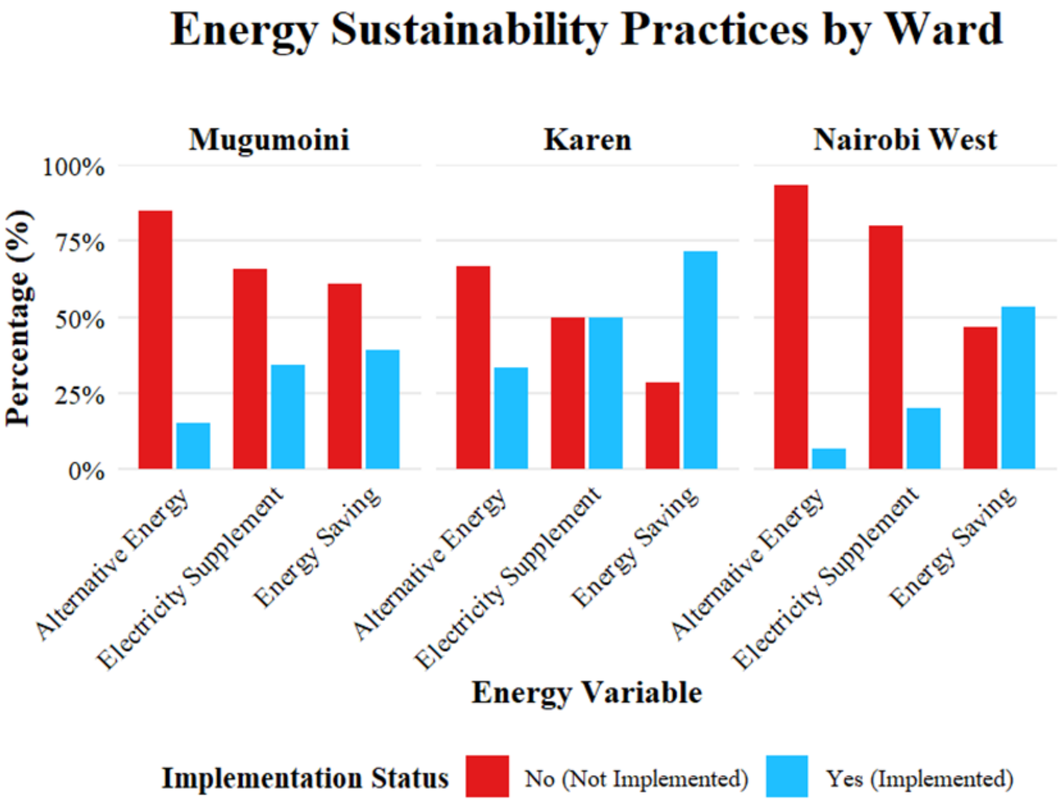


Fig 6.1: Energy Analysis Responses by Ward

All wards reported that they do not use alternative energy sources with Nairobi west at 93.33%, Karen at 66.67% and Mugumoini at 85%.

Karen ward had the highest implementation of energy saving technology across all the wards in the constituency at 71.43%, with Nairobi West also accounting for 53.33% while Mugumoini had the lowest adoption rate at 49.23%.

Karen ward also indicated that they felt the highest impact on utilizing alternative energy sources at 35.71% while Mugumoini reported a 18.75% positive impact and Nairobi West a 7.69% positive impact.

Karen ward indicated that they do need to supplement their energy with half of the respondents at 50% while 80% of the respondents from Nairobi West did not need supplementary energy and 64.86% from Mugumoini also did not need to supplement their energy needs for their businesses.

Appendix 11 – Water Consumption by Ward

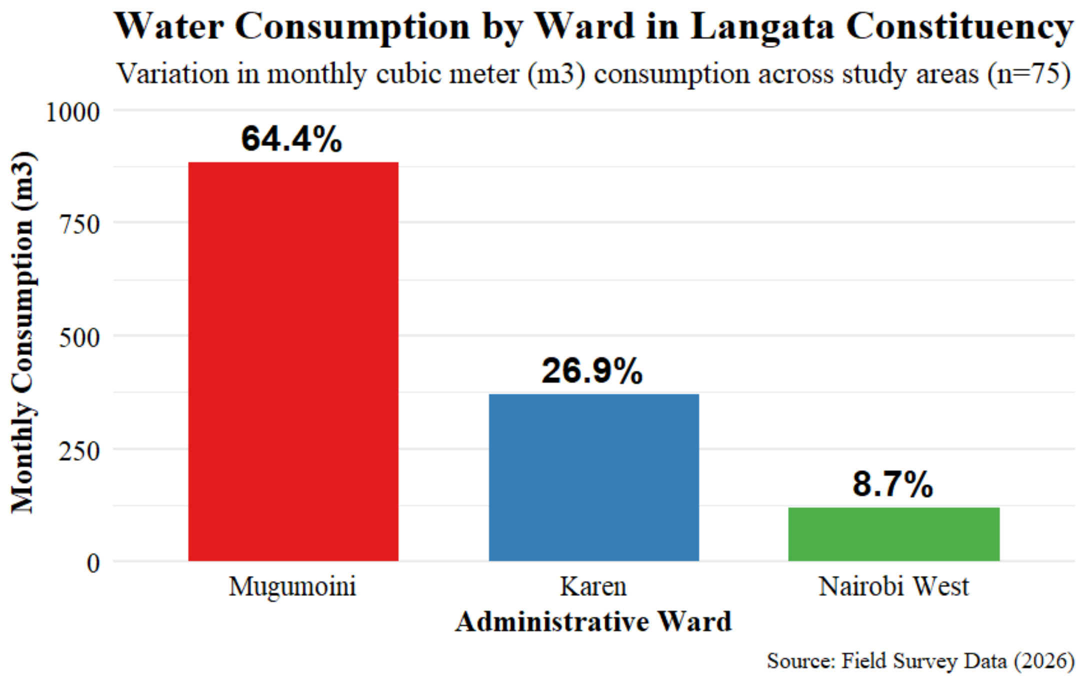


Fig 7.1: Water Consumption by Ward

Mugumoini: This is the largest consumer of water in the constituency accounting more than half (64.4%) of the constituency's water consumption; this can be attributed to the low water harvesting and low water saving technological adoption.

Karen: This is a low consumer of water resources compared to the constituency consumption and this could be attributed to the high water-saving technology implemented within their businesses. The ward recorded that few respondents practiced water harvesting.

Nairobi West: This is the lowest consumer of water resources compared to the constituency's overall consumption, with a relatively low water harvesting and water technology adoption. Most businesses did not need to supplement their water supply and a moderate positive impact was felt by businesses that adopted water saving technologies.

Appendix 12 – Water Responses by Ward

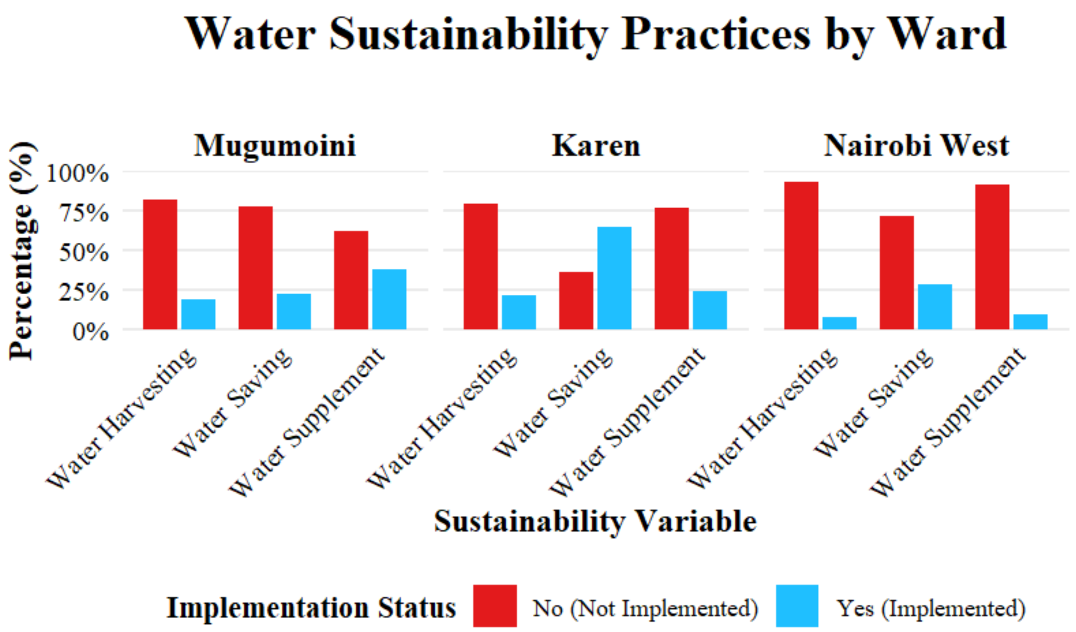


Fig 8.1: Water Responses by Ward

All wards reported that they do not practice water harvesting with Nairobi west at 92.86%, Karen at 78.95% and Mugumoini at 81.58%.

Karen ward had the highest implementation of water saving technology across all the wards in the constituency at 64.29%, with Nairobi West accounting for 28.57% and Mugumoini had the lowest water saving technology rate at 22.22%.

Nairobi West ward indicated that they felt the highest impact on utilizing water saving technology at 38.46%, Karen at 37.5% while Mugumoini had the least impact felt a 25%.

Mugumoini reported a moderate need to supplement the water within their businesses with 37.84% needing the supplement while the majority of Karen and Nairobi West did not need to supplement their water needs.

Appendix 13 – Waste Disposal Expenditure by Ward

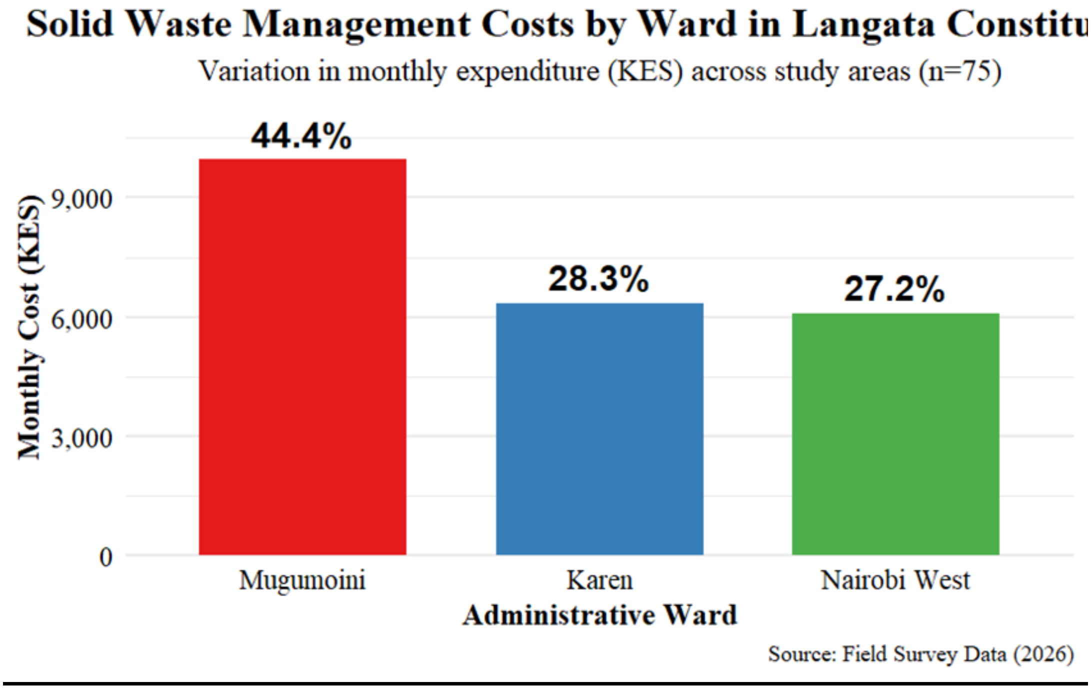


Fig 9.1: Waste Disposal Expenditure by Ward

Mugumoini pays the highest (45.9%) for waste disposal and this could be attributed to the area specific pricing of the ward.

Karen pays a relatively low rate for waste disposal compared to Mugumoini. Karen pays slightly higher for waste disposal than Nairobi West.

Nairobi West pays the least for waste disposal services despite generating a higher waste volume than Karen.

Appendix 14 – Waste Volume by Ward

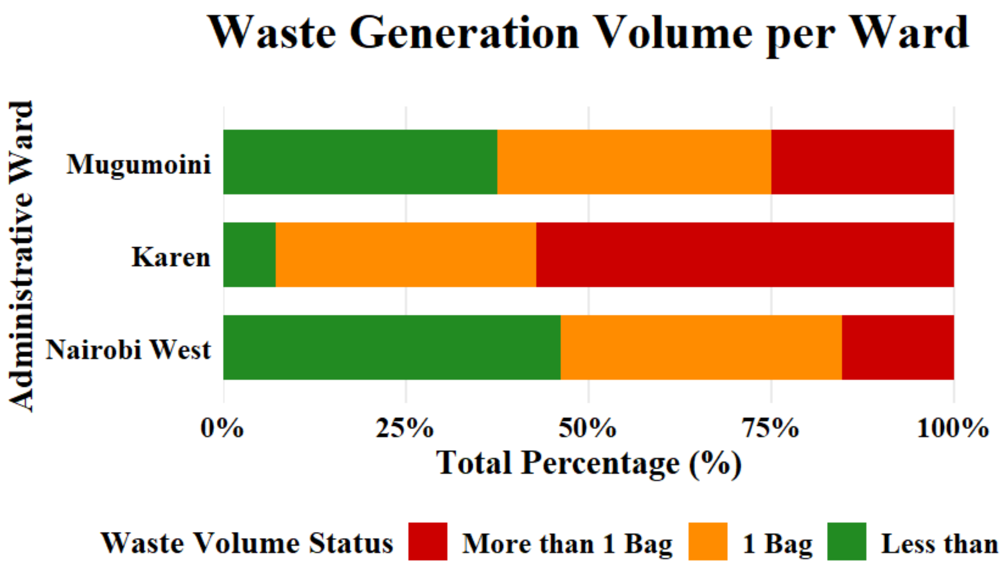


Fig 10.1: Waste Disposal Expenditure by Ward

Mugumoini is the largest waste producer in the constituency where their production of more than 1 bag of waste is more than the total waste generation of Karen ward. Karen ward produces the most waste volume in the less than 1 bag category within the constituency but still produces the least volume of waste in the constituency. Nairobi west produces more waste volume in the 1 bag category and the more than 1 bag category compared to Karen but produces the least volume in the less than 1 bag category in the entire constituency.

Appendix 15 – Waste Recycling by Ward

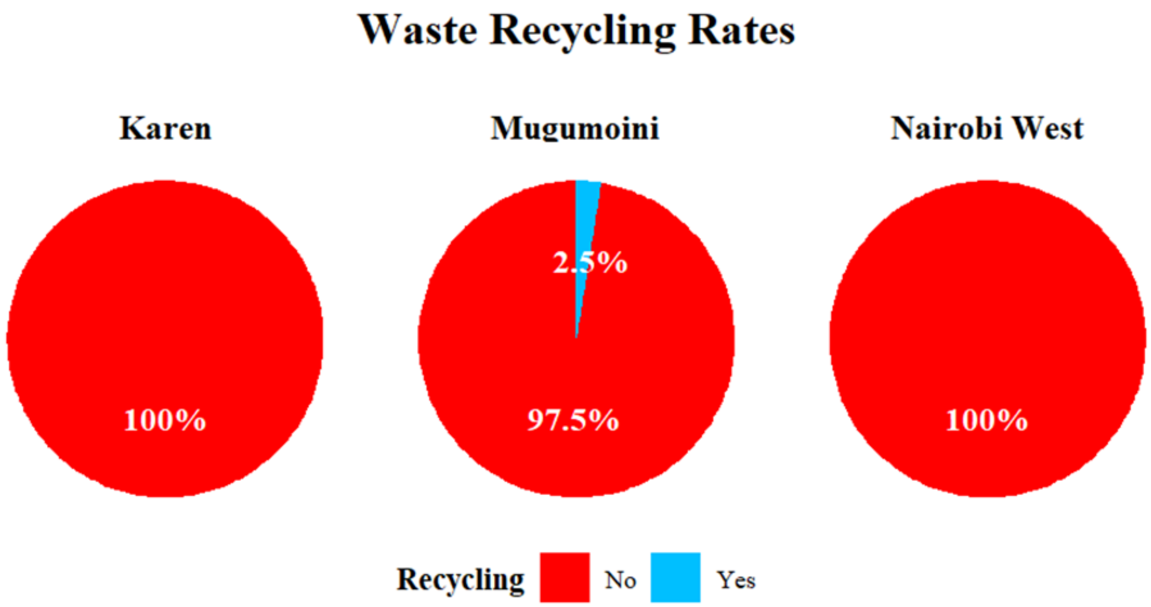
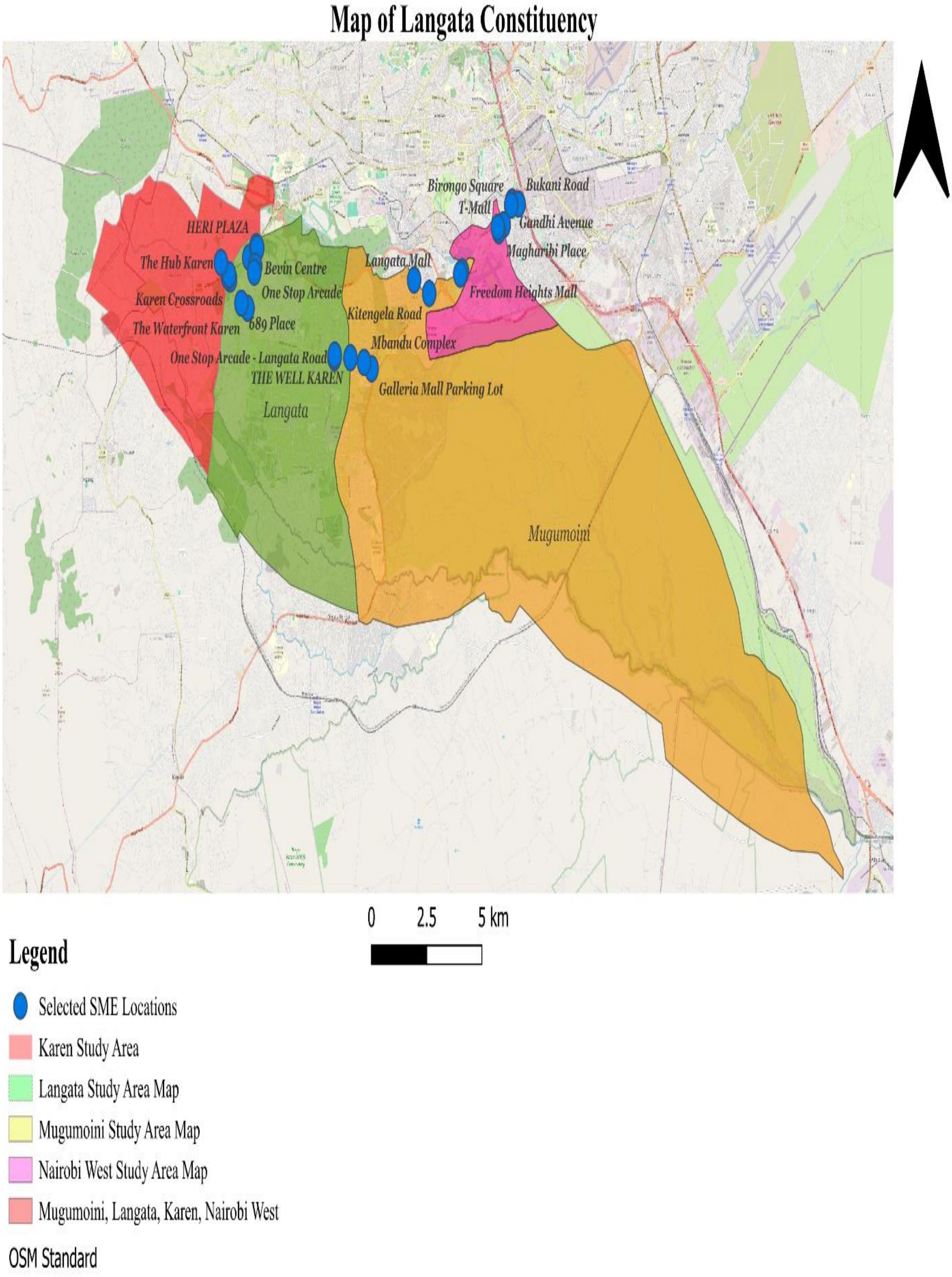


Fig 11.1: Waste recycling by Ward

The waste recycling implementation is extremely low in all the three wards with only Mugumoini accounting for 2.5% of their waste is recycled. This indicates overreliance on waste disposal mechanisms which provides potential for in house recycling or recycling partnerships between waste recyclers and individual SMEs.

Appendix 16 – Study Area Map



Appendix 17 – Research Permit (NACOSTI)

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **224486**

Date of Issue: **28/April/2025**

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9. The Commission may monitor and evaluate the licensed research project for the purpose of assessing and evaluating compliance with the conditions of the License.
10. The Licensee shall submit one hard copy, and upload a soft copy of their final report (thesis) onto a platform designated by the Commission within one year of completion of the research.
11. The Commission reserves the right to modify the conditions of the License including cancellation without prior notice.
12. Research, findings and information regarding research systems shall be stored or disseminated, utilized or applied in such a manner as may be prescribed by the Commission from time to time.
13. The Licensee shall disclose to the Commission, the relevant Institutional Scientific and Ethical Review Committee, and the relevant national agencies any inventions and discoveries that are of National strategic importance.
14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

National Commission for Science, Technology and
Innovation(NACOSTI),
Off Waiyaki Way, Upper Kabete,
P. O. Box 30623 - 00100 Nairobi, KENYA
Telephone: 020 4007000, 0713788787, 0735404245
E-mail: dg@nacosti.go.ke
Website: www.nacosti.go.ke

Appendix 18 – Research Permit Letter

AFRICA NAZARENE
UNIVERSITY

P.O.Box: 53067 – 00200
Nairobi, Kenya.
Tel: 020 252 7170/1 – 5
Email: vc@anu.ac.ke
www.anu.ac.ke

22nd April 2025

TO WHOM IT MAY CONCERN

RE: RESEARCH PERMIT: KAGO KARURI

Kago Karuri Reg. No. (110062952) is a Bonafide postgraduate student at Africa Nazarene University pursuing a master's degree in Environment and Natural Resource Management. This program entails Coursework and Thesis. He successfully completed his coursework and defended his thesis proposal entitled: -

"Towards Green Business Practices: Sustainable Water, Energy, and Waste Management Among SMES in Langata Constituency, Nairobi, Kenya".

Any assistance accorded to him to facilitate data collection and complete his thesis will be highly appreciated.

Sincerely.

Prof. Orpha K. Ongiti
Dean, Postgraduate Studies & Director, Institute of Research