COLLEGE OF TECHNOLOGY AND BUILT ENVIRONMENT

SCHOOL OF CIVIL AND ENVIROMNENTAL ENGINEERING

(ROAD AND TRANSPORT ENGINEERING)

TITLE: ASSESSMENT OF REVERSE LOGISTICS SYSTEM FOR RECYCLABLE AND REUSABLE WASTE GENERATED FROM RESIDENTIAL AND COMMERCIAL AREAS IN ADDIS ABABA

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A Thesis Report Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science in Civil Engineering (Road and Transport Engineering)

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Addis Ababa, Ethiopia

May, 2026

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DECLARATION

I declare that the thesis entitled "Assessment of Reverse Logistics System for Recyclable and Reusable Waste Generated from Residential and Commercial Areas in Addis Ababa" is my original research work and any paper mentioned in this thesis has been given recognition through citation. The research work was done under the guidance of Professor Girma Gebresenbet, at Addis Ababa University, Addis Ababa Institute of Technology, School of Civil and Environmental Engineering.

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ABSTRACT

The study assessed the current reverse logistics practice in selected residential and commercial areas of Addis Ababa, focusing on recyclable and reuseable waste, and mapped the roles of actors with the challenges they face. Data was collected through questionnaires via Kobo Toolbox, field visits, and secondary sources. Analysis was conducted using SPSS and Excel.

Findings revealed that despite the growth in recycling rate in both areas 83-90% of waste is still landfilled. In residential areas, micro and small enterprises (MSEs) collect waste door-to-door while private companies collect from commercial centers and transport the waste to the landfill. However, the collection of recyclables and reuseable waste was dominated by informal collectors. In residential areas, the storage areas were relatively larger, but the storage duration is larger due to scarcity of materials, distance from the main road, and limited informal collectors. In commercial areas, due to higher density of informal collectors, the storage duration was shorter, though space shortage and congestion were the main constraints. Crucially, the study found that collection actors operate without systematic route optimization, relying instead on arbitrary, unstudied route paths. Furthermore, primary collection hubs are allocated arbitrarily without any spatial or logistical engineering studies, resulting in a fragmented network that lacks a centralized hub. This structural inefficiency is further compounded by a critical lack of bailing technology, which results in poor vehicle payload utilization. Additionally, transport schedules fail to account for severe urban traffic constraints; in high density commercial areas, loading and transportation activities overlap with peak daytime hours, severely exacerbating traffic congestion. Consequently, these factors directly lead to high transportation cost. The study concluded that current practices are fragmented, reactive, and inefficient, and increasing logistics costs. To improve efficiency and to support the city transition towards a circular economy, the system should shift from a pull to a push system, prioritize route optimization, adopt differentiated practice based on land use, establish transfer stations for recyclable materials, invest in bailing technologies, collection and transport timings must be strategically shifted to off-peak periods (specifically late evenings, early mornings, or Sundays), promote coordination, integrate digital tools, formally recognize the informal actors, and strengthen source segregation is necessary in both areas.

ACKNOWLEDGEMENT

First, I want to thank God for his guidance. Then, I would like to thank my advisor Professor Girma Gebresenbet, who shaped my research structure and provide me with continues kind instruction, comments, and support throughout this research. For their cooperation and assistance in providing necessary data and insights I also would like to thank Addis Ababa Cleaning Management Agency, sub-city and woreda officers of Addis Ketema and Kolfe Keranio under cleaning management office. I am especially grateful to woreda offices who went with me during field visits to the 58 formal unions by arranging access and facilitate the data collection process. Furthermore, I want to thank actors who participated in this research and my family and friends for their support and encouragement.

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LIST OF ACRONYMS

AACMA: Addis Ababa Cleaning Management Agency

AK: Addis Ketema Sub City

CAS: Complex Adaptive System

CE: Circular Economy

E.C: Ethiopian Calander

ETB: Ethiopian Birr

HDPE: High Density Polyethylene

KK: Kolfe Keranio Sub City

LDPE: Low Density Polyethylene

MSEs: Micro and Small Enterprises

MSW: Municipal Solid Waste

MSWM: Municipal Solid Waste Management

PE: Polyethylene

PET: Polyethylene Terephthalate

PP: Polypropylene

RL: Reverse Logistics

SWM: Solid Waste Management

CHAPTER ONE

1. INTRODUCTION

1.1.Background of the Study

In most countries, waste management is an issue and it relates to the economic, social, and political statues of the country and it is more challenging for low and middle-income countries (Cheru, 2016). According to the World Bank (2023), Ethiopia is categorized as a low-income economy. This economy status affects the infrastructure available for waste management so this leads the city to depend on labor-intensive reverse logistics activities driven by small and micro enterprises and informal collectors.

Addis Ababa, the capital city of Ethiopia, has 11 sub cities. The city is experiencing rapid growth and urbanization. The population of the city has exceeded five million with annual increment (World population Review, 2025). Among developing, cities Addis Ababa is one of but the implementation of solid waste management has not increased as the city expanded and there is population growth. Thus, all sub cities are facing challenge to manage the generated waste.

The population growth led to a parallel rise in waste generation, as waste is generated by human activities. However, a study conducted in Czestochowa by Bajdor et al. (2016) demonstrated that population size is not the only driver of waste. The research found that even if the population size remains stable, waste generation rate can still increase due to change in human behavior, such as increased purchasing power and lifestyle changes that leads to a rise in the consumption of goods and food. Supporting this LSE Cities (2022) mentioned that economic growth in Addis Ababa has improved household income and change the lifestyle of the people's which led to high waste generation in the city. In other word when people earn more, they often change their living standards. Many families are now using more packaged and disposable products, which creates a "use and throw" culture.

Due to these factors the amount of solid waste generated in Addis Ababa has increased rapidly. However, due to poor managed collection system most of the waste end up in open dumps, even though most of the waste could be recycled (JICA, 2024).

According to legal framework Directive 2008/98/EC, which manages waste across the EU, the definition of "Waste" is any substance or object that has been discarded after use when it no longer usable and considers as worthless, defective or not to be used. Its classification is based on origin, type, and characteristics. From these classifications, this study focused on Municipal Solid Waste, which is defined by its urban source.

In the city most of the solid waste is generated from residential areas, followed by commercial centers, street sweeping, industry, hotels, and hospitals. Managing this is becoming significant to overcome the social and environmental challenges that emerges due to the solid waste. According to Gelan (2021), approximately on average 0.15 kg/day/person municipal waste is produced in Addis Ababa between 2016 and 2020 G.C, an average only 80.28% of the generated waste was collected and 19.72% of the waste was uncollected. To mitigate the effect of the waste it must be properly managed. Solid waste management is the process of collecting at the source, sorting, and transporting to facilities where waste is recycled, recovered, or disposing at the land fill in controlled and proper way, which is the final alternative. At this stage, it becomes clear that effective solid waste management is linked to Reverse logistics.

In the local context, Directive No. 157/2016 which governs the solid waste collection and transportation service defines solid waste as any solid or semi solid material that is discarded because it is no longer wanted or its utility has ended. This waste is generated from residential homes, commercial centers, industry and different institutions through human or animal activities.

Effective solid waste management is crucial for Addis Ababa, without it, the city faces environmental pollution, public health risks, impact on the economy, and decline in urban cleanliness.

In according with the private cleaning organization's solid waste collection and transportation service provision procedures directive No. 157/2016, door to door collection is divided as follow:

- Residential Areas: Managed by organized Micro and Small Enterprises (MSEs)
- Non-Residential Areas (Commercial & Institutional): Handled by Private companies.

By this regulatory framework, many private cleaning companies has been registered legally to collect and transport the solid wastes throughout the city.

Besides this, to reduce the pressure on the Koshe landfill, the city has implemented Directive No. 158/2016, which provides guidelines on implementation Incentives for Solid Waste Recycling and Recycling Activities. These directive focuses on the wastes that can be recovered for other purpose, which is turning waste in to new. It aims to integrate waste management with economy to protecting the urban environment.

Eventually, the solid waste management should prioritize the following hierarchy (Directive 2008/98/EC), Preservation-Reuse-Recycling-Recovery-Disposal.

And according to the nine development bands by Whiteman et al. (2021), Preservation-Reduction-Reuse-Recycling-Recovery-Landfill-Controlled Disposal- Uncontrolled disposal.

- Prevention: This focuses on stopping waste at the source or origin. For instance, In Addis Ababa the manufacturing and use of plastic bags is restricted, this policy halts the production of the plastic bag from its sources.
- Reduction: This is reducing the waste generated by using less. For example, buying in bulk using one large bag than using small plastic bags for a number of days.
- Reuse: This is using a material again. For example: using a durable plastic bag
- Recycling: This is a process of breaking down of waste to make a new one or converting the waste into a new. For instance, melting down or shredding to pieces a plastic bottle to create new raw materials or to create handicrafts.
- Recovery: This is used to extract value from waste by converting the waste into composting or energy conversion.
- Disposal: safe landfilling of the waste.

Reverse logistics has been primarily dealt with the reverse flow of mainly defected goods from consumers to production. However, recently it includes the flow of waste to various destinations. Reverse logistics is vital for solid waste management as it involves planning, implementing, and controlling of goods, finance, service and information efficiently and effectively from point of

origin (source) to the point of recovery or recycling (Recyclers) or safe disposal (landfill). It helps collect and return used materials into the economy.

Mbago et al (2025) also defined "*Reverse Logistics involves planning, implementing and controlling the efficient and effective inbound flow and storage of secondary goods and related information, moving opposite to the traditional supply chain direction, with the purpose of recovering value or ensuring proper disposal*,".

In developing cities like Addis Ababa, recyclable waste collected by informal collectors include metal, plastic bottles, glass, and other materials from various locations, including dumping sites and rivers. They are normally not organized and depend on recyclables collected. Despite their importance to the supply chain, they lack coordination and formal support. This creates a significant gap in information flow which is an essential component of logistics. This results in unclear map on the waste movement through the city, leading to inefficiencies, low recovery rate and missed opportunities for reuse and recycling.

If reverse logistics is done in sustainable ways like by encouraging source segregation to ease sorting and grading it can have environmental and economic benefits (Kinobe et al., 2015). However, in Addis Ababa, waste is mixed up even when it is collected from the source so materials that can be recycled become contaminated and eventually end up in the landfills with the rest of the waste.

Recent study by Adem (2024) shows that the waste recovery rate in Addis Ababa has an upward trend. As shown in Figure *1.1*, through the reuse and recycling the materials the volume increased from approximately 35,727 tons in 2012 E.C to over 86,757 tons by 2015 E.C. This shows the increasing importance of the reverse logistics in the waste management and highlights the crucial role of informal and small-scale actors in the urban economy.

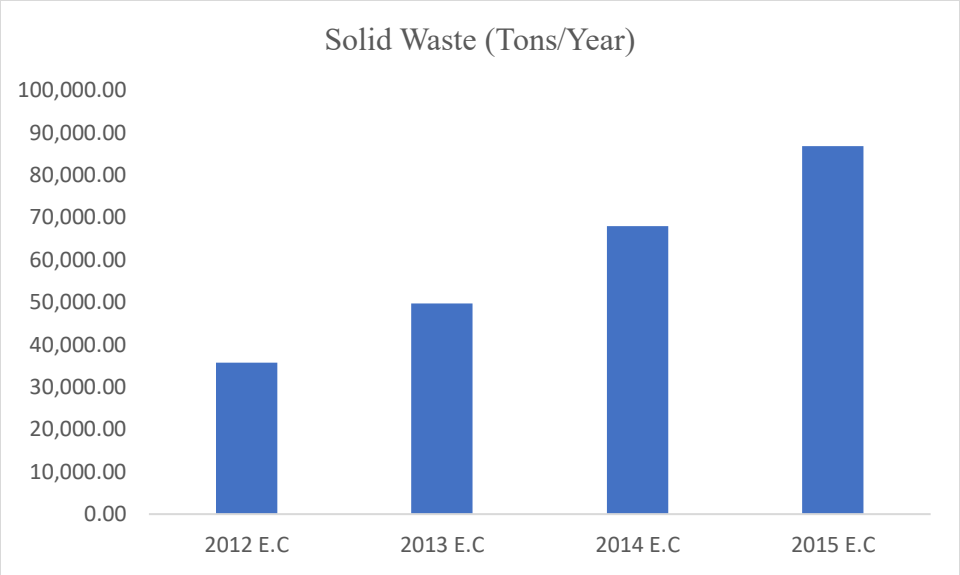

Figure 1.1. Solid waste for reuse and recycling ton/year (Addis Ababa Cleaning Management Agency, cited in Adem (2024))

1.2.Statement of the Problem

Municipal waste generation in Addis Ababa has risen rapidly between 2,400-3000 tons of solid waste daily generated per day from households, commercial centers, institution, and industries. From the total 70% of waste generated is organic and 15% of generated waste is recyclable. (IGC, 2024). Despite this large amount of recyclable waste only small portion is actually recycled. Most of recyclable materials are collected together with organic waste and transported to the landfill creating pressure on the landfill and causing significant environmental and economic losses. This highlights a critical failure in the transition from linear collection model which is collect and dump to a circular reverse logistics system.

Previous studies have identified various barriers to waste management and assess the process. Getachew (2023) mentioned that the topography and fragmented road networks act as logistics bottlenecks, while Dea (2024) stated that due to lack of infrastructure and incentives keeps recycling rate low. Despite the volume of recoverable waste reaching 86,757 tons by 2015 E.C (Adem, 2024), the core issue is not a lack of material but a logistics failure to efficiently move waste from the source to the recyclers.

Dametew (2015) identifies MSEs struggle with lack of well-defined collection mechanisms, lack of training, lack of storage, and inefficient secondary transport links. This results in leakage of valuable materials into the city drainage systems and river banks. As Desta (2022) observes, this illegal dumping causes waterway blockage and in rainy days it causes flooding in the city roads. This flooding leads road deterioration, directly impact the city's transport infrastructure. Moreover, an information gap also affects the reverse logistics effectiveness (Kinobe et al., 2015).

While study by Abdissa et al. (2022) acknowledge the vital role of informal collectors and the weakness of data system, there is a significant research gap there is no comparative study in Ethiopia that assesses reverse logistics efficiency based on urban dominance (Commercial and Residential). Addis Ababa cannot transit to a circular economy if there is no effective logistic framework. According to Ellen MacArthur Foundation (2025) keeping materials in use for as long as possible, reduce waste, and regenerate natural systems is the aim of circular economy. Recyclables fail to reenter the production cycle, and the city misses opportunities for resource conservation and green job creation. This research fills that gap by using a mixed methods approach including field surveying and Kobo toolbox data collection to assess the current practice and actor roles, and challenges in the system. By assessing the two areas, the study provided practical recommendations to optimize transport efficiency, reduce landfill pressure, and support Addis Ababa's transition towards a sustainable, resource efficient circular economy.

1.3.Objective

1.3.1. General objective

The main objective of the thesis was to assess and evaluate the efficiency of reverse logistics practices for recyclable and reusable waste materials generated from residential and commercial areas.

1.3.2. Specific objective

The specific objectives were to:

- Assess and examine the current practice of reverse logistics for waste management in residential and commercial areas;
- Identify and map the key stakeholders and actors involved in the reverse logistics chain.

- Investigate the challenges hindering the effectiveness of the actors of waste collection and handling in the residential and commercial centers.
- Compare material flow of waste between residential and commercial centers.

1.4.Research questions

- How does reverse logistics for waste management currently work in residential and commercial areas?
- Who are the actors in the reverse logistics chain, and what roles do they play?
- What are the challenges (logistics, institutional, and infrastructure) that affect or limit the efficiency of waste recovery practices in the residential and commercial centers?
- Is there a difference in material flow in residential and commercial areas?

1.5.Scope of the study

The study focuses on comparing the recovery of recyclable and reusable waste in residential and commercial areas. Addis Ketema was selected to represent high-density commercial centers with significant traffic congestion, while Kolfe Keranio represents residential areas with challenging topography. The research examined the operational roles of both formal Micro and small enterprises (MSEs) and informal actors. The scope is limited to urban areas with visible recycling activity, where informal collectors and cooperatives are active. The study utilized mixed methods approach, incorporating Kobo Toolbox surveys and field visit. The study emphasized reverse logistics practice, rather than broader waste management issues. Therefore, it didn't cover the chemical processing of recycling or the management of hazardous and medical waste.

1.6.Limitation of the Study

The study focused on a comparative analysis of selected two sub cities. Some data were difficult to assess, especially from the informal actors who do not keep records. Finally, the study was limited by existing information gaps, as the absence of a centralized digital database for first mile collection routes restricted the ability to perform high precision spatial mapping of all transport movements within the study area.

1.7.Significance of the Study

The findings of this study could be significant for several reasons:

- It supports cleaner streets, reduced landfill pressure, and better use of resources, contributing to Addis Ababa's sustainability goals.
- It provides recommendations that can help municipal authorities improve coordination and efficiency.
- It fills a knowledge gap in Ethiopian research by comparing the reverse logistics system for recyclable waste recovery in residential and commercial areas.
- It shows how circular economy principles can be applied in Addis Ababa helping policymakers design strategies that reduce waste and create green jobs.
- By recognizing the role of informal collectors, the study highlights their contribution to the city's waste recovery system and suggests ways to support them.

CHAPTER TWO

2. LITERATURE REVIEW

2.1.Municipal Solid Waste Management

In the local context, Directive No. 157/2016 which governs the solid waste collection and transportation service, defines solid waste as any solid or semi solid material that is discarded because it is no longer wanted or its utility has ended. According to the origin of solid waste, they are often categorized as shown in the Table *2.1*. A study in Uganda by Kinobe et al., (2015) stated that the source of the waste includes households, commercial centers, restaurants, markets and street sweeping through human or animal activities. However, much of this waste has been managed without source segregation.

Table 2.1. Source and type of solid waste (Adem, 2024)

Source	Typical Waste Generator	Types of Solid Waste
Residential	Single and multifamily dwelling	Food waste, paper, cardboard, plastics, textile, leather, yard waste, wood, glass, metal, ashes, special wastes (such as bulky items, consumer electronics, white goods, batteries, oil, tires) and household hazardous wastes.
Commercial	Stores, hotels, restaurants, markets, office building etc.	Paper, cardboard, plastic, wood, food waste, glass, metal, special waste, hazardous wastes
Industrial	Light and heavy manufacturing fabrication, construction sites, power and chemical plant	Housekeeping waste, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes
Institutional	Schools, hospitals, prisons, government centers	Paper, cardboard, plastics, wood, food wastes, glass, metal, special waste, hazardous waste
Construction and Demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc..
Municipal Service	Street cleaning, landscaping, parks, beaches, other recreational areas, water, and waste treatment	Street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other recreational area, sludge
Process	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing	Industrial process wastes, scrap materials, off specification products, slag, tailings
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g. pesticides)

"Solid Waste Management broadly refers to the material flow stream of waste generation to ultimate disposal, and comprise storage, collection, transportation/transfer, processing (reuse/ recycling/composting), and disposal." (Gelan., 2021))

According to Addis Ababa Cleaning Management Agency, for more than 50 years in the city waste collection, transportation and finally disposal at open landfill method was practiced. So, to reduce, reuse, sort, collect, transport, recycle, treat and properly disposal of the collected solid waste from the city, Cleaning Management Agency was established. The agency extends its administrative structure to the sub city and woreda level to achieve its goal.

2.2.The Solid Waste Management Ecosystem in Addis Ababa

The amount of waste generated has increased yearly and which leads to filling the landfill more than its capacity. According to a study by GIZ in 2020, the increase in the amount of wastes creates an opportunity for waste management and circular economy businesses in Ethiopia. In Ethiopia, waste management is the responsibility of local authorities which reflects a decentralized structure. This helps to shift responsibility and action from large central authorities to local authorities. However, the local authorities face challenges due to financial and infrastructure constraints

In Addis Ababa on 2020, the municipality solid waste is around 750 tons/year. 85% of the collected waste ends up in landfill which is Koshe and the rest of the waste will be sent to Reppie which is waste incineration plant. The waste collection fee is included with waste and sewage bills, but it is low. It doesn't cover operational costs, and it doesn't allow subcontractors to develop initiatives for waste treatment.

2.3.Waste Characterization and Generation

A study conducted in Kampala indicates that 92.1% of the total volume of collected solid waste consists of organic waste, such as food and garden waste. This represents a large portion of the collected waste. The study further demonstrated that waste composition is influenced by seasonal changes. Only 40% of the generated waste is collected and managed through controlled disposal at the Kiteezi landfill. The remaining 60% of the waste is dumped in an uncontrolled way which poses environmental and public health risks. The study suggested that the current system which is landfill based is insufficient, so it is suggested to shift toward the resource recovery like

composting and energy generation to convert the waste to a valuable environmental and economic asset. (Komakech et al., 2014). In Addis Ababa 76% of waste generated is from household and followed by 9% from different institution. And from the household waste 74.29%, 17.41 % and 8.27 % are biodegradable organic, recyclable, and hazardous waste respectively. (AACMA, 2022) This shows that the city needs to work on the recycling wastes.

Furthermore, Bajdor et al., (2016) noted that waste generation heavily dependent on the purchasing power and lifestyle changes. Just as seasonal fluctuation affects the waste characteristics, human behavior and economic growth also have an impact on the volume and type of waste generated. As the lifestyles change, people often start using more "use and throw" materials, which rises the waste volume. Furthermore, as the purchasing power increase, the consumption of goods and food rises, leading to increase the waste volume that must be managed. And also, Martinez et al. (2019), mentioned several environmental problems have arisen due to rapid growth of world population to overcome the negative impact of the waste, proper management is relevant. And the final aim of proper waste management is to give green space and recreation area for the citizens. Supporting the above studies Addis Ababa Cleaning Management Agency mentioned that in Addis Ababa, the generation of waste has increased in kind and amount due to rapid population and economic growth in the city, this growth changes the lifestyle and consumption patterns of its residents and visitors.

The major method for disposal of the waste is landfilling so it becomes a burden even if there are other ways like waste reduction, reuse, and recycling for wastes like plastics, paper, aluminum, glass, steel, cardboard, and yard waste. (Kinobe et al., 2015)

2.4.Definition of Reverse Logistics

"Reverse logistics is defined as it the process of planning, implementation and effective control of the efficient flow and warehousing of products which are to be recovered." (Mesjaz-Lech, 2019).

De Brito and Dekker (2002) define reverse logistics as the process of planning, implementing, and controlling the backwards flows of raw materials, in process inventory, packaging and finished goods from manufacturing, distribution, or use point to point of recovery or point of proper disposal. In reverse logistics, the returned products will go through these processes: collection,

inspection, separation, and others: to be recovered, remanufactured, recycled, or reuse. Reuse is an old practice according to the study.

2.5.Evolution and Framework of Reverse Logistics (RL)

Traditionally, logistics focuses on the "forward flow" which is the movement of goods, services, information, and finance from point of origin (manufacturers) to the point of consumption (consumers). According to a study by Kinobe et al., (2015), manufactures of goods are responsible only for the traditional forward logistics which means when the goods go from the factory to the customer but the activities that are after the customer (end user) are not being considered which led to different problems so the reverse logistics concept emergence when the pressure increases on the logistics managers from government policies of deregulations and globalization to find solutions to problem of location, allocation and transportation so this put pressure on the logistics managers to also develop system for the "backward flow" of materials, information, service, and finance to manage and recover the value.

Waste collection from the sources, transportation, reprocessing, value addition and final disposal of products are activities that are involved in reverse logistics (Kinobe et al., 2015). These materials are moves backwards from the end user and processes include information flows associated with tracking and transaction processes.

In the beginning of the reverse logistics activity, it was viewed as costly related to waste disposal. However, according to Mesjasz-Lech (2019), attention shifted to the creation of a "closed loop system" which means materials or products after use should not end up in the landfill but should go back to the point of recovery. Closed loop supply chain was introduced which is using old products to produce a new one.

The main goal of reverse logistics is creation of waste flows characterized by both ecological efficiency and economic effectiveness by creating closed loop system by integrating and coordinating the activities and information on the waste material. Therefore, this evolution aligns with Zero Waste Cities concept, where reverse logistics serve as tool to bridge the gap between waste generation and resource recovery. By introducing the reverse logistics concept to the waste management, one can reduce the quantity of waste and enable waste recovery. It is also linked with

environmental protection by handling waste safely. In addition to this the study in Poland shows that the economic use of municipal waste help to eliminate the negative impact of the waste on the environment.

According to De Brito and Dekker (2002), Due to the scarcity of material in past materials recovery, reuse was the option but after that the emerging of new technology and cheap materials the waste was increasing in western societies. Then again, the waste becomes concerning so the academicians, politicians, media, and society address the issues then again, the system like recycling, reuse, reduction, and other emerged again. One of the best practices was in Europe since the mid-nineties by enforcing legally the recovery or proper disposal of products. And other example in mobile phone manufacturing factories shows that the recovery activities which is remanufacturing is profitable. Moreover, marketing, competition, or strategic has led the companies to the reverse logistics.

According to De Brito and Dekker (2002), reverse logistics is not the same as waste management and green logistics. The waste management focus only on the collection and processing waste, green logistics focus on the environmental aspect on the forward logistics.

According to the study to understand how reverse logistics works these questions has to be answered:

- Why material returns and institutions involve in the reverse logistics?

Either the product is do not function properly, end of its time, their function is not needed any longer. One of the returns is from the customer because of reimbursement guarantees, Warranty return, service return, end of use, or end of life

Under this there are three driving forces that create supply chain loop:

  - Economics (the company will have economic benefits)
  - Legislation (enforcing companies to take back its products to recover),
  - Extended responsibilities (bringing the organizations to engage with reverse logistics).

- What is returned?
- How are the reverse logistics works in practice?

Actors and processes: Actors are independent intermediaries, specific recovery companies, reverse logistics service providers, municipalities taking care of waste collection, public private foundations.

Supporting this a study by Kinobe et al. (2015) highlight that the reverse logistic is driven by three drivers, these are:

- Government legislation
- Economic value to be recovered when the product returns
- Environmental concerns.

In addition to this, Mbago et al. (2025), highlights key drivers of reverse logistics as follow:

- Environmental concerns
- Economic incentives
- Regulatory pressures and
- Technology advancements

which are same as Kinobe et al. (2015), but add one additional driver which is Technology advancement.

Management commitment, strategic partnerships, and technological investments are the primary source of effective reverse logistics system by collaborating with stakeholders and engaging community on the activities. (Mbago et al., 2025)

2.6.Theoretical Framework:

2.6.1. Complex Adaptive System (CAS) Theory

Mbago et al. (2025) stated that CAS theory is used to explain the non-linear functioning of reverse logistics system, where various independent actors such as informal collectors, MSEs, and municipalities must adapt to shift waste volumes and market prices.

2.6.2. The Nine Development Bands (9BDs)

The Nine Development Bands (9BDs) framework was developed by Whiteman et al. (2021). It used as a road map to identify where a county or a city is currently in the global spectrum of waste and resource management. This model has been tested in different countries, including Ethiopia.

This framework was developed on the Integrated Sustainable Waste Management analytical model, which is represented by two interlocked triangles.

- The Physical Triangle: this focuses on the operational parts including: Public health collection, Environment Recovery & disposal, and 3Rs (Reduce, Reuse, Recycle).
- The Government Triangle: this is the driver of the physicals by the policies such as citizens and MSEs in Ethiopia context, financial sustainability and strategic policies

2.7.Waste Management Hierarchy

Within this Nine Development Bands (9DBs), the waste management hierarchy prioritized action order as follow:

- Prevention
- Reduction
- Reuse
- Recycling
- Other recovery
- Landfill
- Controlled Disposal
- Uncontrolled Disposal

By using the Ladders of Control along with this hierarchy, a city's transition can be seen as it moves from uncontrolled dumping towards the professional service level aiming circular economy.

On the other hand, According to Directive 2008/98/EC the waste management hierarchy prioritized action order as follow:

- Prevention
- Preparing for reuse
- Recycling
- Other recovery
- disposal

The EU Directive focuses on the final goals like Zero waste and high recycling rate and it is more for developed countries. The 9DBs is for developing countries like Ethiopia because it focuses on

the current situation and also its breakdown the Disposal into Uncontrolled, Controlled and Landfill which is still challenge in developing countries.

The EU Directive says “Stop dumping” so this goes from top to down on the other hand the 9DBs says “Stop uncontrol dumping and move to the controlled first” this is bottom up because it starts by looking the situation on the ground and provide a ladder climb up towards that top-down goal.

Research in Czestochowa city was conducted to see how well the city follows the waste hierarchy by analyzing the waste that was been recovered and how much was end up in the landfill. Addis Ababa Cleaning Management Agency is promoting the 5Rs, these are: Rethink, Reduce, Reuse, Recycle and Refuse the use of single use items (AACMA., 2022). Ending up the wastes in the landfill is the popular method of handling wastes most of the time. According to JICA (2024), study reduction of waste dumped at the landfill is the priority initiative of the city other than the other initiatives since the remaining capacity of the landfill is serious issue. Desta (2022), stated that in Addis Ababa the implemented option is the least preferable which is disposal but the most preferable option from the waste management hierarchy is prevention and minimization the followed by recycling, reuse and resource recovery.

2.8.Reverse Logistics and Zero waste Cities

According to Mesjasz-Lech (2019) “the zero waste cities concept assumes a 100% recycling index, whereas the concept of reverse logistics focuses on the forming economically effective and ecologically efficient economic system” for both concepts recovering and recycling processes are the root processes aiming to minimize landfill disposal. When implementing the concept of zero waste cities it is necessary to have proper infrastructure to help the material flow efficiently

The waste collected from different area differ in terms of physical and chemical composition. A study in Poland by Mesjasz-Lech (2019), shows that the zero waste cities concept is required to reduce waste in urban areas. And mentioned that reverse logistics is the basic part of the zero waste cities concept since the reverse logistics help to organize the waste flow and infrastructure. In Europe circular economy is sustainable use of resources.

The study shows how the reverse logistics can be used as a tool to achieve zero waste cities by collecting, sorting and recovering the waste. And to make the reverse logistics effective

coordination should be there that involve all the stakeholders. The processes of recovery and recycling are fundamental to both concepts. With respect to this it can be said that reverse logistics supplies specific tools for the realization of the goal of zero waste cities. By increasing the recycling rate of waste, one can reduce the negative impact of waste management system on the environment.

2.9.The Concept of Urban Logistics in Waste Management

According to study in Mexico by Martinez et al. (2019), urban logistics involves all the processes and operations that provide essential service to a community, such waste collection with lowest possible economic, social, and environmental cost for the city sustainability. In the context of reverse logistics, this involves the efficient and effective flow of materials from point of consumption back in to the supply chain. For cities like Addis Ababa, applying the urban logistics principle is important to mitigate the negative impact of waste on the environment, economy and social.

2.10. Optimization of Urban Logistics

In the study by Martinez et al. (2019), two primary strategies were identified for effective waste collection: Micro routing and Macro routing strategies. Macro is about which truck goes to which place (neighborhood) on the other hand Micro is about the specific street to street path. Their research in Mexico utilized a Mixed Integer Linear Programing (MILP) model to address the Vehicle Routing Problem. The study found that by mathematically balancing the collection territories and by ensuring each collection truck has equal workload and optimized path a city can significantly reduce both fuel consumption and the time vehicles spend in the traffic. Moreover, Martinez et al. (2019) states that urban logistics must consider the stochastic (unpredictable) variables, such as fluctuating traffic volumes and varying waste generation rates across the city. This suggest that a static or fixed collection route is often inefficient in a growing city. Instead on the study it is proposed a dynamic model where routes are adjusted based on the specific constraints of each sector.

2.11. The Circular Economy Framework in Waste Management

According to Mesjasz-Lech (2019), By promoting reuse and recycling, and by reducing the landfill use reverse logistics support the circular economy principle.

2.12. Supply Chain Actors and Stakeholder

In many developing countries such as Mexico, the government is responsible for managing urban solid waste and cleanup of green and public spaces (Martinez et al. ,2019).

Mbago et al. (2025) highlights that actors that involve in the reverse logistics are heterogeneous, including consumers, receivers, collectors and processors. In developing countries, the reverse logistics chain is often hybrid of formal and informal actors. According to Kinobe et al. (2015) the primary actors are waste collectors, street children, waste loaders, small scale, merchants, small scale recycling plants, agents, and factories. This study mentions that in developing countries the waste collectors of the reuseable and recyclable materials are informal collectors like street children, meaning the chain must include them. Due to high market value five categories of waste dominate the recycling chain these are plastics, soft polyethylene, paper, textiles, and metal (Kinobe et al., 2015).

The presence of the informal recyclers in the chain help to reduce the load at the landfill. However, in developing counties there is information flow gap that makes decision making for recycling challenging (Kinobe et al., 2015).

In Addis Ababa the waste management has evolved from a centralized to decentralized system which involve Micro and Small Enterprises (MSEs). Desta (2022), mentioned that while the city administration manages secondary transport from the transfer station to the landfill, the MSEs are the primary door to door collectors. Furthermore, In Addis Ketema Sub city acts as “nucleus” for informal recycling activities, particularly for metal. Evaluating these actors is critical as the informal network provides a logistical solution where formal infrastructure is absent. In Addis Ababa this creates a hybrid first mile collection system where informal actors and MSEs bridge the gap between households and formal transfer points.

2.13. Formal and Informal Actor Dynamics

Van de Klundert and Lardinois (1995) define the formal and informal sectors based on their regulatory status. The formal private sectors operate under the government regulations with official business licenses. On the other hand, the informal private sectors consist of unregistered activities carried out by individuals or community enterprises, that engage in small scale value adding

activities with minimal capital. The study mentions that without the integration of the formal and informal sectors the system cannot succeed and will remains a challenge for Addis Ababa's current logistics. Waste collection and recycling are often driven by poverty and a struggle for survival, frequently involving rural immigrants. While most generated waste is organic waste, collectors are attracted to materials with high market value such as paper, metal and plastic because they are easier to extract, handle, and transport. Women and children are often involved on the primary sorting activities. Despite the essential role of the informal actors in the reverse logistics chain their integration with the formal municipal system remains limited due to negative perceptions of informality and lack of commitment to implement the integrated framework.

Tilaye (2014), defines informal sector activities as activities not controlled or regulated by the government. These sectors served as missing link in the reverse logistics chain by moving wastes from the sources where the formal sectors cannot reach. Tilaye (2014) noted that informal actors are more often flexible and responsive to the community needs. The flexibility of the informal collectors is significant logistics advantage in Addis Ababa. Unlike the formal collectors, who relies on large vehicles and fixed schedule the informal collectors can navigate the city's every road network and adjust their collection time as per the residents. Because the informal collectors use non-motorized transport.

Cheru (2016) observed that the government has sometimes viewed informal actors as vermin while those actors see the government as a potential enemy. The study also notes that the main place for informal recycling process in Addis Ababa is Merkato Minalesh Tera. In this place there are many whole sellers and middlemen who sell the collected materials to factories or industries. In addition to selling there are craft men who transform waste to materials like sandals, ropes, chairs, washing container and metal stoves for charcoal. While this creates job opportunities, it is not supported by the government (Cheru, 2016). Finally, Desta (2022) mentions that prior to 2003 lack of coordination between the formal small and micro enterprises and the municipality leads to uncontrol dumping such as disposing the wastes surrounding the municipal containers, drainage lines, riverbanks, and street.

2.14. Empirical Review: International & Industry Lessons

2.14.1. Global Best Practices

In the city of Czestochowa, a major reform took place in 2013 that is often called the "Waste Revolution." Before this reform, the city's waste data was invisible because residents had to sign private contracts with trash companies. To save money, many people chose uncontrolled dumping. The reform changed the system completely by giving the Municipality the mandate to manage the waste. Under this new system, residents pay waste fee directly to the city not to the private companies. In addition to this this reform introduced sorting at the source. If the residents sort their waste at home, they pay a lower fee than those who dispose of mixed waste. (Bajdor et al., 2016)

The best practices from this case includes:

- Improving Visibility
- Financial Incentives
- Reducing work load by sorting at the source

According to Waste management and Circular Economy Policy in Japan by Ko Matsuura, (2024), on Home Appliance Recycling Act, Consumer, Retailer and Manufacturer/ importer are responsible in recycling four type of household electrical appliances, these are: air conditioner, refrigerator TV and washing machines. The retailers are responsible to take back used appliances, manufacturers are responsible to take back and recycle the used appliances and the consumers are required to pay collection, transportation fees and recycling charges when disposing it.

International brands like Adidas and Nike apply reverse logistics by taking back shoes and clothes and recycle them to produce a new product so that not to rely on raw virgin materials. (Mbago et al., 2025)

2.14.2. Circular Economy Business Models in Ethiopia

There are initiatives in circular economy such as Building blocks from reused plastics by a company named Kubik, they create environmental friendly, low carbon, low cost building material from plastic waste by recycling and reusing, solutions for paper recycling by a company called Penda paper , and PET recycling a company called COBA impact manufacturing in Addis Ababa

collects PET and HDPE collect and reuse it to produce flakes for export and produce brooms and brushes. (GIZ., 2020). These business shows the growth in demand for resource recovery.

2.15. Classification of Plastic waste

Enache et al. (2025) and Gnatowski and Kijo Kleczkowska (2025), mentioned that now a days polymer materials solves issues such as corrosion, weight, flexibility, and other additional challenges so it is replacing metal and ceramic materials.

Plastics are classified based on their physical properties and chemical composition. Identifying which type of plastic waste are in the municipal waste stream is crucial. Below listed types of plastic wastes are often used in Addis Ababa by their common household and commercial applications. These are:

- PET (Polyethylene Terephthalate): is petroleum-based polymer which is used as packaging materials for beverages. It is transparent, light weight, unbreakable compared to glass bottle. It doesn't decompose in the land. (Benyathiar et al., 2022). As noted by Benyathiar et al. (2022), since PET can be processed multiple times without losing its physical properties it is highly suitable for mechanical recycling. In addition to this the paper notes that the collected PET should be clean enough to reuse for waster or soda bottles and it must undergo a strict decontamination. So, if it is not clean it can be recycled into polyester fiber which is used to make another material.
- PE (Polyethylene): is thermoplastic which is inexpensive, light weight and durable. There are two types:
    - HDPE (High Density Polyethylene): is hard and does not break down under exposure to sunlight or freezing. (Murat et al., 2020). Its properties are high density, rigid, & strong. Example: Jerrycan, pen cap, bottle cap… Because it is rigid it maintains its volume so to transport this material efficiently it requires crushing or baling machine.
    - LDPE (Low Density Polyethylene): its properties are lower density, highly flexible and transparent. For example: plastic wraps. It is less toxic than other plastics but not commonly recycled (Murat et al., 2020).
- PP (Polypropylene): Its properties are light weight and durable, unlike other plastics PP can withstand high temperatures and it is flexible and can bend a lot of times with breaking. The

polymer chain combination is heterogeneous (De Jesus et al., 2023). For example: Plastic bags (Sack) for grains and construction materials (locally known as Madaberiya)

Beyond municipal waste reduction recycled polymers also have advantage in road construction. As a study by Meena & Rathore. (2023) shows that the LDPE waste can be used as bitumen modifier to enhance pavement stability and resistance to moisture damage. Murat et al. (2020) also investigate the properties of plastic wastes such as HDPE and LDPE to be used in bricks, pavement, and roof tiles.

2.16. Challenges of Solid Waste Management and Reverse Logistics

There are several barriers that block the transition toward to Zero Waste Cities through effective reverse logistics in developing countries like Ethiopia.

2.16.1. Socio Technical and Operational Gaps

The success of reverse logistics and the achievement of zero waste cities goals heavily depend on source segregation which remains a primary challenge in municipal solid waste management. According to Mesjasz-Lech. (2019), even when a city works towards zero waste cities goals, the amount produced directly by the households is increasing in many regions, making the reverse logistics difficult because of unsorted wastes. Therefore, reverse logistics must engage households and create awareness. Supporting this JICA (2024) and Kinobe et al. (2015), noted that because waste segregation at the source is not implemented in developing countries, composting activities and other recycling activities faces challenges. Furthermore, Mesjasz-Lech (2019), in the study identified lack of infrastructure and deficiency in advanced technology as barriers to recycle solid waste effectively.

Cheru (2016) highlights that poor relationship between the informal actors and the government leads to fragmented supply chain because they informal actors operates outside of official regulations; their collection route and volume is not tracked. This leads to Information gap. Beyond physical infrastructure, in developing counties, an information flow gap makes accurate decision making for recycling challenging. (Kinobe et al., 2015).

Kinobe et al. (2015) also revealed that 23% of the waste remain buried in the Kiteezi landfill due to lack of data, lack of market value, limited knowledge and limited value addition activities, which results resource loss.

2.16.2. Institutional and Policy Barriers

According to Gelan (2021), in Addis Ababa the main challenge in the solid waste management is that the government gives insufficient attention to policy and planning. This results in a scarcity of land to different activities such as sorting, temporary storage, and transfer station, alongside an inadequate supply of waste facilities. Similarly, Hirpe and Yeom (2021) and Adem (2024), mentioned that policy weakness, lack of effective enforcement, inadequate infrastructure, lack of skilled workers, lack of proper awareness regarding waste prevention, reduction, reuse and recycling are the main barriers whereas Martinez et al. (2019) highlight that limited funds for urban solid waste management have made the cleanup of green and public space difficult task.

2.16.3. Infrastructure and Topographical Barriers to Logistics

The major challenge in urban logistics is the physical infrastructure. Due to poor domestic recycling infrastructure and incentives, the recycling rate is low which is estimated around 4%. There are a lot of informal collectors and a few plastics and paper recyclers. The informal collectors travel around the city to collect recyclable materials, like plastic bottles, cardboard, and metal scraps. The 3Rs (reduce, reuse and recycle) and circular economy models are still on progress and evolving. The goal of the country to reduce, reuse and recycle the waste brings business opportunities in different areas. However, collection of waste throughout the cities is challenging because of logistics and transportation issues. In addition to this the lack of machineries like machine which is used to compress and make it manageable bundles the collected plastic bottles while storage and transport.

According Desta (2022), waste collection system in Addis Ababa has faced shortage of containers, poor access to some parts of the city and lack of proper land to place the container. Furthermore, due to lack of awareness, lack of easy and attractive alternatives and inadequate waste collection and transport system, the residents dump waste in any accessible places like drains, roadsides, river banks and empty sites, which creates scattered sources that are much harder to collect than centralized points.

The geographical and urban structure of Addis Ababa with the socio-economic status of the population makes the collection process challenging. Variations in topography make some areas inaccessible for collection trucks especially where proper road networks are lacking. This is important when comparing resident areas like Kolfe Keranio sub city where steep terrain is a factor to commercial centers like Addis Ketema sub city where there is high traffic jam and road blockage. Additionally, the condition of the fleet itself hinders the operation. Cheru (2016) noted that lake of maintenance, poor condition of roads and shortage of paved roads in the city have reduced the number of functional trucks, the reverse logistics interrupted, causing waste to accumulate at the transfer station and primary collection points.

2.17. Small Enterprises and Sub city Specific challenges

According to Dametew (2015), small and medium enterprises in Ethiopia faces a lack of technical knowledge, inadequate storage area, and poor internal collection system. Due to these logistic obstacles the enterprises do not involve in the recycling but they sell the materials to local collectors. Similarly, Desta 2022, mentioned in recycling activities getting land to build recycling facilities, financial barriers, technological and human capacity constraints, in adequate support are challenges the MSEs faces. In Kolfe Keranio sub city the primary bottlenecks are topography and poor road networks that forces the waste collators to carry waste manually, which slow down the process (Getachew, 2023). Dea (2024) estimates the recycling and composting rate in Addis Ketema were estimated to be only 5 %, a low rate is due to poor domestic recycling and composting infrastructure and lack of incentives. Finally, JICA (2024), highlights the working environment and conditions is challenge such as the transfer depot is utilized on a temporary basis, and daily disposal at landfill is challenging due to limited availability of heavy machineries and insufficient skilled operators.

2.18. Synthesis of Literature and Research Gap

While the existing literatures covers the general reverse logistics and solid waste management, there is a significant research gap regarding the comparison between two different types of areas based on their dominance (residential and commercial area) on the reverse logistics system on the solid waste management.

CHAPTER THREE

3. RESEARCH METHODOLOGY

This chapter describes the methods used for the data collection and analysis to answer the research questions and to achieve the stated specific objectives of the study.

3.1.Study Area

The study was conducted in Addis Ababa, where two sub cities were purposively selected based on their dominance in residential area and commercial areas. Addis Ketema is designated as the commercial center due to the presence of Merkato. The sub city represents Addis Ababa's commercial core and informal recycling center (Desta, 2022). Kolfe Keranio is designated as residential area based on high residential density. The selection of residential area was further supported by waste generation data from Adem (2024) study. The data shows Kolfe Keranio is one of the sub cities with the highest waste generation in the city due to its high residential density.

Figure 3.1. Map of Addis Ababa showing sub city divisions

Table 3.1. Population Size of the Sub-cities

Sub-city	Population (2022 G.C)
Kolfe Keranio	604,226
Addis Ketema	359,735

Source: Central Statistical Agency of Ethiopia (2022)

3.2.Institutional Framework

Solid waste management is decentralized system that involves different bodies under Addis Ababa Cleaning Management Agency such as sub cities, woredas, MSEs to have proper solid waste collection, disposal and recycling.

3.2.1. Administrative Chain of Command

The structure of supervision and chain of command for the waste management in Addis Ababa is as shown on Figure *3.2*.

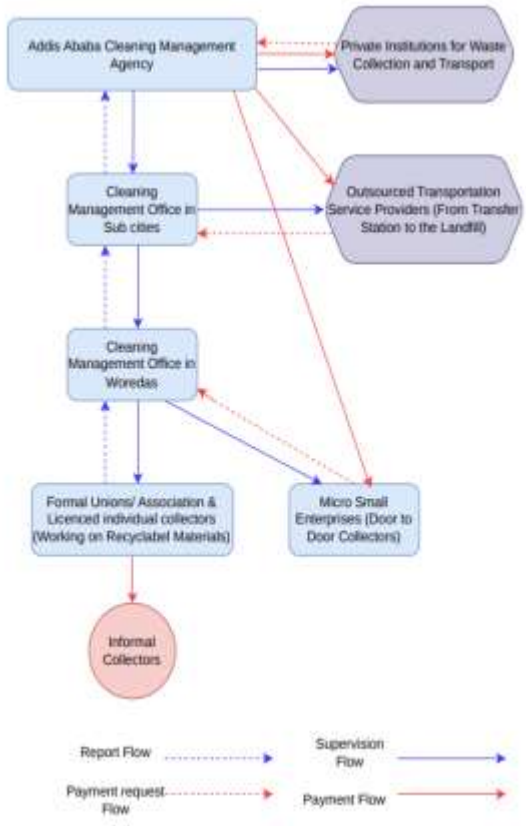

Figure 3.2. Structure of Solid Waste Management in Addis Ababa

As shown in Figure *3.2*, the structure of waste management in Addis Ababa follows top to down admirative hierarchy. In reality through field visit the system involves Informal collectors. They collect recyclable materials from different areas including from drainage and rivers and sell them to the formal small enterprises by weight.

1. Addis Ababa Cleaning Management Agency (AACMA)

Addis Ababa Cleaning Management Agency is the responsible body to manage the waste generated in the city and responsible for the waste management service in the city. In all sub cities and woredas there is an office called Cleaning Management Office which work closely with AACMA on the solid waste collection, transportation, and recycling.

2. Sub cities

In Addis Ababa there are 11 sub cities. The sub city act as a bridge between the AACMA and Woredas and the main responsibilities of the sub cities are:

- Supervise the Woreda Cleaning and Management office works
- Transport the waste collected by the Small micro enterprises from the depot to the landfill
- Supervise the transportation company (Outsourced) when assigned by the AACMA
- Create market linkage
- Manage road cleaning service

3. Woreda

The woreda team work under the control of the sub cities. The main responsibility of the woreda is monitoring and controlling MSEs and formal unions.

4. MSEs

They are grouped workers that are registered and start working under the woreda supervision like door-to-door collection of solid waste generated from households, then transport to the depot or temporary station then they sort the waste at the depot. After that they sold the recyclable materials like plastic bottle, metal… and the remaining waste will be sent to the landfill by the sub city vehicles or outsourced transport company then by the volume of waste they collected (kilogram) they will request payment and after the approval of woreda, sub city and AACMA the payment will be done.

5. Formal unions

They are working as a group only on the recycling materials. They will purchase the materials from the informal collectors then they will accumulate and sell to recyclers or factories.

5. Transportation service outsourced

AACMA outsource the transportation of collected waste from the transfer depots to the landfill especially when for the transportation distance is longer for the sub cities and sub cities will manage the transportation service.

Table 3.2. Average distance to landfill and percentage of waste transported by sub city and outsourced (JICA 2024).

Sub city	**Average Distance to Landfill Site (km)**	**Waste Amount Transported (%)**	
		By Sub city	**Outsourced**
Addis Ketema	10.3	71%	29%
Akaki Kality	17.7	60%	40%
Arada	12.7	24%	76%
Bole	17.9	16%	84%
Gulele	16.7	100%	0%
Kirkos	8.2	100%	0%
Kolfe Keranio	4.8	99%	1%
Lemi Kura	23.7	3%	97%
Lideta	7.6	57%	43%
Nifas Silk Lafto	7.3	89%	11%
Yeka	20.4	36%	64%
Total		**57%**	**43%**

6. Private companies

For the collection and transportation of waste from different commercial centers and institutions to the landfill AACMA assigned private companies and they are supervised directly by AACMA.

3.2.2. Mapping of Logistics Actors

In Addis Ababa assigned collection MSEs in each woredas provide coverage for nearly the entire city. According to the schedules arranged by the woreda to collect waste from various locations, the MSEs manage the collection process. However, as no formal studies have been conducted on this, the MSEs currently determine their own routes.

Table 3.3. Roles and Responsibilities of Solid Waste Collection and Transportation Actors in Residential Areas and Commercial centers

Activity Type	**Service Provider**	**Operational Mechanism and Route**	**Oversight Body**
Primary Collection	Door to Door Collection MSEs	Door to door waste collection from households to transfer station (depot)	Woreda
Secondary Transportation	Sub city government trucks or Outsourced trucks	Transport waste from transfer station (depot) to the landfill	Sub city
Collection and Transportation	Private companies	Direct collection and transport from commercial centers and institutions to the landfill	AACMA

3.3.Study Design and Data Collection

In this study Mixed Method was used, by integrating both quantitative survey data and qualitative field observations.

3.3.1. Target Population

- Administrative Leaders: at the Sub city and Woreda level
- Formal Unions and Micro and Small Enterprises
- Recyclers

3.3.2. Sampling technique

Selection of Sub cities

Two sub cities were selected based on their dominance on residential area and commercial center (Purposive sampling).

- Addis Ketema
- Kolfe Keranio

Selection of Woreda

From the two selected sub cities, five woredas from each were purposively selected based on their dominance in either commercial center or residential area.

Selection of Formal Unions & MSEs

Census sampling was applied, all registered and active formal unions and MSEs were selected from the selected 10 woredas. Total of 58 unions.

Table 3.4. Distribution and Sampling of Formal Unions and MSEs

Area Type	Woreda	No of Active Formal Unions & MSEs	Sampling Method
Residential	W4, W5, W6, W8, W10	35	Census
Commercial	W1, W3, W5, W8, W10	23	
Total		**58**	

Selection of Sub cities and Woredas Respondents

Key respondents were selected from

- Recycling and Reuse department
- Solid waste Collection and Transport department

These respondents are targeted because they directly involve in managing the reverse logistics chain in the sub cities and woredas.

Table 3.5. Staff Composition of Targeted Municipal Departments

	Under Cleaning Management Office		
	Solid Waste Collection and Transport	**Recycling and Reuse**	**Total Population**
Sub city Level	1 Leader, 10 expertise	1 Leader, 7 expertise	39
Woreda Level	1 Leader, 5 expertise	1 Leader, 2 expertise	90

- **Sub city Level Sampling**

For the sub city level officials, the entire population was invited to participate which represents census sampling technique because the population size is small and manageable.

- **Woreda Level Sampling**

For the woredas to determine the sample size Yamane (1967) formula was applied at a 95% confidence level.

$n=N/1+ N(e)^2$

Where:

- n= Requires sample size
- N= Total Population of the targeted departments
- e= Level of precision (Margin of error), 5%

$n= 90/ (1+(90*(0.05^2)))$

$n= 90/ (1+0.225)$

$n=90/1.225$

n= 73.47= 74 Respondents.

Table 3.6. Summary of Population and Sampling Outcomes

Target Population	Population Size	Sampling Method	Sample Size	Actual Responses	Response Rate %
Sub cities Level Officials	39	Census	39	32	82.05%
Woreda Level Officials	90	Yamane Formula	74	72	97.30%

Selection of Recycler Respondents

The selection of recyclers was conducted using snowball sampling. The unions and sub city officers were asked to identify the recyclers to whom they most frequently sold the collected materials. Based on that and willingness to participate in the study seven recyclers were selected.

3.3.3. Data Collection Tools

Data were collected from both primary and secondary sources:

- Primary data: collected using structured questionnaires by Kobo Toolbox and field visit.
- Secondary data: gathered from past published papers, AACMA, and sub cities.

Table 3.7. Summary of Questionnaire

Stakeholder/ Actor	Focus Areas in Questionnaire
Sub-city Officers	Incentives for formal unions, recovery centers planning, integration of informal collectors, allocation of trucks, GIS route optimization, transfer station upgrades, coordination gap, institutional challenges
Woreda Officers	Scheduling of collection, monitoring, coordination with formal unions, transport barriers, support to unions, records of informal collectors
Formal unions and MSEs	Road accessibility, material flow, contamination issues, transportation methods, minimum volume requirements, communication with recyclers, facility size, collection methods, types of materials collected, machinery availability, operational challenges
Recyclers	Source of raw materials, supply chain reliability, machine availability, challenges

3.3.4. Data Collection Procedures

- Sub city and woreda officers: questionnaires were distributed directly to the targeted population by visiting each office. Response was recorded using Kobo Toolbox.
- Formal unions and MSEs: data collection involved visiting all 58 unions hubs. Structured questionnaires were administered face to face, with response recorded using Kobo Toolbox.
- Recyclers: questionnaires were distributed and collected during visit to recycler hubs.

In addition, secondary data were gathered and compiled from AACMA, sub cities and woredas records. Field observation was also conducted during site visit.

3.4.Data Analysis and Presentation

Before the analysis the answers from Kobo Toolbox were exported to Excel. The Statistical Package for Social Sciences (SPSS) computer software was used to analyze the collected data.

3.4.1. Normality Test

For continuous and discrete data normality check was applied to check if it is normality distributed or not.

Table 3.8. Normality test results (Kolmogorov-Smirnova and Shapiro-Wilk) for area of facility and number of informal collectors in the two sub cities.

Variable	Area Type	Kolmogorov-Smirnova	df	Sig.	Shapiro-Wilk	df	Sig.
Area of facility (m^2)	Commercial	0.289	22	<.001	0.761	22	<.001
	Residential	0.242	35	<.001	0.768	35	<.001
Number of informal collectors	Commercial	0.265	21	<.001	0.826	21	0.002
	Residential	0.181	35	0.005	0.894	35	0.003
PET collected (Kg/day)	Commercial	0.324	16	<.001	0.573	16	<.001
	Residential	0.203	26	0.007	0.874	26	0.004

From Table *3.8* the normality test shows that area of facility, number of informal collectors, and PET collected violated the normal distribution assumptions ($p< 0.05$). Therefore, non-parametric tests were used in the analysis.

3.4.2. Descriptive Statistics

Percentages were calculated for categorical responses to provide a clear picture of the distribution of responses between residential and commercial areas. for ordinal and numerical variables, median and interquartile range (IQR) were used to describe central tendency.

3.4.3. Inferential Statistics

- **Single answer categorical questions**: analyzed using Chi Square test. Fisher's Exact Test result was used as a more reliable alternative if there is remark under the table that mention cell counts were small the assumptions of Chi Square were not met, when applying the Pearson's Chi Square test to assess the difference between the sub cities.
- **Multiple answer categorical questions**: the questions were transformed to binary variables (selected=1, not selected= 0) and analyzed each answer with Chi Square test.

- **Ordinal and Numerical questions**: analyzed using Mann Whitney U test to compare medians between residential and commercial areas.
- **Open ended questions**: were included to capture perceptions and experiences. These questions were analyzed thematically.

P values and Effect Sizes

A threshold of $p < 0.05$ was used to determine statistical significance along with Cramer V value and r.

- According to Cohen (1988) for Mann Whitney U test,

  effect size (r) = $Z/\sqrt{n}$, where: 0.1-small, 0.3- medium, 0.5- large
- For Chi square/ Fisher's Exact test, Cramer's V value was reported on SPSS result, where <0.2= weak; 0.2-0.4= moderate; >0.4= Strong

Table 3.9. Statistical Test Applied

Type of Data	Statistical Test Applied	Effect Size
Numeric (continuous and discrete)	Normality test results (Kolmogorov-Smirnova and Shapiro-Wilk)	-
Continuous and Discrete	Mann Whitney U	r (Cohen's)
Ordinal	Mann Whitney U	r (Cohen's)
Nominal	Pearson Chi Square/ Fisher's Extract	Cramer's V

CHAPTER FOUR

4. RESULT AND DISCUSSION

This chapter presents the data collected from different actors and stakeholder across the municipal solid waste reverse logistics networks of Addis Ababa. Building upon the research methodology outlined in the previous chapter, this chapter evaluates current operational practices, key actors, challenges, and flow of materials within commercial and residential areas.

4.1.Overview of Waste Generation in The Sub Cities

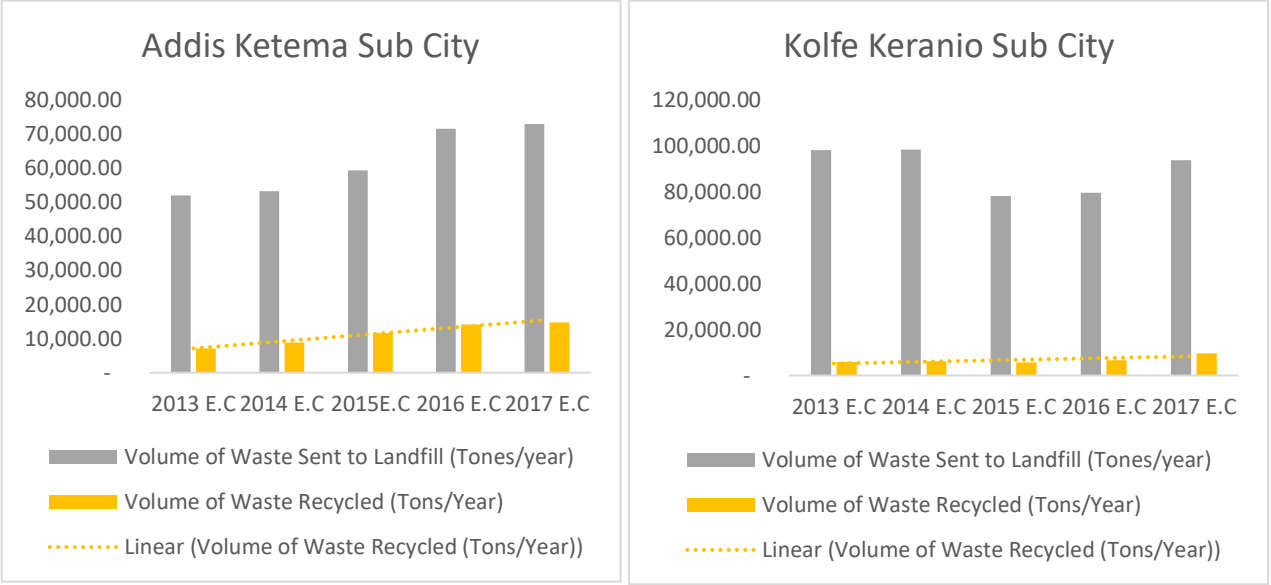

Figure 4.1. Annual waste disposal vs Recycling in Addis Ketema and Kolfe Keranio (2013-2017 E.C)

Source: Compiled by the author from AACMA, Addis Ketema and Kolfe Keranio Sub City Cleaning Management Office reports (2013, 2014, 2015, 2016, and 2017 E.C).

As shown in *Figure 4.1* the waste generation and landfill disposal volume is higher in Kolfe Keranio due to its dominance in residential area, where as the volume of waste recycled is higher in Addis Ketema due to its commercial center dominance. The data shows change in 2015 E.C, where four woredas from Kolfe Keranio moved to Addis Ketema and one to Gulele sub city so the volume of waste generated decrease on this year in Kolfe Keranio. The recycling rate in Addis Ketema in 2017 was 16.83% whereas in Kolfe Keranio it was 9.26%, this shows that commercial areas are more involved in recycling activities than residential areas. The result also show over

83% to 90% waste is still being sent to landfill. This indicate that despite growth in recycling, disposal remains the dominant pathway.

4.2.Current Reverse Logistics Practices

Waste characterization

To make things clear municipal wastes are categorized in to these groups:

- Direct reusable: items that can be used again without processing, like packaging materials.
- Recyclable: items that need processing before reuse, such as plastics, paper, metals and glass.
- Compostable: organic wastes that can be turned into bioenergy or fertilizer, like food scraps.
- Dangerous goods: hazardous waste that needs special handling.
- Non-Recyclable: non-hazardous waste that cannot be recycled or compost.
- Ashes and Fines

Recyclable and Reuseable Material collected at the hub

Types of waste collected by Formal unions and MSEs

- Polyethylene Terephthalate (PET)

Figure 4.2. PET waste collected and stored at the hub

- High Density Polyethylene (HDPE)

Figure 4.3. HDPE waste collected and stored at the hub

- **Polypropylene (PP)**

Figure 4.4. PP waste collected and stored at the hub

- **Cardboard and Paper**

Figure 4.6. Cardboard waste collected and stored at the hub

- Low Density Polyethylene (LDPE)

- **Metal**

Figure 4.5. Metal collected and stored at the hub

- **Glass bottle**

Figure 4.7. Glass bottle collected and stored at the hub

- **Compost**

According to different studies 60% of the waste is organic which is the major component of the solid waste generated and collected is organic waste. This waste can be transformed into compost which helps the waste reduction at the source and create job opportunities. So far very little is worked on compost and currently in all sub cities they are working on it.

Figure 4.8. Compost preparation at the site

Primary Recyclable and Reusable Waste: Materials List, Collection Method, and Processing

The percentage represent the recyclable and reusable waste, not total municipal solid waste.

Table 4.1. Collection Sources, Material Types, and Processing

Variable	Category	Commercial	Residential	p value	Cramer's V value
Primary collection source (Recyclable & Reusable waste)	Informal collectors	73.90%	62.90%	0.393	0.242
	Commercial and Institutions	4.30%	8.60%		
	Door to Door	0.00%	11.40%		
	Other	21.70%	17.10%		
Materials collected	Plastic Bottle	73.90%	77.10%	0.779	0.037
	Metal	47.80%	74.30%	0.04	0.269
	Glass bottle	26.10%	54.30%	0.034	0.279
	Paper	47.80%	40.00%	0.556	0.077
	Cardboard	69.60%	68.60%	0.936	0.011
	Jerrycans	60.90%	80.00%	0.111	0.209
	Organic	4.30%	11.40%	0.639	0.123
	Electronics	0.00%	2.90%	1	0.107
Material Processing at formal unions hub	Only Sorting	91.30%	94.30%	1	0.058
	Cleaning/ Washing	0.00%	0.00%	-	-
	Crushing/ Grinding	0.00%	0.00%	-	-
	Baling/ Pressing	0.00%	0.00%	-	-
	Other	13.00%	11.40%	1	0.024

Table 4.1 shows that in residential and commercial areas the majority of unions purchase the materials from informal collectors (73.90% in commercial and 62.90% residential). However, none of the actors involved in the collection and transport apply route optimization. Instead, they decide individually which path to take, often without coordination. This leads to overlapping routes, increased travel time and the operational cost.

Some union formed by women and mothers are supported by the sub city collect papers from governmental institutions such as from sub city office, woreda office and post office. There are also individual legal collectors that purchase from household's door to door this was observed in residential are (11.4%) this is because of the distance from the main roads which leads to limited

access to informal collectors. The Other is for the organic collectors they collect from Markets Atekelt Tera, fruit shop. The finding shows (Fisher's Exact, p= 0.393**;** Cramer's V= 0.242) no statistically significant difference in both areas with weak association which means the recyclable materials collection primarily rely on the informal collectors in both areas.

Figure 4.9. Informal collectors selling materials by kg to formal collectors

The most commonly collected material in both areas was plastic bottle with no significant difference. However significant difference was observed for Metal and Glass bottle, where both materials were collected more in residential area than commercial. The effect size is moderate association. Other materials such as paper, cardboard, jerrycans, organic and electronics shows no statistically significant difference in the two sub cities with negligible to weak effect sizes.

Dominant activity in the material processing practice in both areas was only sorting (commercial 91.3% and residential 94.3%). In addition to this no respondent reported value addition activities such as washing, grinding and bailing activities, this reveals that there a significant bottleneck in the service flow. The Fisher's Exact test result (p=1.000) also confirms that there is no statistically significant difference between the two areas. The effect size (Cramer's V) indicate there is negligible association. These finding indicate there is uniform practice in the two areas.

Transfer Station and Formal Unions Hubs (Logistics Node)

Transfer station and hubs serve as an intermediate place between the source and the final destination. In each woredas there is one transfer station or depot which is used to sort the collected waste and store it before transporting it to the final disposal place. In this station the collected waste stays only up to 24 hrs. The MSEs also use this station for sorting and store the recyclable materials until it reaches the minimum amount to sell. In one woreda the transfer station area is not comfortable for the truck due to poor road condition and this leads for the truck to stop working

continuously and they informed this leads to delay and the maintenance cost is so costly. And in other woreda the transfer station has taken for temporary it was given on the road which is not right. All the transfer station are open only one is covered or in building. Desta (2022), stated that AACMA has not yet finalized the set up to select transfer stations based on road accessibility, area, slope, sensitive area such as schools, churches, mosques, etc. in the city. Currently the land allocation for formal unions was not based on a study of transport accessibility, logistics efficiency or other demand. As a result, many unions operate from locations that are lacking proximity to major collection points. This increases the transportation distances. Field visit further revealed that many unions hub are located near to the river, which raises environmental concerns and complicate logistics.

Figure 4.10. Waste collection hubs along the riverbank

Figure 4.11. Transfer station in Kolfe Keranio

Figure 4.12. Transfer station in Addis Ketema

Facility Capacity and Daily PET Collection

Over all, within the study area, a total of 58 hubs (including the transfer stations) were identified. Of these, 35 hubs are in residential areas and 23 in commercial areas.

Table 4.2. Number of Hubs in each Woredas

Area Type	Woreda	No of Hubs		Area Type	Woreda	No of Hubs
Residential Area	W4	7		Commercial Area	W1	5
	W5	6			W3	7
	W6	10			W5	4
	W8	6			W8	2
	W10	6			W10	5
	Total	**35**			**Total**	**23**

Table 4.3. Comparison of Facility Capacity and Daily PET Collection in Commercial area vs Residential area

Variable	Area Type	Median	IQR (Q1-Q3)	Mann Whitney U	Z value	p value	Effect size (r)
Area of facility (m^2)	Commercial	70	36.25-212.5	307.5	-1.274	0.203	0.169
	Residential	100	40-500				
PET collected (Kg/day)	Commercial	45	22.5-160	202.5	-0.143	0.886	0.019
	Residential	50	30-85				

As shown in Table 4.3 in commercial area the facility area median was 70 m^2 (IQR=36.25-212.5), where as in residential the median was 100 m^2 (IQR=40-500). The result shows that in residential area facilities tended to be larger and more variable than those in commercial area. However, the Mann Whitney U test indicate there is no statistically significant difference between the two areas (U=307.500, Z=-1.27, p=0.203, r=0.17). The effect size also indicates small effect which means there is difference but it is weak. The boxplot in Figure *4.13* illustrates that residential area has several larger facilities extending up to 1000 m^2 and a wider spread. On the other hand, facilities

in commercial areas are more concentrated below 400 m^2 this is because of high urban density and land scarcity.

When looking at the daily collected PET amount, the median volume collected daily in commercial area was 45 kg/day (IQR= 22.5-160) and 50 kg/day (IQR=30-85) in residential. The Mann Whitney U test result (U=202.500, Z=-0.143, p=0.886, r=0.019) show there is no statistically significant difference between the two areas. The effect size was negligible; this indicate that in residential and commercial areas the volume of PET collected daily broadly is similar. In addition to that Figure *4.14* Figure *4.14*. Boxplot of Daily Collected PET Volume (kg/day) in Residential and Commercial areashows in commercial area have a wider spread where there are unions that collect extreme volume up to 1000 kg/day, while in residential the volume is concentrated below 200kg/day. This finding indicates that even if there are some unions in commercial area that collect high volume of PET. Overall, daily PET collection doesn't differ significantly in the two area and also it shows that having bigger facility doesn't mean waste will be collected more.

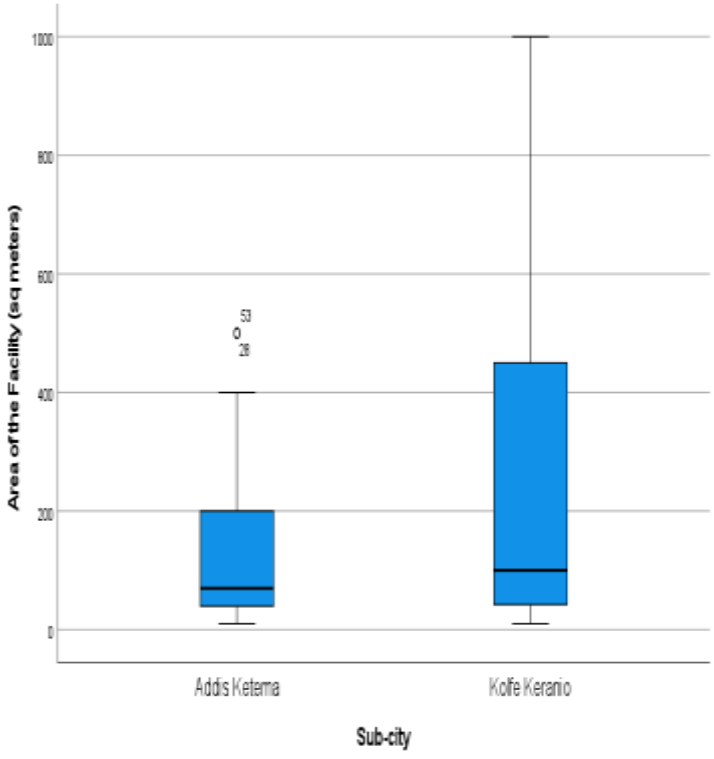

Figure 4.13. Boxplot of Facility Area (m^2) in Residential and Commercial area

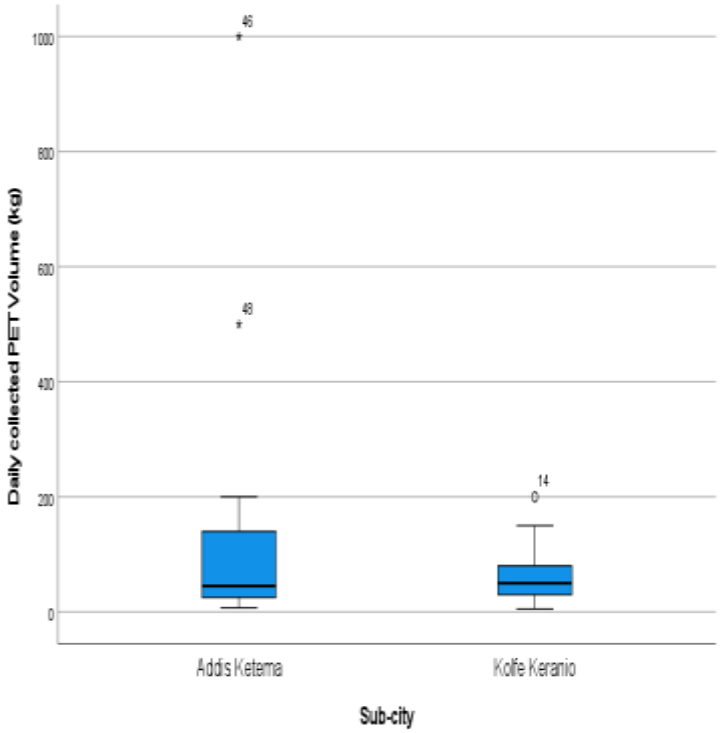

Figure 4.14. Boxplot of Daily Collected PET Volume (kg/day) in Residential and Commercial area

Storage Duration

Table 4.4. Mann Whitney U test result for storage duration

Variable	Area Type	Mean Rank	Median	Mann Whitney U	Z value	p value	Effect size (r)
Storage Duration	Commercial	20.91	3	205.000	-3.811	<.001	0.5
	Residential	35.14	4				

Table *4.4* shows the storage duration of collected materials in the hub in the two areas. The result indicates the median storage duration in commercial area was 1-2 weeks (mean rank=20.91), where as in residential area was more than 2 weeks (mean rank= 35.14). The Mann Whitney Test result (U=205.000, Z=-3.811, p=<.001, r=0.5) shows there is statistically significant difference and the effect is large which indicate that there is strong difference between the areas. This indicate that the recyclable materials remain longer in storage in resident areas than commercial areas which increase the risk of contamination or cause damage to the materials.

Standards and Control Practices for Value Preservation

These responses were from sub-city and woreda officers on practices they enforce or provide, and also reflect the perceptions of them based on institutional experience and oversight, not household compliance.

Table 4.5. Analysis of Quality Standards, and Value Loss Points (Response from sub-city and Woreda officers, perception based, not measured)

Variable	Category	Commercial	Residential	p value	Cramer's V value
Standards to prevent value loss	Yes	43.80%	73.30%	0.095	0.3
	No	56.30%	26.70%		
Standards/ Practice	Segregation at Source (different sacks provided by sub city officers)	87.50%	93.30%	1	0.099
	Color/Type sorting	6.30%	13.30%	0.6	0.12
	Baling/ compacting	0.00%	0.00%	-	-
	Cleaning/ washing	6.30%	13.30%	0.6	0.12
	Other	0.00%	0.00%	-	-
Location of major value loss in the supply chain	Source	37.50%	53.30%	0.85	0.17
	Transport	6.30%	6.70%		
	Market	25.00%	20.00%		
	Storage	31.30%	20.00%		
Reasons for mixed waste at sorting sites (as perceived by woreda officers)	Household mixing	66.70%	72.70%	0.402	0.177
	Collector mixing during transport	20.50%	24.20%		
	No separate containers	12.80%	3.00%		

From Table *4.5* Chi Square test result for the standard to prevent value loss was $X^2p= 0.095$, which is greater than 0.05. This indicate there is no statistically significant different between the two areas. The Cramer's V result was 0.3 which indicate there is moderate association between the area

type and the presence of standards. In practice residential areas (73.3%) more likely to have standard compared to commercial area (43.8%) which is more divided.

For the practices adopted to ensure recyclables don't lose value due to contamination the result shows that segregation at source was the most common practice in both areas with 87.5% report in commercial and 93.3% in residential area. The Chi Square Tests shows (p=1.000, Cramer's V= 0.099) no significant difference and indicating very weak association. During site visits in residential area, woreda officers were observed distributing two types of sacks door to door and raising awareness to sort waste in to bio degradable and non-bio degradable categories. In addition, waste disposal bins were placed along roads separated into residual and recyclable. Other practices such as color/ type sorting and cleaning were reported at very low rate while bailing/compacting were not practice at all. Over all the finding shows in both areas segregation at source is the dominate practice while more advanced processing methods are not being practiced.

Figure 4.15. Woreda officers distributing two types of sacks door to door

For the location of major value loss in the supply chain Fisher's Exact Test result was 0.850 which is much greater than 0.05. This indicate there is no statistically significant different between the two areas. The Cramer's V result was 0.170 which indicate there is weak association between the area type and perception of value loss. This result shows that both areas more agree on the main source of value loss is at the collection stage (no sorting at source) though (53.3%) of Addis Ketema officers also emphasize storage constraints, while 20.0% of Kolfe Keranio officers' places

less emphasize storage limitation. This indicate commercial areas are also more concerned with storage challenges while their perceptions are broadly similar.

The Fisher's Exact Test result for mixed waste at sorting sites was p= 0.402, which greater than 0.05. This result indicates there is no statistically significant difference between the two areas. In addition, Cramer's V result was 0.177, suggesting weak association. This shows that most woreda offices in both sub cities (66.7% in commercial and 72.7% in residential) confirmed household mixing was the dominant reason. Collection mixing during transport was also reported, though at lower levels. According to the MSEs sometimes the waste comes mixed so they sort there on the other hand some woreda staffs inform that sorting problem is not only the household but also the MSEs they said when collecting the waste, the MSEs put the sorted waste together in the truck. Overall, this suggest that there are similar perceptions in the two areas, with household practices being the primary source of contamination.

4.3.Stakeholders and Actors in Reverse Logistics

Analysis of the Reverse Logistics Phase

Field data collection in residential and commercial area confirmed that the final recovery stage in Addis Ababa is not a single destination. Instead, as visualizes in Figure *4.16* and Figure 4.17, the reverse logistics divided in to two flows. The first is formal flow which is monitored and controlled by AACMA, sub cities and woredas. Whereas the other flow is informal path which operate outside from formal oversight.

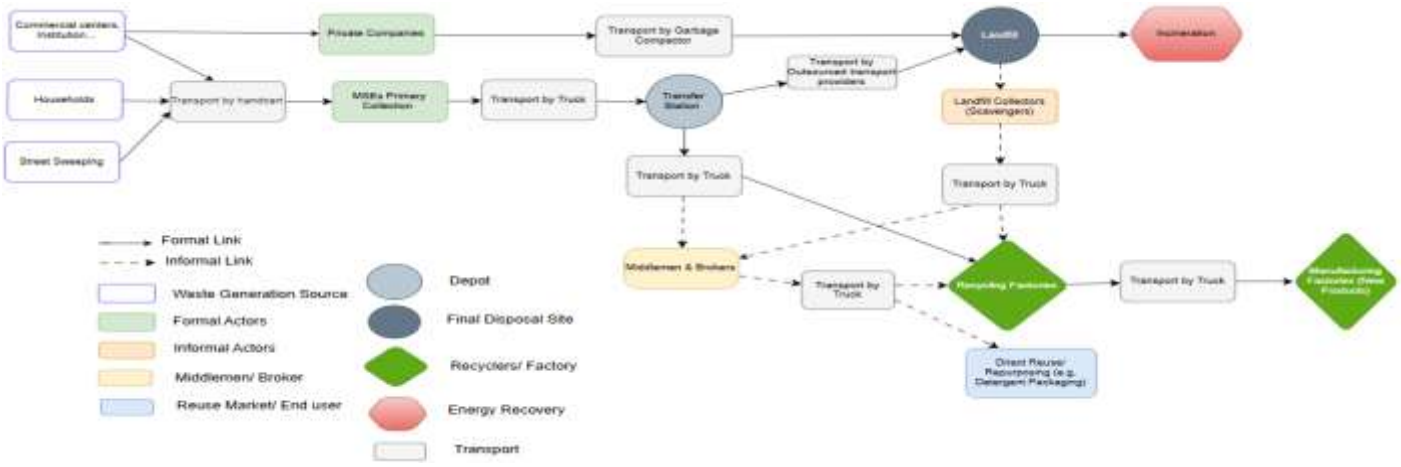

Figure 4.16. Municipal Waste Management and Recovery Flow Chart

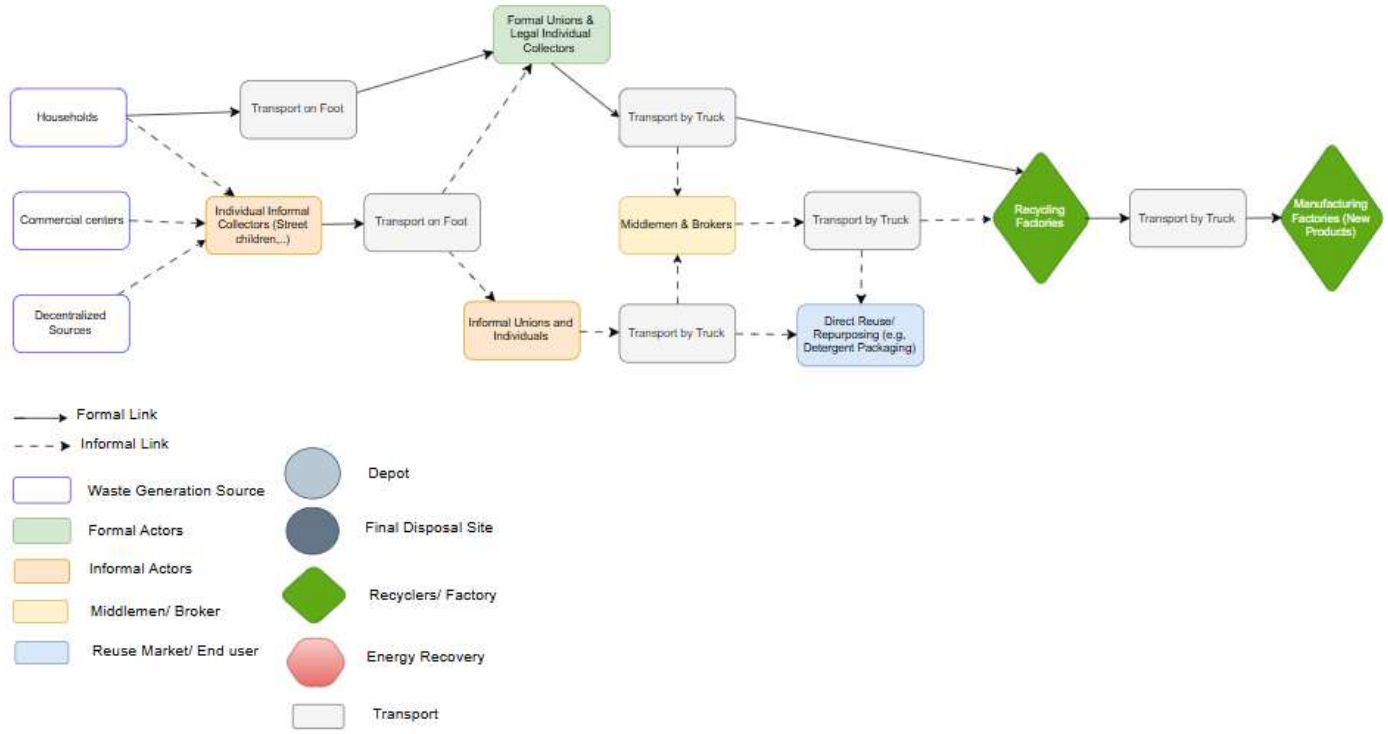

Figure 4.17. The Multi Actor Reverse Logistics Network for Reuseable and Recyclables

In residential areas waste is collected door to door by MSEs, where houses receive service twice per week and condominium blocks are serviced three times per week to manage higher accumulation rate. In commercial areas such as Merkato, waste collection is restrictive. Private companies are assigned to collect from each commercial buildings once a week on Sunday. Because of severe urban traffic congestion in the area the vehicle access is not possible during the rest of the days. So, this forces the commercial building operators to use the basements as temporary transit point to store the waste for the week. This increases the risk of material contamination.

Figure 4.18. MSEs collecting waste

The system has four logistics phases, which represent the movement of materials from upstream (the point of generation) to downstream (point of recovery or disposal).

Phase 1: Upstream Collection

This phase is the first mile because it is the starting point of the whole process where informal and formal actors such as MSEs, legal individual collectors, informal collectors interact with the source directly. Mostly in these phase large sacks are used to carry the recyclable waste but trucks are also used by MSEs when collecting the waste door to door. Finally, in this phase the waste is gathered and stored in depots or collection hubs.

Phase 2: Mid-Stream Point and Transport

In this phase the gathered materials are sorted by type and manually compacted into sacks by small unions are then moved to large unions or middlemen like in Merkato using trucks. Since there is no bailing machine the trucks end up being filled with air than the actual weight of the materials.

Phase 3: Value Addition

In this phase the collected materials are moved to recyclers. The actors add value to the materials by washing, grinding and melting to produce raw materials.

Phase 4: Downstream Recovery

This is the final stage and has three main pathways. These are:

- Reuse Path: The material such as jerrycan will be sold locally to businesses such as detergent makers.
- Manufacturing: The materials that are recycled are going to be used to make new materials.
- Disposal: This one is the least preferable option. Waste that cannot be recycled or reused will be sent to Reppie where waste is covered to energy.

Operational and Comparative Flow

Table 4.6. Comparison of reverse logistics path way

Feature	Formal MSE system Door to Door collectors	Formal Union/ Associations and Licensed Individual collectors	Informal Actors
Logistics Trigger	Fixed Schedule	No schedule	Market value/Price (On demand)
Transport Mode	Handcarts and Trucks	Rental truck	Sacks, pushcarts, rental trucks
Primary Goal	Sanitation, waste removal & income generation	Resource recovery & income generation	Resource recovery & income generation
Infrastructure	Transfer Stations (depot)	Storage Hub	Informal hubs

Table *4.6* highlights the difference between the pathways. The formal unions purchase from the informal collectors and also in some areas the people who live around there bring to their place and sell to them. There are also women and elders who collect from different areas like institution and sell to them. So, the formal unions store the materials until it fills one truck or reach the required weight then they will sell it to other big union or directly to recycling factory. Legally registered middlemen are licensed for trading material and pay tax this is differ from the unions since this is individual. For some formal unions land is provided by the sub city but some of them in commercial areas rent another place since it is not enough to store the materials.

Licensed individual collector (Legal Korale) possesses the mobility to navigate dense urban areas like commercial areas. They function as both collectors and small-scale buyers. All the unions perform manual compaction (Volume Reduction) to make transport more efficient before selling to larger broker or factories

From the field observation and interviews the fundamental pathways are similar in residential and commercial areas but their operational characteristics vary. In residential area the flow is dominated by formal unions but the volume of recyclables is relatively low, whereas in commercial areas informal union or actors dominate the sector handling different types of materials like cardboards, electronics, metal, plastics, and others. For instance, the informal actors collect discarded tires and convert it to functional basins as shown in Figure *4.19* then sell it to rural areas

to use it as washbasins and animal feeding troughs. This indicate that they are performing value addition to the non-biodegradable materials. And also, there are other informal actors that collect and sell electronics that was discarded. This highlights the innovative role of informal actors in commercial centers; the informal unions are strongest because there are so much material and cash moving quickly.

Figure 4.19. Informal Activities in Commercial Areas

Post Disposal Recovery and System Efficiency

The waste transported to the landfill is not the terminal waste, a highly organized network of landfill collectors (scavengers) acts as a post disposal recovery mechanism, they extract materials that were not sorted by formal door to door MSEs. These materials are then aggregated at the landfill and then sell to brokers or recycling factories. This shows that the efficiency of sorting at source in Addis Ababa remains low, pushing the logistics burden of recovery to the very end of the supply chain.

Unfair Market Competition in Reverse Logistics

Field interviews revealed a significant logistics and economic tension between formal and informal actors. Formal unions are burdened by tax obligation and municipal service requirements. The informal unions on the other hand operate without tax overhead, allowing them to offer a higher purchase price per kilogram to individual informal collectors. This creates a leakage in the formal reverse logistics chain, where high value materials are diverted away from formal union, threatening their financial sustainability and ability to invest in better transport equipment. If the formal union cannot get the high value recyclables, the transportation cost will be higher than their income.

Number of Informal Collectors

The figures represent estimates that is provided by the formal unions regarding number of informal collectors who frequently supply materials. Since the unions do not have formal record so these values are rough estimation rather than precise counts.

Table 4.7. Comparison of Number of Informal Collectors between Residential and Commercial Area

Variable	Area Type	Median	IQR (Q1-Q3)	Mann Whitney U	Z value	p value	Effect size (r)
Number of informal collectors	Commercial	10	5-37.5	240.000	-2.181	0.029	0.291
	Residential	7	0-12				

Table *4.7* shows the estimated number of informal collectors that bring frequently materials to the union and sold as per the result commercial area with median of 10 (IQR=5-37.5) have the highest number of informal collectors compared to residential area with median of 7 (IQR=0-12). The Mann Whitney U test result also confirmed that there is statistically significant difference (U=240.00, Z= -2.181, p= 0.029, r= 0.291). The effect size also shows moderate effect. In Figure *4.20* shows that in commercial area the distribution is wider with several large values up to 70 collectors compared to residential area. This finding indicates that there are more informal collectors in commercial centers, so this complicate coordination in commercial centers compared to residential areas.

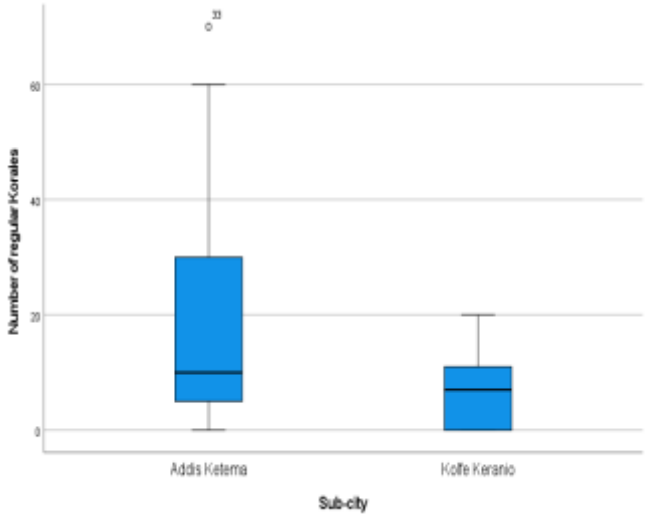

Figure 4.20. Boxplot of Number of Informal Collectors in Residential and Commercial area

Data Availability and Status to Integrate Informal Collectors

Table 4.8. Availability of Data and Integration Status of Informal Collectors

Variable	Category	Commercial	Residential	p value	Cramer's V value
Number of informal collectors' data availability	Yes recorded	33.30%	42.40%	0.708	0.098
	Estimate only	25.60%	24.20%		
	No data	41.00%	33.30%		
Existence of formal system to link the informal collectors with formal unions	Yes, active link	20.50%	21.20%	0.494	0.140
	Informal Link	46.20%	33.30%		
	No link	33.30%	45.50%		

From Table *4.8*. Availability of Data and Integration Status of Informal CollectorsTable *4.8* Chi Square test result for the data availability on how many informal collectors operate in the areas was $X^2p=0.708$, which greater than 0.05. This result indicates there is no statistically significant difference between the two areas. In addition, Cramer's V result was 0.098, suggesting very weak association. In commercial area most officers (41.0%) reported there is no data recorded whereas in residential area 42.0% report there is data recorded. This indicate both areas are broadly similar with slight differences. Overall, the finding suggests that although some woredas have begun documenting informal collectors, there are woredas with lack of data which hinder integrating the informal actors in to the reverse logistics chain. Several woredas officers mentioned that collecting data is challenging because many informal collectors migrate from rural areas without Id and do not have permanent working places, moving instead to locations where income opportunities are greater. The other Chi Square test result was for the existence of formal system to link the informal collectors with formal unions which was $X^2p= 0.494$. This result indicates there is no statistically significant difference between the two sub cities. In addition, Cramer's V result was 0.14, suggesting weak association. The finding shows that in committal area most officers reported there is informal links 46.2%. Overall, in both sub cities there is no formal link.

Sub city and Woreda perception of informal collectors

Table 4.9. How do the Woreda Officers and Sub city Officers View Informal Collectors (Sub city vs Woreda Levels)

Woreda perception of informal collectors					
Area Type	**Essential partners**	**Tolerated**	**Viewed as unauthorized operator**	**p value**	**Cramer's V value**
Commercial	38.50%	28.20%	33.30%	0.161	0.225
Residential	36.40%	12.10%	51.50%		
Sub city perception of informal collectors					
	Essential partners	**Unauthorized**	**Neutral/Ignore**	**p value**	**Cramer's V value**
Commercial	43.80%	50.00%	6.30%	0.024	0.479
Residential	6.70%	93.30%	0.00%		

From Table *4.9* Chi Square test X^2p= 0.161, which indicates there is no statistically significant difference between the two areas according to the woreda officers report. In addition, Cramer's V result was 0.225, suggesting weak association. The finding shows significant proportion of woreda officers acknowledge the importance of informal actors in the chain. Whereas the Fisher's Exact Test result from the sub city officers report for how sub city categorize informal collectors was 0.024, which indicate there is statistically significant difference between the sub cities. The Cramer's V result was 0.479 which shows moderate association, this means there is some difference (In residential areas 93.3% of officers categorize informal collectors as unauthorized while in commercial areas officers were more divide with 43.8% categorize as essential partners and 50% as unauthorized) but also there is still overlap. This shows meaningful difference. This also show there is information gap between the sub city and woreda officers in both areas.

Future plan to integrate informal collectors into the system

Table 4.10. Plan to integrate informal collectors (Sub city vs Woreda Levels)

Sub city officers						
Area Type	**Yes, there is an active plan**	**It is under discussion**	**No plan at the moment**	**Not considered**	**p value**	**Cramer's V value**
Commercial	46.20%	15.40%	35.90%	2.60%	0.562	0.17
Residential	33.30%	12.10%	48.50%	6.10%		
Woreda officers						
Area Type	**Yes, being implemented**	**In discussion phase**	**No plan**		**p value**	**Cramer's V value**
Commercial	31.30%	43.80%	25.00%		0.902	0.115
Residential	33.30%	33.30%	33.30%			

From Table *4.10* the Fisher's Exact Test result for the sub city officer's response was p= 0.562, which greater than 0.05. This result indicates there is no statistically significant difference between the two areas. Cramer's V result was 0.170, suggesting weak association between the area type and future plan to integrate informal collectors in to the system. And also, the Fisher's Exact Test result from the woreda officers' response was 0.902 which is much greater than 0.05. This means there is no statistically significant difference between the two areas. The Cramer's V result was 0.115, which indicate there is weak association between area type and the presence of directives. In both areas mixed approaches were reported.

Facilitation of market linkages between formal unions and recycling factories

Table 4.11. Facilitation of market linkages (Sub city vs Woreda Levels)

Sub city officers					
Area Type	**Yes**	**No**	**In progress**	**Fisher's Exact (p value)**	**Cramer's V value**
Commercial	81.30%	6.30%	12.50%	1.000	0.177
Residential	86.70%	0.00%	13.30%		
Woreda officers					
Area Type	**Yes**	**No**		**Fisher's Exact (p value)**	**Cramer's V value**
Commercial	94.90%	5.10%		0.235	0.169
Residential	84.80%	15.20%			

From Table *4.11* the Fisher's Exact Test result for the sub city responses was 1.000 which is much greater than 0.05. This indicate there is no statistically significant different between the two sub cities. The Cramer's V result was 0.177 which indicate there is weak association between the area type and facilitation practices. Both area officers confirmed the existence of market linkage between formal unions and recycling factories. And according to the woreda officers report Fisher's Exact Test result was p= 0.235, which greater than 0.05. This result indicates there is no statistically significant difference between the two sub cities. In addition, Cramer's V result was 0.169, suggesting weak association. This shows that most woreda offices in both sub cities reported that the woreda provides such support by coordinating with sub city (94.9% in commercial area & 84.8% in residential area). A small portion indicated that it is the responsibility of the formal unions. Overall, the finding indicates that there is similar perception on the facilitating market linkage for recyclables.

4.4.Coordination and Institutional Roles

Coordination Gap

Table 4.12. Coordination gap between sub city and woredas

Sub city vs Woreda				
Area Type	**Excellent**	**Good**	**Fair / Moderate**	**Poor**
Commercial	6.30%	37.50%	56.30%	0.00%
Residential	13.30%	20.00%	53.30%	13.30%
Woreda vs Unions and Factories				
Area Type	**High Gap-No regular communication**	**Medium Gap-Occasional coordination**	**Low Gap - Regular coordination**	**No link with factories at all**
Commercial	17.90%	46.20%	20.50%	15.40%
Residential	6.10%	54.50%	33.30%	6.10%

Table 4.13. Mann Whitney U test result for coordination gap

Level of Coordination	Area Type	Mean Rank	Median	Mann Whitney U	Z value	p value	Effect size (r)
Sub city vs Woreda	Commercial	14.94	3	103	-0.747	0.455	0.13
	Residential	17.13	3				
Woreda vs Unions and Factories	Commercial	35.41	2	601	-0.52	0.603	0.061
	Residential	37.79	2				

Table *4.12* and Table *4.13* shows perceptions of coordination gaps. Mann Whitney U test revealed that coordination gap between the sub city and woreda was significantly same in the two areas. Both sub cities reported a median of 3 (Moderate), U= 103.000, z=-0.747, p=.455. The effect size was small (r=0.13), which indicate there is only negligible practical difference. The mean rank of residential area (17.13) is slightly higher than commercial area (14.94), this shows residential area respondents tend to lean more towards fair/poor rating. However, this difference is not statistically significant. This suggest there is coordination challenge in both residential and commercial centers.

For the coordination gap between Woreda, Unions and Factories the Mann Whitney test result (U=601.00, p= 0.603) shows that there is no statistically significant difference between the two areas in their perception of coordination gaps. The median value for both areas was 2.00, corresponding to Medium Gap. The effect size (0.061) indicates that the difference between the area is negligible.

Sub city's and Woreda 's waste management priority

Table 4.14. Sub city's and Woreda's Current Waste Management Priority

Respondent Level	Area Type	Waste Minimization/ Prevention	Recycling & Recovery	Disposal/ Dumping	Balanced Approach	p value	Cramer's V value
Sub city officers	Commercial	31.30%	37.50%	0.00%	31.30%	0.467	0.32
	Residential	26.70%	20.00%	13.30%	40.00%		
Woreda officers	Commercial	38.50%	28.20%	7.70%	25.60%	0.739	0.145
	Residential	33.30%	39.40%	3.00%	24.20%		

Using responses from sub cities officers, the waste management priority in the two areas was examined with the Fisher Exact Test result as shown on Table *4.14*. The result was p=0.467, which indicate that there is no statically significant difference in waste management priorities between commercial and residential areas. In addition to this to assess the strength of the relationship, Cramer's V was calculated, the result was 0.320, These shows moderate association between area type and waste management priority. This means even if commercial area lean more towards Recycling & Recovery while residential area leans more towards Balanced Approach, there is still overlap.

The Fisher's Exact Test result from the responses from woreda officers was p= 0.739, which indicate there is no statistically significant difference between the two areas. In addition, Cramer's V result was 0.145, suggesting weak association. The findings show that woreda officers in both areas reported similar waste management priorities. In commercial area waste minimization/ prevention (38.5%) and recycling/ recovery (28.2%) were the most reported priorities, while in residential area recycling/ recovery (39.4%) and waste minimization/ prevention (33.3%) were

dominant. This suggest that both areas share comparable priorities, with prevention and recovery being the main focus areas of the current waste management strategies.

Administrative Roles, Data Collection Frequency and Training

Table 4.15. Administrative Roles, Data Collection Frequency and Training

Variable	Category	Commercial	Residential	p value	Cramer's V value
Primary role of Woreda	Operational /Collecting	20.50%	21.20%	0.698	0.114
	Regulatory/ Monitoring	66.70%	72.70%		
	Financial Support	12.80%	6.10%		
Data collection frequency	Daily	48.70%	42.40%	0.774	0.192
	Weekly	17.90%	15.20%		
	Every two weeks	0.00%	3.00%		
	Monthly	33.30%	36.40%		
	Irregularly / No schedule	0.00%	3.00%		
Training to woreda staff	Yes	93.80%	53.30%	0.015	0.462
	No	6.30%	46.70%		

From Table *4.15* the Fisher's Exact Test result for primary role of woreda was p= 0.698, which indicate there is no statistically significant difference between the two areas. In addition, Cramer's V result was 0.114, suggesting weak association. This shows that most woreda offices in both areas (66.7% in commercial and 72.7% in residential) confirmed that the main role of woreda is regulatory/ monitoring is dominant.

The Fisher's Exact Test result for data collection frequency was p= 0.774, which greater than 0.05. This result indicates there is no statistically significant difference between the two areas. In addition, Cramer's V result was 0.192, suggesting weak association. This shows that most woreda offices in both areas confirmed that frequency of data collection is on a daily and monthly basis, which emerged as the dominant approaches. The Fisher's Exact Test result for training to woreda staff was 0.015, which indicate there is statistically significant different between the two areas. The Cramer's V result was 0.462 which indicate there is moderate association between the area type and providing training. In practice, 93.8% of Addis Ketema officers reported that they had been providing training on recycling whereas only 53.3% of Kolfe Keranio offices reported they

had been providing. This shows meaningful difference in commercial areas it shows there is strong commitment to technical training compared to residential areas.

4.5.Challenges Hindering Effectiveness

Logistics Barriers, Operational Gaps, and Road Accessibility

Table 4.16. Perceived RL Challenges and Operational Gaps, Transport Barriers, and Road Accessibility

Category	Variable	Commercial (%)	Residential (%)	p value	Cramer's V
Institutional Challenges	Traffic Congestion	50.00%	20.00%	0.135	0.313
	Lack of sorting space	75.00%	33.30%	0.032	0.418
	Low market price	43.80%	26.70%	0.458	0.178
	Distance to factories	25.00%	20.00%	1	0.06
	Lack of coordination	50.00%	46.70%	1	0.033
	Other	18.80%	0.00%	0.226	0.317
Transport Barriers	Traffic Congestion	43.60%	39.40%	0.719	0.042
	Narrow Roads	41.00%	54.50%	0.252	0.135
	Slopes	17.90%	30.30%	0.219	0.145
	Lack of Trucks	61.50%	39.40%	0.061	0.221
Operational Gap	Collection gap	35.90%	51.50%	0.182	0.157
	Sorting gap	51.30%	30.30%	0.072	0.212
	Transportation gap	38.50%	33.30%	0.652	0.053
	Market gap	35.90%	33.30%	0.82	0.027
	Lack of digital data and monitoring	5.10%	0.00%	0.496	0.155
	Lack of communication and coordination with informal collectors	20.50%	21.20%	0.942	0.009
Road Accessibility	Accessible	69.60%	65.70%	0.781	0.125
	Narrow/ Crowded	8.70%	17.10%		
	Very Difficult	21.70%	17.10%		

Table *4.16* summarizes reverse logistics challenges faced by the two areas. Lack of space more affect commercial areas (75%) compared to residential areas (33.3%), with Chi Square test (p=0.032, Cramer's V=0.418) shows there is significant difference in the two sub cities. Traffic

congestion was also challenge in commercial areas (50%) than in residential areas (20%) though there is no statistically significant difference. Other challenges such as low market price showed practical difference but were not statistically significant. In contrast, the distance to factories and lack of coordination were perceived similarly in both areas. Finally, there are additional issues mentioned only in commercial areas such as lack of market linkage, minimum volume requirements for sending collected material to the recyclers, and vehicle time restriction for heavy trucks.

All the listed barriers have no statistically significant difference (all $p > 0.05$) and also the association between the area type and the barriers were weak (Cramer's $V<0.25$). However, commercial areas are more constrained by truck shortage (61.5% vs 39.4%) while residential areas struggle with narrow roads (54.5% vs 41%) and slopes (30.3% vs 17.9%).

Figure 4.21. Narrow roads and Traffic Congestion in Commercial Areas

Figure 4.22. Narrow Road and Slope Areas in Residential Areas

The operational gap was reported differently in the two areas. In commercial areas (51.3% vs 30.3%) sorting gap was the major gap, however there was no statistically significant difference ($X^2P= 0.072$, Cramer's $V= 0.212$) where as in residential areas (51.5% vs 35.9%) collection gap was reported as major but not significant. The remaining gaps were similar in the two areas. This shows the more challenge faced in commercial areas is sorting whereas in residential areas more with collection. Most of the roads are reported as accessible in both areas (69.60% in commercial

and 65.70% in residential). Narrow road was reported more on residential areas while very difficult road condition was more common in commercial areas. The statistical test (Fisher's Exact, p= 0.781; Cramer's V= 0.125) indicate there is no significant difference between the areas, with weak association.

Operational Challenges, Market Barriers and Financial Constraints

Table 4.17. Operational Challenges, Market Barriers and Financial Constraints for MSEs and Formal Unions

Category	Variable	Commercial (%)	Residential (%)	p value	Cramer's V value
Operational Challenges	High Transport Cost	69.60%	88.60%	0.071	0.237
	Lack of storage space	69.60%	60.00%	0.458	0.097
	Traffic Congestion	39.10%	22.90%	0.183	0.175
	Payment Delay	13.00%	28.60%	0.165	0.182
	Poor quality/ mixed waste	26.10%	8.60%	0.072	0.237
	Other	30.40%	22.90%	0.519	0.085
Challenges when selling materials	Transport cost	78.30%	88.60%	0.289	0.139
	Low price	21.70%	25.70%	0.729	0.045
	Poor quality	17.40%	11.40%	0.7	0.085
	Long distance	39.10%	71.40%	0.015	0.321
Financial problem	High Transportation cost	65.20%	85.70%	0.067	0.24
	Payment Delay	13.00%	25.70%	0.244	0.244
	High Rent	21.70%	28.60%	0.561	0.076
	Low selling price	30.40%	22.90%	0.519	0.085
	Lack of capital	60.90%	22.90%	0.004	0.383
	Other	17.40%	2.90%	0.075	0.253
Material prices stability	Changes weekly	0.00%	8.60%	0.445	0.193
	Stable	13.00%	14.30%		
	Unpredictable	87.00%	77.10%		

From Table *4.17* the results indicate the challenges the unions face has no statistically significant difference ($X^2p > 0.05$) in both areas. The Cramer's V value also indicate there is weak to very weak association. One of the challenges reported more in commercial area was mixed waste supporting this on field visit as shown in Figure *4.23* it was observed that mixed waste reach at the hub in commercial areas than residential area.

Figure 4.23. Mixed Waste Sorting at the Hub

The most frequently reported challenge in the two sub cities is transport cost (78.3% & 88.6%). And there no statistically significant difference in the two areas with weak association ($X^2p=0.289$, Cramer's V= 0.139), whereas distance to the factory was reported more frequently in residential areas (71.4%) than commercial areas (39.10%), the result ($X^2p=0.015$, Cramer's V= 0.321) shows there is statistically significant difference in the two sub cities with moderate association. Other challenges showed no significant difference and the effect size is negligible.

The most common financial challenge in the two areas is also high transportation cost. The result ($X^2p=0.067$, Cramer's V=0.240) shows there is no statistically significant difference in the two areas. On the other hand, clear difference is shown in lack of capital (commercial (60.9%) & residential (22.90%)), with moderate association. The other additional financial challenges reported by the MSEs in residential areas is frequent vehicle maintenance due to poor road condition which causes delays in waste collect schedules. For price stability the results (Fisher's Exact p= 0.445; Cramer's V= 0.193) indicate there is no significant difference in the two areas with weak association. This indicate that price instability is a common challenge in both areas.

As shown in Figure 4.24 in commercial areas cardboards are temporary stored on pedestrian walkways due to lack of designated depots. And the informal collectors manually transport the materials.

Figure 4.24. Primary Collection and Temporary Storage in Commercial Areas

Factory Requirements, Impact of Transport Delay, and Material Profitability

Table 4.18. Factory Requirements, Impact of Transport Delay, and Material Profitability

Category	Variable	Commercial (%)	Residential (%)	p value	Cramer's V value
Minimum volume required for factory transport	Yes, we must wait until we have a full truckload	87.00%	74.30%	0.769	0.178
	Yes, we must reach a specific weight	8.70%	11.40%		
	No, we are the ones who transport it ourselves regardless of amount	0.00%	2.90%		
	No, they collect whatever amount we have	4.30%	11.40%		
Impact of transport delay	Frequently	0.00%	2.90%	0.56	0.164
	Sometimes	47.80%	34.30%		
	Never	52.20%	62.90%		
Most profitable material for unions	Plastic Bottle	56.50%	51.40%	0.864	0.259
	Jerrycans	0.00%	5.70%		
	Metal	26.10%	17.10%		
	Cardboard	8.70%	8.60%		
	Paper	0.00%	2.90%		
	Organic	8.70%	8.60%		
	Other	0.00%	5.70%		

Table *4.18* shows majority of the unions (87% in commercial and 74.3% in residential) reported that they must wait until they have full truckload to transport the material. The statistic test (Fisher's Exact p= 0.769; Cramer's V= 0.178) shows there is no significant difference in the two areas with weak association.

The impact of transport delay was not reported as frequent issue. The majority reported it never impacts the material (52.2% in commercial and 62.9% in residential). The statistic test (Fisher's Exact p= 0.560; Cramer's V= 0.164) confirmed there is no significant difference in the two areas with weak association.

In both areas the most profitable material is plastic bottle (56.5% in commercial and 51.4% in residential). The statistic test (Fisher's Exact p= 0.864; Cramer's V= 0.259) shows there is no significant difference in the two areas with moderate effect size.

4.6.Communication and Logistics

Transportation to factory

Table 4.19. Current Communication Method, Logistics, and Safety Standards

Category	Variable	Commercial (%)	Residential (%)	p value	Cramer's V value
Transportation to factory	Own truck	4.30%	0.00%	0.457	0.179
	Rented truck	69.60%	65.70%		
	Buyer's truck	26.10%	34.30%		
Communication method unions use	Personal Phone Call	82.60%	82.90%	1.000	0.043
	In person visit	13.00%	14.30%		
	Through a Middleman/Broker	4.30%	2.90%		
Availability of adequate worker safety gear	Yes, all	0.00%	5.70%	0.027	0.346
	Partially	13.00%	40.00%		
	No	87.00%	54.30%		

Table *4.19* shows most of the unions transport materials to factories using rented trucks (69.6% in commercial and 65.7% in residential). The statistic test (Fisher's Exact p= 0.457; Cramer's V= 0.179) shows there is no significant difference in the two areas with weak association. This shows transport challenges in the absence of fixed schedules; unions wait until they reach the required

volume before renting vehicles. As a result, trucks often operate without route optimization and sometimes even starting trip empty. This practice increases the transportation costs and reduces efficiency.

Most of the unions communicate with recyclers through phone calls (82.6% in commercial and 82.9% in residential). The statistic test (Fisher's Exact p= 1.000; Cramer's V= 0.043) shows there is no significant difference in the two areas with very weak association. This leads to information gap since there is no digitalized system.

Majority of the unions (87% in commercial and 54.3% in residential) reported that they don't have adequate worker safety gear. The statistic test (Fisher's Exact p= 0.027; Cramer's V= 0.346) shows there is no significant difference in the two areas with moderate association.

4.7.Future Planning and Infrastructure

Critical facility needed to improve RL

Table 4.20. Infrastructure needed and Land allocation Plans

Category	Variable	Commercial (%)	Residential (%)	p value	Cramer's V value
Critical facility needed to improve RL	More Land/Sites	69.20%	48.50%	0.036	0.345
	Baling Machinery	5.10%	24.20%		
	Better Trucks	5.10%	15.20%		
	Training	20.50%	12.10%		
Existence of master plan to allocate land for recovery centers (Sub city Officers)	Yes, active plan	50.00%	86.70%	0.029	0.392
	No, land is a major constraint	50.00%	13.30%		
Existence of master plan to allocate land for recovery centers (Woreda Officers)	Yes, active plan	23.10%	45.50%	0.045	0.237
	No, land is a major constraint	76.90%	54.50%		
Plan to upgrade transfer station into value addition centers	Yes	75.00%	66.70%	0.704	0.092
	No	25.00%	33.30%		
Use of GIS for route optimization	Yes	6.30%	13.30%	0.600	0.120
	No	93.80%	86.70%		

From Table *4.20* the Fisher's Exact Test result for critical facility needed to improve RL was p= 0.036, which indicate there is statistically significant difference between the area. In addition, Cramer's V result was 0.345, suggesting moderate association between the area type and perceived facility needs. The finding shows that in commercial areas, the majority of the woreda officers emphasized the need for more land/ site (69.2%), followed by training (20.5%). In contrast, in residential areas emphasize the need for more land/ site (48.5%) but also considerable importance to bailing machinery (24.2%) and better trucks (15.2%). This suggest that land availability is common concern for both areas while residential areas officers perceive infrastructure gaps like truck and bailing machine. This reflects difference in operational challenges and priorities because in residential area there is more diverse needs.

The Chi Square test Pearson X^2p result for the existence of master plan to allocate land specifically for Recovery centers within each Woreda was p=0.029, this indicate that there is statical significant difference between the two areas. The Cramer's V test result was 0.392 which indicate that there is moderate association between the area type and the presence of master plan. From residential areas 86.7% of the officers reported there is active plans compared to commercial areas (50%). This shows there is meaningful difference in planning.

From the above table Chi Square test X^2p= 0.045, which less than 0.05. This result indicates there is statistically significant difference between the two areas. In addition, Cramer's V result was 0.237, suggesting moderate association between the area type and perceptions of future facility development. Most of Addis Ketema officers (76.9%) reported there is no plan to build additional transfer station or recovery center while In Kolfe Keranio (45.5%) of the officers reported there is plan. Overall, this suggests residential areas appears more engaging in planning for infrastructure expansion.

The Fisher's Exact Test result for plans to upgrade transfer stations into value addition centers was p= 0.704, which greater than 0.05. This result indicates there is no statistically significant difference between the two sub cities. In addition to this Cramer's V result was 0.092, suggesting very weak association between the sub city type and planning. This shows that most of the sub cities offices in the two areas (75% in Addis Ketema and 66.7% in Kolfe Keranio) confirmed there is plan.

The Fisher's Exact Test result for use of GIS for route optimization was 0.06, this indicate that there is no statistically significant difference between the two sub cities. The Cramer's value was 0.12, which indicate there is weak association between the area type and the use of GIS. This means in both sub cities most of the officers (in commercial 86.7% and In residential 93.8%) reported that GIS is not used in the areas

4.8.Support and Incentives

Institutional Support and Budget Allocation

Table 4.21. Institutional Support, Incentives, and Budget Allocation

Category	Variable	Commercial (%)	Residential (%)	p value	Cramer's V value
Unions Supported by Woreda	Yes, regular support	52.20%	77.10%	0.098	0.28
	Rarely	34.80%	20.00%		
	Never	13.00%	2.90%		
Logistics Support	Land	71.80%	72.70%	0.930	0.01
	Machinery	5.10%	3.00%	1.000	0.052
	Transport	17.90%	12.10%	0.493	0.081
	Facilitating linkage with recycling factories	48.70%	66.70%	0.125	0.181
	Monitoring/regulation	48.70%	57.60%	0.453	0.088
Incentives for woredas and formal unions (Sub city officers)	Yes	68.80%	60.00%	0.611	0.091
	No	31.30%	40.00%		
Incentives for formal unions (Woreda Officers)	Yes	28.20%	36.40%	0.459	0.087
	No	71.80%	63.60%		
Budget allocated for recycling	Yes	17.90%	21.20%	0.727	0.041
	No	82.10%	78.80%		

Table *4.21* shows that the majority of the unions (52.2% in commercial and 77.1% in residential) reported that they received regular support from the woreda such as monitoring. The statistic test

(Fisher's Exact p= 0.098; Cramer's V= 0.280) shows there is no significant difference in the two sub cities with weak association.

In both areas (71.8% in commercial and 72.7% in residential) most of the woreda officers reported land provision as logistics support. Minimal support reported in both sub cities (5.1% in commercial and 3% in residential) was providing machinery. Other form of support was reported at varying levels. None of the differences between the areas were statistically significant difference (all p>0.05). Cramer's V< 0.25 which shows there is weak association that indicate the logistic support is broadly similar in the two sub cities.

The sub city officers mentioned that the incentives are provided by coordinating with Addis Ababa Cleaning Management Agency. the Chi Square test Pearson X^2p result for providing incentive was p=0.611, which indicate that there is no statically significate difference between the two sub cities in incentive provision. The Cramer's V test result was 0.091, which indicate there is very weak association between the area type and incentive practices. This means both areas show similar tendencies in providing incentives.

Addis Ketema sub city officers highlighted the incentives include certificates, trophy, subsidies for formal unions engaged in recycling activities of compost, cardboard and paper. Kolfe Keranio officers mentioned similar incentives, but also include material support such as equipment (hammer, PPE), and performance-based payment, including 15% additional zoning payment for door-to-door collectors (MSEs) when their area is kept clean.

The Chi Square test X^2p=0.459, which greater than 0.05. This result indicates there is no statistically significant difference between the two areas. In addition, Cramer's V result was 0.087, suggesting very weak association. This shows that most woreda offices in both sub cities reported that there is no reward system for formal unions. Overall, this suggest a similar perception in both sub cities that there is no structured reward system being the dominant reality.

The Chi Square test X^2p=0.727, which greater than 0.05. This result indicates there is no statistically significant difference between the two sub cities. In addition, Cramer's V result was 0.041, suggesting very weak association. The findings show that majority of woreda officers in both sub cities reported there is no specific budget dedicated to recycling. This suggest that in both

sub cities the recycling activities are under general cleaning budget, which may limit the effectiveness of recycling activities.

4.9.Comparison of Material Flow and Income Generation

Table 4.22. Six Months Volume of Recyclable Material and Income Generated in Residential and Commercial Area in (2018 E.C)

Area Type	Woreda	PET (kg)	HDPE (kg)	Metal (kg)	Paper & Cardboard (kg)	Glass Bottle (kg)	Unions generated income (Birr)
Residential Area	W4	157,016.00	206,023.00	135,560.00	75,630.00	10,418.00	15,018,410.00
	W5	177,389.00	144,402.00	182,798.00	75,625.00	18,192.00	21,200,930.00
	W6	102,074.00	151,323.00	71,616.00	44,416.00	7,821.00	9,987,836.00
	W8	140,236.00	144,083.00	137,945.00	119,045.00	8,102.00	22,810,678.00
	W10	332,600.00	354,750.00	318,400.00	288,100.00	13,150.00	19,162,400.00
	Total	**909,315.00**	**1,000,581.00**	**846,319.00**	**602,816.00**	**57,683.00**	**88,180,254.00**
Commercial Area	W1	466,997.50	-	89,999.97	586,764.64	3,718.00	45,837,006.00
	W3	365,400.00	182,608.64	149,999.95	167,647.04	2,188.00	6,816,490.00
	W5	226,720.00	182,608.64	59,999.98	-	-	4,907,220.00
	W8	318,900.00	91,304.32	28,965.50	171,823.52	2,124.00	6,158,400.00
	W10	405,725.00	136,956.48	119,999.96	429,558.80	-	6,404,020.00
	Total	**1,783,742.50**	**593,478.08**	**448,965.36**	**1,355,794.00**	**8,030.00**	**70,123,136.00**

Source: Compiled by the author from Addis Ketema and Kolfe Keranio Sub City Cleaning Management Office Report (2018 E.C)

As shown in Table *4.22*, there is clear difference in the material volume between the areas. In the commercial areas there is higher volume of PET and Cardboard, where as in residential area there is higher volume of metal and glass bottle compared to commercial area. This discrepancy is likely because metal is predominantly collected by informal actors in commercial area and these figures

represents the volume collected by the formal unions. The total income in both areas indicate that the logistics system is a significant economic driver for the unions.

4.10. Analysis of Downstream Reverse Logistics Chain

In the data collection stage, the formal unions were asked to which factory or recycler they gave the materials they have collected so according to their response they don't have fixed place so these are the places they send: Kolfe Keranio, Addis Ketema, Addisu Gebeya, Holets, Adama, Bishoftu and others so to understand the final stage of revers logistics data is collected from 6 recyclers/ factories from mentioned places.

Table 4.23. Profile of recyclers

Recycler Id	Location	Experience	Primary Materials	Monthly Capacity (Tons)
AK-01	Addis Ketema	6	Plastic shoe	15
AK-02	Addis Ketema	4	Plastic shoe	5
AK-03	Addis Ketema	4	HDPE (Jerrycans, Cap)	7
AK-04	Addis Ketema	2	PET Plastic Bottle (Highland)	40
KK-01	Kolfe Keranio	10	HDPE (Jerrycans, Cap..), LDPE shrink wrap (to pack water bottle)	20
KK-02	Kolfe Keranio	18	HDPE (Jerrycans, Cap..), LDPE shrink wrap (to pack water bottle), PP Bag	50
GK-01	Gullele	4	PET Plastic Bottle (Highland), LDPE shrink wrap (to pack water bottle), HDPE (Jerrycans, Cap..)	260

According to the data collected from the recyclers the most problematic stage of the chain is the last mile transport which is from the union to the recycling center. The challenges include:

1, High Transport and Fuel Costs

Every recycler mentioned that high transport cost due to fuel price as primary bottleneck.

2, Lack of centralized Collection hubs

Most of the recyclers mentioned that the absence of the central collection hubs makes the collection challenging.

3, Supply Chain Consistency and Middlemen

The flow of materials is unpredictable and irregular this prevents planning production schedules and the use of their full capacity. For instance, unions reported that collection of plastic bottle increases during rainy season because flood carry bottles from drainage system into the river where informal collector collects them. On the other hand, cardboard supply decreases during rainy season because it becomes unusable when wet. Dependence on middlemen create inconsistent supply because unions and collectors don't deliver directly so the materials pass through brokers who controlled the flow.

Beyond seasonal fluctuations, recyclers also mentioned that security issues in the country affects the material flow from regional areas to recycling center.

Analysis of Recyclers Operations and Output

In the study area there is no single path, but multi-tiered system

✓ Circular Manufacturing

Case Example: Plastic Shoe Recyclers in Addis Ketema Sub city

Machineries used for recycling:

- Weighing Scale
- Crushing / Grinding Machine,
- Injection molding machine.

Process: used plastic shoe are collected from across Ethiopia and then transported to the recycling center then using the machines. The waste will be crushed and melted and shaped in to a new shoe sole which is then sold to other shoe manufactures.

This is circular with in the center which reduce the need for secondary transport of semi-finished goods.

Figure 4.25. Plastic Shoe Recycling

✓ Intermediate Processing (Value addition)

Machineries used for recycling:

- Weighing Scale
- Baling Machine / Compactor
- Washing Line
- Sorting Conveyor Belt
- Crushing / Grinding Machine

These recyclers do not produce final consumer product. Instead, they only wash and crush the materials in to small pieces. This process is crucial part they add value by cleaning and crushing but they require secondary transport to move the flakes to a pelletizing factory.

There are also some unions that manual washing and sorting they are performing value addition early in the chain.

Figure 4.26. Material washing and crushing process

✓ Specialized Pelletizing (Raw material Production)

Machineries used for recycling:

- Weighing Scale
- Pelletizer/ Recycling Machine

Process: These recyclers only focus on the raw material production

The study found that these facilities sometimes bypass the local union system and import the crushed materials from outside Ethiopia such as Djibouti, Kenya, and Yemen. This shows that the local supply is sometimes less efficient or consistence than importing form other countries.

Figure 4.27. Raw material production process

✓ All in One Industry Recovery

Machineries used for recycling:

- Weighing Scale
- Baling Machine / Compactor
- Washing Line
- Sorting Conveyor Belt
- Crushing / Grinding Machine
- Pelletizer/ Recycling Machine
- Extruder

Output: Finished goods such as tables, chairs, brooms, and other household items.

All interviewed recyclers confirmed that the recycled output is not used in food or drink packaging due to contamination risks.

Entreprenures

During the study visit there are entrepreneurs that works on the recycling at home one of the recyclers visited, fabricate local recycling machinery to produce brooms from PET bottles.

Figure 4.28. Recycling PET and produce broom

Figure 4.29. Creative recycling and reuse in Addis Ketema and Kolfe Keranio

Logistics Strategy

According to Zhang and Zhao (2008), pull supply chain is when the production is triggered by the consumers demand (storage capacity limit). In these consumers are taken as core so production is organized based on consumer demand. This is information led system.

From the data collected from the recyclers and unions the collected materials will be transported to the recycling center only when the formal or informal unions call and report the have full vehicle materials which is Reactive (Pull) Logistics Model.

As shown in Figure *4.30* The model is dependent on the unions collection and storage capacity rather than optimized transport schedule. This might create emergency transport. This result in trucks going empty to collected materials, materials overflowing and becoming contaminated while waiting for a pickup.

Several recyclers mentioned they are operating below 50% of their capacity. The under operating is directly result of the pull system since the recyclers cannot predict or plan their production schedule because the supply flow is inconsistent.

As mentioned before some recyclers import materials from other countries this shows that the current pull system is too slow or inconsistent.

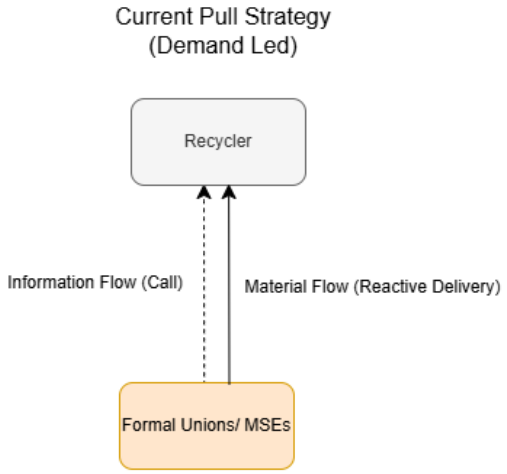

Figure 4.30. Current Pull strategy

4.11. Comparative Analysis and Synthesis

Overall, the results show that both areas (residential area and commercial area) have similarities but also differences in the reverse logistics system.

- Commercial areas are characterized by high number of informal collectors, shorter storage duration, innovative informal recycling practice, but there is also space constraint and congestion challenges.
- Residential areas show longer storage durations, fewer informal collectors, stronger institutional support, but weaker integration of informal actors.

Even if PET collected volume is higher in commercial areas, the statistical analysis shows no significant difference across the two area. However, the storage duration in commercial areas was shorter, due to higher number of informal collectors operating in the commercial area compared to residential area. Since the collected materials reaches the required volume and it sold quickly without storing them for long periods. On the other hand, in residential areas collected materials are stored for longer period due to fewer collectors and slower accumulation of required volumes. In both areas PET dominate material collection in addition to this in residential areas metal and glass were also major material collected compared to commercial areas. There are no value addition activities in the hubs only sorting was done and it is identified that household mixing is primary source of contamination. Both areas heavily relay on informal collectors. Therefore, the results shows that the revers logistics practices in Addis Ababa are heavily dependent on the informal collectors and also confirmed that the system is limited in value addition capacity.

The system operates through dual pathways: formal way under municipal and informal without it. There was also a difference in perception of informal collectors under the sub city. In residential areas the officers viewed them as unauthorized operators on the other hand in commercial areas most of them viewed then as essential partners. There is weak data on informal collectors and there are no formal linkages.

Space constraint is more issue in Addis Ketema which limit storage capacity, and many officers reported there is no plan to construct recovery center due to lack of available land in commercial areas and also unions frequently asked to relocate due to the constraint. Traffic congestion is also a significant challenge in this area, as vehicles could not park near by the hub to load the collected

materials day time, forcing unions to delay loading until night time. Capital constraint limited the ability of the unions to invest in value adding activities such as cleaning, bailing, or crushing. As a result, in both areas materials were manually compacted and transported without reaching full capacity of the vehicle, which increase the transport costs. Transport cost was reported as major challenge in both sub cities.

Figure 4.31. Manual compaction of plastic bottles into sacks

There is also moderate communication gap in both areas and waste management prioritization was also different in woreda and sub cities this misalignment in prioritization weakened the institutional collaboration and integrating informal actors.

In commercial areas integration of informal collectors is under discussion while in residential areas lean to there is no plan. Market linkages were facilitated but uneven. There are critical infrastructures needed such as recovery centers, transfer station upgrades, trucks, machineries and GIS for rout optimization. Structural and institutional gap were also observed. There is no central hub for coordination, there are brokers involve in the activity, and most of the factories are outside Addis Ababa. Current union formation rules requirements are Addis Ababa Ids and members of the unions which exclude many participants who migrate from outside the city. Consequently, they will form union and operate informally.

CHAPTER FOUR

5. CONCLUSION AND RECOMMENDATION

5.1.Conclusion

This study evaluated the efficiency of reverse logistics system in selected commercial and residential areas of Addis Ababa. The results showed that the performance of reverse logistics rely on the land use. Commercial areas achieved a recycling rate of 16.83%, while residential area reaches only 9.26%. Despite the growth of recycling rate in both areas majority of waste (83% to 90%) end up land fill.

The assessment of the current reverse logistics practice in both areas showed that the system relies on informal collectors, while unions mainly perform sorting at their hubs. In residential areas, the storage area is relatively lager. However, the material storage duration remains longer due to material scarcity, distance from the main road and minimum informal collectors. In commercial areas there is higher density of informal collectors so the storage duration is less but the storage area is smaller. In both areas the largest volume of waste collected and most profitable is PET.

Stakeholder analysis showed fragmented network of actors, involving MSEs, unions, licensed individual collectors, informal actors, and private companies, outsourced transport companies, AACMA, sub city and woreda officers. The formal system operates under the municipality oversight, whereas the informal actors remain outside of the regulation. In commercial areas there is larger informal networks which complicate the coordination but enhancing recovery. The informal sectors dominate high value recovery because they have higher purchase prices and lower overheads than formal unions, which creates logistics leakage by divert the materials from the formal to the informal actors. Institutional perceptions of informal collectors remain divided ranging from essential partners to unauthorized operators which reflects there is weak integration.

In commercial areas challenges are space shortages, traffic congestion, and reliance on temporary storage such as pedestrian walkways and basements, whereas in residential areas struggle with longer storage duration due to material scarcity, distance from the main road, and poor road condition which increase the contamination risk and reduce the efficiency. Across both areas, common challenges include the absence bailing technology due to lack of capital identified as

constraint which leads to high transportation cost and reduces fleet productivity because the vehicle reaches it volumetric capacity not its weight capacity, weak segregation at the source is still inefficient because there is still recovery network at the landfill. This leads to material contamination, and it increase the logistics cost, reliance on pull system, lack of storage space, unfair competition, fragmented communication with no reliable data on the informal actors. In addition, a critical challenge identified in the study is the absence of optimized route selection for waste collection. MSEs and also informal collectors currently select their own path without formal studies.

Material flow differs in the two areas, in commercial areas there is higher volume of PET and cardboard, whereas in residential areas there is more metal and glass than the commercial areas. the reverse logistics system is generating income for both formal and informal actors. This proves that logistics for waste management does not only protect the environment but also create job for many people in the city. And is economic driver as it generates 158,303,390.00 Birr across the study areas within 6 months in 2018 E.C.

Overall, the reverse logistics system in Addis Ababa succeeds in diverting recyclables and generating income but remain constrained by weak coordination, minimal value addition and reliance on informal recovery. In line with Complex Adaptive System Theory, outcomes emerge from the interaction between formal and informal actors rather than central control this shows that there are information gap and fragmented communication in both areas where there is no central data base or digital platform where waste volume is tracked. Studies (Kinobe et al. (2015) and Mbago et al. (2025)) identified the key drivers of RL and these align with this study finding, where the significant income generated by the unions confirm that economic value is the major motive for the actors, environmental concerns also driver since the system is implemented to make the city clean. However, the study also shows that there is gap in regulatory pressures such as integrating informal actors to the formal system and also there is lack of technology advancements. These missing drivers hinders the city's transition process to circular economy.

5.2.Recommendations

Based on the study findings to improve the reverse logistics system in Addis Ababa the following recommendations are proposed:

Operational Improvements:

- The current system should transit from Pull system to Push system. According to Zhang and Zhao (2008), push strategy is when the materials are delivered based on the supplier capacity. Since consumers' demand cannot be known or predicted. As shown in Figure *5.1*
- The transport vehicles for recyclable materials should operate with fixed schedule like the door-to-door collection based on forecasting the unions capacity instead of waiting for a trigger call.
- Assigning trucks to collect from multiple unions in one trip to optimize route and fuel cost.
- The city should stop using same approach. Specifically, in commercial centers such as Merkato, the waste collection system should be modernized so that the high frequence waste generated will be handled properly since the area is a major trade center.
- Route optimization must be prioritized for waste collection to reduce duplication and minimize costs.
- For the Transportation of recyclable materials in high density commercial areas such as Merkato, it is recommended to shift collection schedules to off peak hours and specific low traffic days such as late evening, early in the mornings or Sunday. This will improve the reverse logistics efficiency.

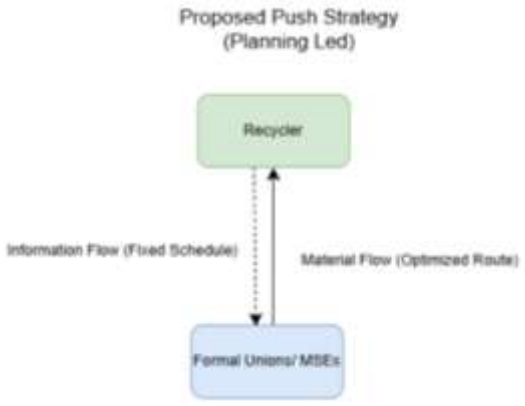

Figure 5.1. Proposed Push strategy

Infrastructure Requirement:

- Baling/ Compaction machine to ensure that the scheduled route maximizes the vehicle's weight capacity, not just its volume.
- To prevent overflow during factory downtime such as due to machine maintenance the proposed push system should include centralized collection hub that act as buffer to store the materials temporarily when the recycler is offline.
- The city must improve road maintenance.
- The selection of hub location be governed by a strict, criteria-based evaluation framework. Site selection must prioritize high transport accessibility, environmental safety, and distance from the source and recyclers to minimize the logistics costs.
- Frequent relocation of unions from one workspace to another should be avoided.
- Digital system should be integrated to bridge the information gap so that waste volume in real time can be tracked, allowing unions and recyclers communicate better and ensure that the supply of the material much the demand.
- The city should encourage recyclers to locate their factories nearby unions

Policy and Economic Support:

- The government should integrate the informal actors to the system to reduce logistics leakage.
- The government should facilitate loans and search for sponsors to support the unions purchasing value adding machineries.
- The use of plastics waste for road construction should be promoted.
- Work on market linkage

Environmental Awareness and Enforcement:

- Stronge enforcement is required on source segregation.
- Continuous awareness creation and training on value addition is required
- Working on the source, provide materials like machineries for recycling by searching sponsors, provide training

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Appendix A: Questionaries

Appendix A.1. For Sub City Officers

Questioneries for Sub-city Officers

Section 1: Basic Information

Unique Id

____

Sub-city ([illegible])

- ◯ Addis Ketema ([illegible])
- ◯ Kolfe Keranio ([illegible])

Respondent's Role

____

Respondent's Gender

- ◯ Male
- ◯ Female

GPS Point of the Sub-city Office

____

latitude (x.y °)

____

longitude (x.y °)

____

altitude (m)

____

accuracy (m)

____

tps://kf.kobotoolbox.org/#/forms/a9ka8ok3QuBJsv5gbFSCjQ/landing 1

Section 2

[illegible] (Which of the following best describes the Sub-city's current waste management priority?)

- ◯ Disposal/Dumping ([illegible])
- ◯ Recycling & Recovery ([illegible])
- ◯ Waste Minimization/Prevention ([illegible])
- ◯ Balanced Approach ([illegible])

[illegible] (Does the Sub-city provide specific incentives for Woredas or Mahbers that achieve high recovery rates?)

- ◯ Yes ([illegible])
- ◯ No ([illegible])

[illegible] (If Yes, please describe the incentives)

____

Section 3

[illegible] (Recovery Centers) [illegible] (Is there a Sub-city master plan to allocate land specifically for "Recovery Centers" within each Woreda?)

- ◯ Yes, active plan ([illegible])
- ◯ No, land is a major constraint ([illegible])

[illegible] (How does the Sub-city prioritize the distribution of heavy machinery (compactors, trucks) among Woredas?)

- ◯ Based on waste volume ([illegible])
- ◯ Based on Woreda request ([illegible])
- ◯ Even distribution ([illegible])
- ◯ No machinery provided ([illegible])

[illegible] (Transfer Stations) [illegible] (Are there plans to upgrade "Transfer Stations" into "Value Addition Centers" (with sorting and baling machines)?)

- ◯ Yes ([illegible])
- ◯ No ([illegible])

[illegible] (How many trucks are specifically allocated for recyclable transport across the Sub-city?)

[illegible] (Does the Sub-city use GIS or digital maps to optimize the collection routes for the trucks?)

- ◯ [illegible] (Yes)
- ◯ [illegible] (No)

[illegible] (Who is responsible for the fuel and maintenance of the Mahber-owned vehicles?)

- ◯ [illegible] (The Mahber)
- ◯ [illegible] (The Woreda)
- ◯ [illegible] (Shared Budget)

[illegible] (Does the use of mixed vehicles cause delays in collecting "Inorganic" (recyclable) bags?)

- ◯ [illegible] (Yes)
- ◯ [illegible] (No)

[illegible] (What percentage of waste collection vehicles in Woreda are owned by the Mahbers vs. the Woreda?)

[illegible] If "Yes" What do these standards focus on

- ☐ Segregation at source (using different bags/sacks) / [illegible]
- ☐ Color/Type sorting / [illegible]
- ☐ Baling/Compacting / [illegible]
- ☐ Cleaning/Washing / [illegible]
- ☐ Other / [illegible]

If your answer is "Other," please mention ([illegible])

[illegible] (Has the Sub-city provided any technical training on "Reverse Logistics" or "Value Chain Management" to Woreda staff?)

- ◯ [illegible] (Yes)
- ◯ [illegible] (No)

Section 5

[illegible] (How would you rate the coordination gap between the Sub-city and Woredas regarding recycling logistics?)

- ◯ Poor ([illegible])
- ◯ Fair / Moderate ([illegible])
- ◯ Good ([illegible])
- ◯ Excellent ([illegible])

[illegible] (Why is reverse logistics challenging in this area)

- ☐ Traffic/Congestion ([illegible])
- ☐ Lack of sorting space ([illegible])
- ☐ Low market price ([illegible])
- ☐ Distance to factories ([illegible])
- ☐ Lack of coordination ([illegible])
- ☐ Other

If your answer is "Other," please mention ([illegible])

[illegible] (Does the Sub-city penalize Mahbers if they fail to collect recyclables for more than a week?)

- ◯ [illegible] (Yes)
- ◯ [illegible] (No)

Section 4

[illegible] (How does the Sub-city's official policy categorize informal collectors (Korales)?)

- ◯ Essential partners ([illegible])
- ◯ Unauthorized ([illegible])
- ◯ Neutral/Ignore ([illegible])

[illegible] (Is there a sub-city directive to integrate/formalize these Korales into licensed Mahbers?)

- ◯ Yes, being implemented ([illegible])
- ◯ In discussion phase ([illegible])
- ◯ No plan ([illegible])

[illegible] (Are there standards set by the Sub-city to ensure recyclables don't lose value due to contamination?)

- ◯ Yes ([illegible])
- ◯ No ([illegible])

[illegible] (Does the Sub-city have a specific Reverse Logistics protocol or a separate "Drop-off Point" for hazardous waste (Batteries/Medicines))

- ◯ Yes, we have a specialized system ([illegible])
- ◯ No, it is currently managed within the general waste stream ([illegible])
- ◯ It is under development ([illegible])

Section 6

[illegible] (In your view, where is the most significant "Value Loss" in the recyclable waste supply chain?)

- ◯ Source (No sorting) / [illegible]
- ◯ Transport (High costs) / [illegible]
- ◯ Storage (No space) / [illegible]
- ◯ Market (Low prices from factories) / [illegible]
- ◯ Other ([illegible])

[illegible] (Does the Sub-city facilitate formal contracts/market linkages between Mahbers and large recycling factories?)

- ◯ Yes ([illegible])
- ◯ No ([illegible])
- ◯ In progress

If your answer is "Other," please mention ([illegible])

[illegible] (What is the one policy change you recommend to improve reverse logistics at the sub-city level?)

Appendix A.2. For Woreda Officers

Questions for the Woreda Officials

Section 1: Basic Information

(Unique ID Number)

____

(Sub-city)

- ( ) (Addis Ketema)
- ( ) (Kolfe Keranio)

(Woreda)

____

(Job Title/Role)

____

Gender of the respondant

- ( ) Male
- ( ) Female

(GPS)

latitude (x.y °)

longitude (x.y °)

altitude (m)

accuracy (m)

1

Section 2: Collection and Transport

(Who is primarily responsible for ensuring recyclable waste is collected and transported from the source (households/shops) to the Mahber hubs?)

- ( ) (Woreda)
- ( ) (Mahbers)
- ( ) (Informal Collectors (Koroles))
- ( ) (Shared Responsibility (Mixed))

(Is there a standardized schedule for how often waste should be collected?)

- ( ) (Yes (Fixed schedule))
- ( ) (No (Varies by collector))
- ( ) (Only for certain areas)

(What is the main barrier for efficient waste transport in this Woreda?)

- [ ] traffic congestion
- [ ] narrow roads
- [ ] slopes
- [ ] lack of trucks
- [ ] Other

(In your view, what is the main reason waste is often mixed when it reaches the sorting sites?)

- ( ) (Household mixing)
- ( ) (Collector mixing during transport)
- ( ) (No separate containers)

Section 3: Woreda support

(What is the Woreda's main role in the reverse logistics chain?

- ( ) (Operational /Collecting)
- ( ) (Regulatory/ Monitoring)
- ( ) (Financial Support)

(What kind of logistical support does the Woreda provide to the Mahbers?)

- [ ] land
- [ ] machinery
- [ ] transport
- [ ] Facilitating linkage with recycling factories
- [ ] Only monitoring/regulation
- [ ] none
- [ ] Other

If the answer is other please mention

____

(At what interval (frequency) does the Woreda collect data on the volume of waste collected and sold by the Mahber?)

- ( ) Daily
- ( ) Weekly
- ( ) Every two weeks
- ( ) Monthly
- ( ) Quarterly
- ( ) Irregularly / No schedule
- ( ) Other

(Does the Woreda help Mahbers find large recycling factories (buyers), or is it the Mahber's job?)

- ( ) (Yes)
- ( ) (No)

(Is there a reward system for Mahbers that recover the highest volume of plastic/metal?)

- ( ) (Yes)
- ( ) (No)

Section 4: Budget and Facilities

(Which of the following best describes the Woreda 's current waste management priority?

- ( ) Disposal/Dumping
- ( ) Recycling & Recovery
- ( ) Waste Minimization/Prevention
- ( ) Balanced Approach

(Does the Woreda have a specific budget dedicated to "Recycling" or "Resource Recovery" separate from "Cleaning"?)

- ( ) (Yes)
- ( ) (No)

(What is the most critical facility the Woreda needs to improve Reverse Logistics (Recycling)?)

- ( ) (More Land/Sites)
- ( ) (Baling Machinery)
- ( ) (Better Trucks)
- ( ) (Training)

(Is there a plan to build more 'Transfer Stations' or 'Recovery Centers' in this Woreda?)

- ( ) (Yes)
- ( ) (No)

Section 5: Informal collectors

(Does the Woreda have a record or estimate of how many informal collectors (Korales) operate in this area?)

- ( ) Yes recorded
- ( ) Estimate only
- ( ) No data

(Is there any formal system to link informal collectors with the Mahbers to improve waste flow?)

- ( ) (Yes, active link)
- ( ) (Informal Link)
- ( ) (No link)

ወረዳው የቆራሌዎችን ሚና በሪሳይክሊንግ የሚሆኑ ቆሻሻዎችን አሰባሰብ ሂደት ውስጥ እንዴት ያየዋል? (How does the Woreda view the role of informal collectors in the supply chain?)

- ◯ እንደ አስፈላጊ የሥራ አጋር እናያቸዋለን (As essential partner)
- ◯ ተግባራቸው በሚፈቀደው እንዲሰሩ ይፈቀድላቸዋል (Tolerated)
- ◯ እንደ ከተማ ውበት ስጋት ወይም እንደ ህገ-ወጥ እናያቸዋለን (Viewed as unauthorized operator)

መደበኛ ያልሆኑ ሰብሳቢዎች (ቆራሌዎች) መደበኛው ስርዓት ያልደረሰባቸውን ሰፈሮች ወይም የቆሻሻ አይነቶች ይሸፍናሉ ብለው ያምናሉ? (Do you believe informal collectors (Korales) cover neighborhoods or waste types that the official system misses?)

- ◯ አዎ (Yes)
- ◯ የለም (No)

መደበኛ ያልሆኑ ሰብሳቢዎችን (ቆራሌዎችን) ወደ ህጋዊ የቆሻሻ አያያዝ ስርዓት ለማስገባት ወይም ተሳታፊ ለማድረግ የታቀደ የወደፊት እቅድ ወይም ፖሊሲ አለ? (Is there any future plan or policy to formalize/integrate informal collectors (Korales) into the official waste management system?)

- ◯ አዎ፣ የታቀደ እና እየተተገበረ ያለ እቅድ አለ (Yes, there is an active plan)
- ◯ በውይይት ደረጃ ላይ ይገኛል (It is under discussion)
- ◯ በአሁኑ ሰዓት የታቀደ ነገር የለም (No plan at the moment)
- ◯ እንደ አማራጭ አልታየም (አይቻልም ተብሎ ይታሰባል) (Not considered)

Section 6: Gap & Recommendation

በወረዳው፣ በማህበራት እና በሪሳይክሊንግ ፋብሪካዎች መካከል ያለው የሥራ ቅንጅት ክፍተት (Coordination Gap) ምን ይመስላል? (How would you describe the coordination gap between the Woreda, the Mahbers, and the recycling factories?)

- ◯ ከፍተኛ ክፍተት -መደበኛ ግንኙነት የለም (High Gap-No regular communication)
- ◯ መካከለኛ ክፍተት- አልፎ አልፎ ቅንጅት አለ (Medium Gap-Occasional coordination)
- ◯ ዝቅተኛ ክፍተት - መደበኛ ቅንጅት አለ (Low Gap -Regular coordination)
- ◯ ከፋብሪካዎች ጋር ምንም አይነት ግንኙነት የለም (No link with factories at all)

ቆሻሻን ከመሰብሰብ ጀምሮ ፋብሪካ እስኪደርስ ባለው ሂደት (Supply Chain) ውስጥ ትልቁ ክፍተት የት ነው? (In the process from waste collection to reaching the factory (Supply Chain), what is the biggest gap?)

- ☐ ከምንጩ የሚሰበሰብበት መንገድ ደካማ መሆን (Collection gap)
- ☐ የመለያ ቦታ እና የማከማቻ መሳሪያዎች እጥረት (Sorting gap)
- ☐ ወደ ፋብሪካዎች ለማጓጓዝ ያለው ከፍተኛ ወጪና የመኪና እጥረት (Transportation gap))
- ☐ ከሪሳይክሊንግ ፋብሪካዎች ጋር ያለው የገበያ ትስስር ደካማ መሆን (Market gap)
- ☐ የመረጃ አያያዝ እና የክትትል ስርዓት አለመኖር (Lack of digital data and monitoring)
- ☐ ከመደበኛ ውጪ ሰብሳቢዎች (ቆራሌዎች) ጋር የሥራ ቅንጅትና ግንኙነት አለመኖር (Lack of communication & coordination with informal collectors)

ወረዳውን ከቆሻሻ የጸዳ ለማድረግ መስተካከል ያለበት ዋነኛው ፖሊሲ ምንድነው? (What is the single biggest policy change needed to make the Woreda a "Zero Waste" model?)

በዚህ ክፍለ ከተማ የቆሻሻ አሰባሰብና ትራንስፖርትን (Reverse Logistics) ለማሻሻል የእርስዎ አስተያየት ምንድነው? (What is your recommendation to improve the reverse logistics of waste in this specific sub-city?)

Appendix A.3. For MSEs and Formal Unions

Section 1: (Basic Information)

የማህበሩ ስም? (Name of the Mahber)

_____

ክፍለ ከተማ (Sub-city)

- ቀጨኔ መድኃኒዓለም (Kolfe Keranio)
- አዲስ ከተማ (Addis Ketema)

ወረዳ (Woreda)

_____

የመረጃ ሰጪነት ደረጃ? (The Respondent Role)

_____

የተጠያቂው ጾታ (Gender of the Respondent)

- ወንድ (Male)
- ሴት (Female)

ይህ ማህበር በቆሻሻ አሰባሰብ እና አያያዝ ዘርፍ ላይ ለስንት ጊዜ ሰርቷል? (How long has this Mahber been working in solid waste collection/management?)

_____

የመረጃ ሰጪነት ደረጃ? (The Respondent Role)

_____

የተጠያቂው ጾታ (Gender of the Respondent)

- ወንድ (Male)
- ሴት (Female)

ይህ ማህበር በቆሻሻ አሰባሰብ እና አያያዝ ዘርፍ ላይ ለስንት ጊዜ ሰርቷል? (How long has this Mahber been working in solid waste collection/management?)

_____

ትክክለኛ መገኛ (GPS)

_____

latitude (x.y °)

_____

longitude (x.y °)

_____

altitude (m)

_____

accuracy (m)

የማከማቻ ቦታው ፎቶ (Facility Photo)

Click here to upload file. (< 10MB)

በማህበሩ ውስጥ በአሁኑ ሰዓት ያሉ አባላት/ሰራተኞች ብዛት ስንት ነው? (Total number of formal members/employees?)

_____

በቋሚነት ቆሻሻ የሚያመላልሱ ኮራሌዎች ብዛት? (Number of regular Korales)

_____

የማህበሩ ዋና ቆሻሻ አሰባሰብ ዘዴ ምንድነው? (What is the primary collection method of this Mahber?)

- በየቤቱ በመሄድ (Door-to-Door)
- ከኮራሌዎች በመግዛት (Buying from Korales/Informal)
- ከንግድ ቤቶች እና ከተቋማት (Commercial and Institutions)
- ሌላ (Other)

If your answer is other, please mention

_____

ማህበሩ ባለቤትነቱን ቆሻሻ ወደ ሪሳይክለሮች ለማጓጓዝ የራሱ ተሽ ተሽከርካሪ አለው? (Does the Mahber own vehicles for transporting waste to the recyclers?)

- አዎ (Yes)
- የለም (No)

ማህበሩ ለቆሻሻ ማጓጓዣነት በአሁኑ ወቅት በሥራላይ ስንት የማህበሩ ተሽከርካሪዎች ይጠቀማል? (How many operational vehicles does the Mahber currently use for waste transport?)

_____

Section 2

Road Access (የመንገድ ሁኔታ)

- Accessible (ምቹ)
- Narrow/Crowded (ጠባብ/የተጨናነቀ)
- Very Difficult (በጣም አስቸጋሪ)

[illegible]? (Material Processing)

- [ ] Only Sorting ([illegible])
- [ ] Cleaning/Washing ([illegible])
- [ ] Crushing/Grinding ([illegible])
- [ ] Baling/Pressing ([illegible])
- [ ] Other

If your answer is other, please mention

[illegible]? (Is this hub located in a Market or Residential area?)

- ( ) Market/Commercial ([illegible])
- ( ) Residential ([illegible])
- ( ) Mixed ([illegible])

[illegible]? (Where does most of your waste come from in this location?)

- ( ) Households ([illegible])
- ( ) Korales/Informal ([illegible])
- ( ) [illegible] (Commercial)
- ( ) [illegible] (Institutions)

[illegible]? (How is the waste usually received from households during door-to-door collection?)

- ( ) [illegible] (Completely Mixed)
- ( ) [illegible] (Partially Sorted)
- ( ) [illegible] (Fully Sorted (Dry vs Wet))

[illegible]? (After collecting mixed waste, how much time does the Mahber spend sorting it into recyclables?)

- ( ) [illegible] (Less than 2 hours a day)
- ( ) [illegible] (Half a working day)
- ( ) [illegible] (Most of the working day)
- ( ) [illegible] (We don't sort; we dump it mixed at the landfill)

[illegible]? (Which materials do you collect at this hub?)

- [ ] [illegible] (Plastic Bottle) (Highland)
- [ ] [illegible] (Metal)
- [ ] [illegible] (Glass bottle)
- [ ] [illegible] (Paper)
- [ ] [illegible] (Cardboard)
- [ ] [illegible] (Jerrycans)
- [ ] [illegible] (PP Bag)
- [ ] [illegible] (Organic)
- [ ] [illegible] (Phones, computers, cables)
- [ ] [illegible] (Old clothes/Textiles)
- [ ] [illegible] (Hazardous: Batteries, chemicals, oils)
- [ ] [illegible] (Old furniture)
- [ ] [illegible] (Expired medicines)
- [ ] Other

If your answer is other, please mention

Section 3 (Operation & Quality)

[illegible]? (How often do you receive waste that is already clean and sorted?)

- ( ) always ([illegible])
- ( ) sometimes ([illegible])
- ( ) rarely ([illegible])
- ( ) never ([illegible])

[illegible] "[illegible]" [illegible]? (What are the most common "dirty" materials mixed with the recyclables?)

- [ ] food_waste ([illegible])
- [ ] Toilet waste (Diapers, Tissue) ([illegible])
- [ ] dust_dirt ([illegible])
- [ ] medical_waste ([illegible])
- [ ] Chemicals (Oil, Paint, Detergents) ([illegible])
- [ ] Other

[illegible]? (Does receiving mixed waste increase your daily operational costs?)

- ( ) [illegible] (Yes significantly)
- ( ) [illegible] (Yes slightly)
- ( ) [illegible] (No)

[illegible]? (What is your biggest physical barrier to sorting more waste?)

- ( ) Waste arriving mixed/combined ([illegible])
- ( ) Lack of sorting space ([illegible])
- ( ) No water for cleaning ([illegible])
- ( ) Distance from source ([illegible])

[illegible] (%) [illegible]? (Roughly what percentage (%) of your recyclable materials is supplied by informal collectors (Korales)?)

Section 4: Infrastructure and Machinery

[illegible] (Do you have a baling/pressing machine to reduce transport volume?)

- ○ [illegible] (Yes)
- ○ [illegible] (No, too expensive)
- ○ [illegible] (No, no electricity)

Section 5: The out put

[illegible] (Which material brings the most money for the Mahber?)

- ○ [illegible] (Plastic Bottle) (Highland)
- ○ [illegible] (Metal)
- ○ [illegible] (Glass bottle)
- ○ [illegible] (Paper)
- ○ [illegible] (Cardboard)
- ○ [illegible] (Jerrycans)
- ○ [illegible] (PP Bag)
- ○ [illegible] (Phones, computers, cables)
- ○ [illegible] (Hazardous: Batteries, chemicals, oils)
- ○ [illegible] (Old clothes/Textiles)
- ○ [illegible](Organic)
- ○ [illegible] (Old furniture)
- ○ [illegible] (Expired medicines)
- ○ Other

If the answer is other, please mention

[illegible] (PET) [illegible]? (Daily collected PET Volume (kg))

1 ኪሎ ወረቀት ስንት ይገዛሉ? (Buying Price)

____

ከአንድ ኮራሌ 1 ኪሎ ፕላስቲክ ስንት ይገዛሉ? (Buying Price (from Korale))

____

ለፋብሪካ 1 ኪሎ ፕላስቲክ ስንት ይሸጣሉ? (Selling Price (to Factory))

____

ከአንድ ኮራሌ 1 ኪሎ ጀሪካን ስንት ይገዛሉ? (Buying Price (from Korale))

____

1 ኪሎ ጀሪካን ስንት ይሸጣሉ? (Selling Price (to Factory))

____

1 ኪሎ ወረቀት ስንት ይሸጣሉ? (Selling Price (to Factory))

____

1 ኪሎ ካርቶን ስንት ይገዛሉ? (Buying Price)

____

1 ኪሎ ካርቶን ስንት ይሸጣሉ? (Selling Price (to Factory))

____

1 ኪሎ ብረት ስንት ይገዛሉ? (Buying Price)

____

1 ኪሎ ብረት ስንት ይሸጣሉ? (Selling Price (to Factory))

____

1 ኪሎ ጠርሙስ ስንት ይገዛሉ? (Buying Price)

____

1 ኪሎ ጠርሙስ ስንት ይሸጣሉ? (Selling Price (to Factory))

[illegible] (Storage Duration)

- ○ < 3 Days
- ○ 4-7 Days
- ○ 1-2 Weeks
- ○ > 2 Weeks

How stable is the price of these materials? [illegible]

- ○ stable [illegible]
- ○ changes weekly [illegible]
- ○ unpredictable [illegible]

Section 6

[illegible] (Transportation to Factory)

- ○ Our own truck [illegible]
- ○ Rented truck [illegible]
- ○ Buyer's truck [illegible]
- ○ Carts/Other [illegible]

[illegible] (How do you communicate with the factory to arrange a pickup?)

- ○ Personal Phone Call [illegible]
- ○ In-person visit [illegible]
- ○ Through a Middleman/Broker [illegible]
- ○ The Factory has a regular schedule [illegible]
- ○ Other [illegible]

If the answer is other, please mention

[illegible] (Does the delay in transportation cause the materials to get damaged or rejected by buyers?)

- ○ Frequently [illegible]
- ○ Sometimes [illegible]
- ○ Never [illegible]

[illegible] (Is there a minimum volume (weight or quantity) you must reach before the Factory agrees to transport the materials?)

- ○ Yes, we must wait until we have a full truckload [illegible]
- ○ Yes, we must reach a specific weight (e.g., 500kg) [illegible]
- ○ No, they collect whatever amount we have [illegible]
- ○ No, we are the ones who transport it ourselves regardless of amount [illegible]

[illegible] (How far is the nearest recycling factory from this hub? (km))

የሰበሰቧቸውን ለፋብሪካዎች ለመሸጥ ትልቁ ፈተና ምንድነው? (What is the biggest challenge when selling collected materials?)

- [ ] transport cost (የትራንስፖርት ዋጋ መጠይድ)
- [ ] low price (ዝቅተኛ የመግዣ ዋጋ)
- [ ] poor quality (የቆሻሻው ጥራት ዝቅተኛ መሆን/መቀላቀል)
- [ ] long distance (ከፋብሪካዎች መራቅ)

ለማህበሩ ዋነኛው የገንዘብ ችግር ምንድነው? (What is the main financial problem for this Mahber?)

- [ ] የመጓጓዣ/የነዳጅ ውዱ (High transport cost)
- [ ] የከፍያ መዘግየት (Delayed payment)
- [ ] የቦታ ኪራይ (High rent)
- [ ] ዝቅተኛ መሸጫ ዋጋ (Low selling prices)
- [ ] የሥራ ማስኬጃ ካፒታል እጥረት (lack of capital)
- [ ] Other

If the Answer is 'Other' Please mention

ከቆሻሻ አሰባሰብ እስከ ሽያጭ ባለው ሂደት ውስጥ ዋነው የትራንስፖርት/የሎጅስቲክስ ችግር ምንድነው? (What is the biggest challenge in the "Reverse Logistics" process (from collection to selling)?)

- [ ] High Fuel/Transport Costs (የነዳጅ/የትራንስፖርት ዋጋ መጠይድ)
- [ ] Lack of storage space (የመጋዘን እጥረት)
- [ ] Traffic congestion in the city (የትራፊክ መጨናነቅ)
- [ ] Delayed payment from factories (ከፋብሪካዎች ከፍያ መዘግየት)
- [ ] Poor quality/mixed waste (ቆሻሻው ያልተዘፃ/የተደበለ መሆኑ)
- [ ] Other (ሌላ)

If the Answer is 'Other' Please mention

ከወረዳው ማንኛውም አይነት ድጋፍ ያገኛሉ? (Do you receive any support from the Woreda?)

- ( ) አዎ - በመደር (Yes, regular support)
- ( ) አልፎ አልፎ (Rarely)
- ( ) በጭራሽ (Never)

ሰራተኞቹ በቂ የደህንነት መጠበቂያዎች (ጓንት፣ ማስክ፣ ቦት ጫማ) አሏቸው? (Do workers have enough safety gear (Gloves, Masks, Boots)?)

- ( ) አዎ - ሙሉ (Yes, all)
- ( ) በከፊል (Partially)
- ( ) የለም (No)