



**ASSESMENT OF CURRENT SOLID WASTE LOGISTICS SYSTEM RELATED
TO SOLD WASTE MANAGEMENT: THE CASE OF KIRKOS SUBCITY,
ADDIS ABABA**

BY: TAMIRU ADMASSU

ADVISOR: SHEFERAW MITIKU(PhD)

**A THESIS IN PARTIAL FULFILMENT OF THEREQUIRMENT OF THE MASTERS OF
ARTS INLOGISTICS AND SUPPLYCHAIN MANAGEMENT**

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TAMIRU ADMASSU

ADVISOR: SHEFERAW MITIKU (PhD)

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List of Acronyms/Abbreviations

A. A. _____ Addis Ababa City

CSA _____ Central Statistics Agency

DC _____ Distribution Center

ENDA _____ Environmental Development Action

MSEs _____ Micro and Small Enterprises

MSW _____ Municipal Solid Waste

NGOs _____ Non Governmental Organizations

RL _____ Reverse Logistics

SWL _____ Solid Waste Logistics

SWM _____ Solid Waste management

SCM _____ Supply Chain Management

UNEP _____ United Nations Environment Program

UNDP _____ United Nations Development Program

STATEMENT OF DECLARATION

I, the undersigned, declare that this research work, titled **Assessment of the Current Solid Waste Logistics System Related to Solid Waste Management: The case of Kirkos sub city, Addis Ababa**, is my original work, and has not been presented for the award of Degree or Diploma Program in this or any other institution. All sources of materials used for the project have been duly acknowledged.

Declared by:

Name: Tamiru Admassu

Confirmed by Advisor:

Name: Dr. Shiferaw Mitiku

Signature _____ Signature _____

Date _____ Date _____

June, 2017
Addis Ababa University School of Commerce

APPROVAL

This is to certify that this thesis has been submitted in partial fulfillment of the requirements for the award of master in Logistics and Supply Chain Management with my approval as Advisor and Examiner.

Approved by Examining Board

.....
Advisor: Shiferaw Mitiku (PhD) Signature Date

.....
External Examiner Signature Date

.....
Internal Examiner Signature Date

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Abstract

Solid waste, which is a consequence of day-to-day activity of human kind, needs to be managed properly. Addis Ababa City, like other cities in developing countries, faces problems associated with poorly managed solid waste operation & logistics. This study concerns about assessment of the city's current municipal solid waste management & logistics system problems. The survey was conducted in Kirkos sub city in Addis Ababa. Different sampling methods were employed to select the study units including: Random sampling, observation and purposive sampling. Both qualitative & quantitative data were collected, it was information collected through survey and secondary sources also used. The study discovered that there is low performance of SWM in the sub city mainly due to: lack of properly designed collection system and time schedule, inadequate and malfunctioning operation equipment, throwing of refuse to the nearby rivers, poor condition of the final dumpsite, absence of recycling, absence of waste recovery, practice of energy option, waste separation and composting are among the management challenges facing the sub city. Finally, the study forwarded some important recommendations towards improving the waste management practices.

Keywords: Logistics, Municipal solid waste, Solid Waste Management, Disposal System, Optimization, Sub city

Chapter One:INTRODUCTION

1. Background of the Study

Logistics deals with the planning and controlling of material flows and related information in organization both in the public and private sectors. Broadly speaking, its mission is to get the right material to the right place at the right time while optimizing a given performance measures e.g. minimizing a total operating cost and satisfying a set of constraints (e.g. Budget constraints).Logistics problems can arise in firms and public organizations producing services. This is the case of garbage collection, mail delivery, public utilities, and after sales services.

A logistics system is made up of a set of facilitieslinked by transportation services facilities are sites wherematerials are processed e.g.manufacturing and assembly centers,warehouses, Distribution centers (DCs),transshipment points, transportation terminals, retail outlets ,mail sorting centers, dump sites,garbage Incinerators, composting and recycling centers, transfer stations and etc.,(GianpaoloGhiani,GilbertLaporte,Roberto Musmanno,2004) .

The ever-increasing world population has increased resource consumption thathas manifested itself in increased waste generation, placing excessive pressure on cities' municipal authorities to provide the services efficiently andeffectively. This isdue to the lack of resources and organization and the complexity of the systems. Most municipalauthorities are unable to provide efficient waste collection. As a result, unsatisfactorymanagement means public complaints are the order of the day.

Addis Ababa city started its solid waste management some four decades back. The Service cannot meet changing demands. The social waste collection service is unsatisfactory, and scenes of scattered waste are common in most part of the city (UNDP, 2004). As a result, the population has the opinion that the municipal solid waste collection service is not functioning properly.

Some of the constraints that make the service unsatisfactory in SWM in KirkosSub city are inter-related. e.g. insufficient cost recovery leadsto a lack of finance and therefore a lack of funds for training, to pay attractive staff salary and to upgrade SWM technologies. However, not all issues of concern of SWM are related to lack offunds or lack of equipment.

In Addis Ababa, Kirkossub cityonly about three to fourth of the waste generated is collected and transported to the landfill. The rest is left on vacant plots, along streets, in drainage channels, inopen sewer lines. Therefore the researcher believes that in order to alleviate the problems

related with solid waste management which is observed in Addis Ababa City: Solid Waste management & Logistics system has a major solution.

Transportation services plays a vital role in moving waste materials between facilities using vehicles and equipments such as trucks, tractors, trailers, crews, pallets, containers, cars and trains. The Kirkos Sub city has 7(seven) trucks that are directed to collect waste in the city. The vehicle fleet used consists of vehicles with different loading capacity and the private sector also involve in collection and transport of waste that mainly produced by institutions and most of them use old vehicles previously used by industrialized nations.

The MSW that is generated daily in Kirkos sub city has to be managed in a sustainable manner. An integrated and efficient solid waste management and logistics system can enable the Sub city to enhance the service quality and expand the coverage of the service. As far as the problems exist and the condition gets worse, it is important that research is done in this area.

In Ethiopia, some Researches were conducted in the area of Solid Waste management and none of these researches are directly related with Solid Waste Logistics System. Therefore, the aims of this study is to assess the current solid waste logistics System particularly the issues related with Solid Waste Management and Logistics system : Waste generation and Composition, Collection, Sorting, storage, Composting, Recycling, incineration and Disposal processes. And Waste transport system, Solid waste facilities and Equipments and Solid Waste management integration in Addis Ababa Kirkos Sub city.

2. Statement of the problem.

Inadequate municipal and industrial dry waste collection and disposal creates a range of environmental problems in Addis Ababa. A considerable amount of waste ends up in open dumps or drainage systems. The present SWM system in Addis Ababa, with limited participation of private sector, relies entirely on municipality which is expected to provide the full range of waste collection and disposal. It is proving to be an impossible task, and the services are found to be inadequate. About 25% of the waste generated in Addis Ababa remained uncollected and made the city environment aesthetically unpleasant. (The sub city sanitation office, 2017)

According to a study report by ARRETELIA (2013) there are a number of constraints related to policies, proclamations, regulations, institutions and co-operatives and co-ordination between stakeholders that cause operational and management inefficiencies in Addis Ababa including

Kirkos Sub city. These barriers ultimately lead to limited waste collection coverage and practices like uncontrolled dumping.

There is lack of reliable and recent data on waste generation and composition, etc. There are unclear objectives of SWM i.e. what the ultimate aims of SWM in the city are just to get rid of waste or maximize reduction, reuse and recycling and recovering.

The municipalities are not open about their policies on SWM. Complaint mechanisms are unclear. What is mentioned for the enforcement of regulation and fines not clearly known by residents, etc.

The collection process efficiency is hindered by insufficient capacity of containers, so that waste overflows from them, absence of lids on containers, high loading heights which lead to impractical waste loading, lack of tools and protective gear for waste-pickers, lack of preventive maintenance and therefore long out-of-service periods of vehicles/trucks, use of old containers, lack of platform (space of the waste-pickers), low frequency of waste collection by drivers.

Shortage of finance is probably the most frequent mentioned obstacles for efficient and effective SWM. Lack of funds is directly related to a lack of cost recovery. If users fees do not cover any significant part of the expenditure on SWM and the municipalities are expected to fill the gaps all the time, it is hard to imagine how there will ever be sufficient funds. Lack of funds just means that there is a large activity, but resources (financial, human, institutional, technical, and material) are limited. Proper use of these resources is the real root of the problem.

The private SWM sector often lacks capacity and experience to operate and manage SWM services at an adequate level. As said, this is due to the fact that SWM is a new field in the country. This is true, because educational and vocational training centers or systems are not developed or established to prepare them for managing a similar business in many cases.

Many heads of the institutions do not give the necessary attention to SWM activities. For example employees without the necessary qualifications and experiences are assigned in the section. In addition, whenever staffs are disobedient, they are placed at Cleansing Offices. Cleansing Administration office heads do not participate in SWM planning. They do not prepare their own budgets, etc.

Some of the aforementioned constraints to progress in SWM are inter-related. e.g insufficient cost recovery leads to a lack of finance and therefore a lack of funds for training, to pay attractive staff salary and to upgrade SWM technologies. However, not all issues of concern of SWM are

related to lack of funds or lack of equipment. Also there is no any system of using economies of scale (i.e. the decline of average cost as scale increases) in refuse transportation and disposal.

Because of the above mentioned factors SWM in A.A Kirkos sub city is at low service coverage of collection, limited reuse/recycling, high operational cost, poor quality of services, very low customer satisfaction, lack of environmentally sound, ineffective & inefficient system so that the Solid Waste logistics practice is not integrated, the service quality is poor and costly.

3. Research Questions.

The following research questions have already been answered by the study:

- How is Solid Waste Management operation (Waste generation, collection, sorting, storage, composting, Recycling, incineration and disposal) being conducted at Kirkos Sub city, Addis Ababa?
- How is the Solid waste transport System in the sub city?
- How are the solid waste logistics facilities and Equipments in use in Kirkos sub city?

4. Objective of the Research.

4.1. General objective.

The main objective of the study was to assess the existing Solid waste logistics management system with related to solid waste management including collection, sorting, composting, recycling, incineration, disposal and transportation to reduce the impact of waste on health and the environment and develop an improved system in Addis Ababa Kirkos Sub city Administration.

4.2. Specific objectives.

- To assess Solid Waste Management process including Waste generation, collection, sorting, storage, composting, Recycling, incineration (Waste to Energy) and disposal processes in the sub city.
- To analyze Solid waste transport System and the problems related with the current solid waste transport system in the sub city.
- To assess the Existence of the necessary (appropriate) solid waste logistics facilities and Equipments and their utilization.

5. Significance of the study.

Solid Waste logistics System is one of the challenge facing cities of developing countries, including Addis Ababa. Therefore, assessing the problem and identifying the solution will help to provide information to policy makers to enable them to come up with appropriate policies formulation regarding how to enhance solid waste logistics management service quality, cost optimization and service coverage. It broadens the understanding of Solid waste logistics management and will aid policy makers .Finally, the study can be used as reference for further research conducting on these topic and related issues.

6. Scope of the study.

The scope of the research is bound to conducting an assessment on current waste logistics system of Addis Ababa, Kirkos Sub City. The study covers the assessment of waste collection, sorting, composting, storage, composting, recyclingincineration,disposal practice and transportation system, transferring use of solid waste facilities in the sub city based on Solid Waste management and Solid waste logisticssystem. The study has not been covered the logistics management of other types of wastes (liquid and gaseous) and also in the studythe role of the participation of the community has not been considered. Simple random, purposive and observation is used other than others research methods.

7. Limitationof the study

Like any other research, this study encountered the following limitations and constraint. Some of these are

- Limited or few literature and research on solid waste Logistics System in Ethiopian context for reference andlimited availability and access to documents related to solid waste Logistics System
- Time constraint of some interviewees and survey respondents due to busy office works.
- The overall time constraint of the research program.

8. Meanings of Key terms

- **Logistics:** The term logistics is used interchangeably to mean supply chain management (SCM). It refers to the strategic management of the overall supply chain including procurement, manufacture, distribution and waste disposal Logistics involves planning, creating and monitoring flows of goods and information. All the definitions encompass processes of moving and handling goods and materials, from the beginning to the end of

the production, the sales process and waste disposal, with an emphasis on satisfying customers and enhancing business competitiveness.((Waters, 2010).

- **Optimization:** It is one aspect in waste management that has been left out. Its main objective is to minimize travel distances and reduce the fleet size used. Optimized routes can be achieved using new technologies such as GIS, a tool that is able to display and manipulate both geographic and spatial information. Optimization of waste collection with an increase in truck capacity reduced the distance and travel time to dispose of the waste (Joel Robert Kinobe, 2015)
- **Reverse Logistics :**The Council of Logistics Management (CLM) defines RL as the “term often used to refer to the role of logistics in recycling, waste disposal, and management of hazardous materials; a broader perspective includes a relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials, and disposal”(G. Don Taylo, 2009)
- **Municipal solid waste-** refers to solid wastes from houses, streets and public places, shops and offices which are very often the responsibility of municipal or other governmental authorities.(Ministry of Urban and Construction Development :Urban Planning, Sanitation and Beautification Bureau,2012)
- **Solid waste management** may be defined as the discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations, and that is also responsive to public attitudes.
(Ministry of Urban and Construction Development: Urban Planning, Sanitation and Beautification Bureau, 2012)
- **Sub City:** The second level in administrative hierarchy in Addis Ababa.

9. Organization of the Research.

This study has been organized in to five chapters. The first chapter presents the introduction. The Second chapter shows the literature review while the third chapter contains brief description of the research design. The fourth chapter presents and analyzes the results. Finally, chapter five will present the conclusions and recommendation of the study respectively.

Chapter Two

Review of Related Literature

1. Introduction

Logistics is a word that seems to be little understood, if at all, by nearly anyone not directly associated with this professional and very important discipline. Many, when hearing someone say they work in the logistics field, associate it with some quantitative, technological, or mathematical practice. Some even confuse logistics with the study of language (i.e., linguistics). The fact is, logistics is a very old discipline that has been, currently is, and always will be, critical to our everyday lives. The origin of the term logistics comes from the French word “logistique,” which is derived from “loger” meaning quarters (as in quartering troops). It entered the English language in the nineteenth century.

The practice of logistics in the military sector has been in existence for as long as there have been organized armed forces and the term describes a very old practice: the supply, movement, and maintenance of an armed force both in peacetime and in battle conditions.

The practice of logistics in the business sector, starting in the latter half of the twentieth century, has been increasingly recognized as a critical discipline. The first professional association of logisticians was formed in 1963, when a group of practitioners and academicians formed the National Council of Physical Distribution Management, which in 1985 became the Council of Logistics Management, and then in 2004 the Council of Supply Chain Management Professionals (“The Council”). Today, this organization has thousands of members around the world.

The Council, early on, recognized that there was confusion in the industry regarding the meaning of the term logistics. Over the years, they have provided, and adjusted to changing needs, a definition of logistics that is the most widely accepted definition worldwide. Just as important, they recognized that the relationship between logistics and supply chain management was not clearly understood by those who used these terms often interchangeably. The Council struggled with the development of a broader definition of logistics and its relationship to supply chain management that would be widely accepted by practitioners around the world. In 2003, the Council published the following definitions, and boundaries and relationships for logistics management:

Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and

related information between the point of origin and the point of consumption in order to meet customers' requirements. (G. Don Taylo,2009)

Logistics deals with the planning and control of material flows and related information in organizations, both in public and private sectors. Broadly speaking, its mission is to get the right material to the right place at the right time while optimizing a given performance measure (e.g. minimizing total operating costs and satisfying a given set of constraints (e.g. budgetconstraints) The term logistics is used interchangeably to mean supply chain management (SCM). It refers to the strategic management of the overall supply chain including procurement, manufacture, distribution and waste disposal (Waters, 2010).Logistics involves planning, creating and monitoring flows of goods and information. All the definitions encompass processes of moving and handling goods and materials, from the beginning to the end of the production, the sales process and waste disposal, with an emphasis on satisfying customers and enhancing business competitiveness.

2. Theory of the concept of solid Waste management and Solid Waste Logistics System

Waste management is the collection, transportation, processing, recycling or disposal, and monitoring of waste materials. The term usually relates to materials produced by human activity, and is generally undertaken to reduce their effects on health, the environment or aesthetics. "Waste handling is one of the greatest challenges facing humankind in modern times in spite of the numerous technological advancements that has been experienced in recent time. Waste management is the collection, storage, transportation, processing, recycling or disposal, and monitoring of waste materials.

Waste generally involves solid, liquid, gaseous or radioactive substances, with different methods and fields of expertise for handling each. The growing importance of environmentalism is suggested to have two major impacts on logistics management: 1) a broadening of the scope of logistics, and 2) an influence on the way logistics managers do their jobs. With respect to broadening the scope of logistics, the logistics discipline has generally focused on transportation, warehousing, inventory management, and so on, from the perspective of forward distribution, i.e., producer-to-consumer movement of products. Because of environmentalism, the concept of "reverse" distribution, that is, consumer-to-producer movements, has become more prevalent. In fact, the Council of Logistics Management recently sponsored a research project focusing on

"reverse logistics", which is defined as "all issues relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials, and disposal." As pointed out above, environmentalism will have a tremendous influence on the way that logistics managers do their jobs. For example, concerns about solid waste disposal have caused firms to develop more efficient packaging and to recycle.

A reverse supply chain is the network of activities involved in the reuse, recycling, and final disposal of products and their associated components and materials. William noted that on the economic point of view, reverse logistics leads to employment and revenues to the people engaged in the activities while socially it widens the technology industry evidenced from the sectors which are interested in the E-waste recycling

Reverse logistics differs from waste management in that it focuses on the addition of value to a product to be recovered and then the outcomes do enter a new supply chain while waste management involves mainly the collection and treatment of the waste products that have got no new use (M.P. De Brito , R. Dekker, 2002.)

Reverse logistics is a process in which a manufacturer systematically accepts previously shipped products or parts from the point for consumption for possible recycling, remanufacturing, or disposal. A reverse-logistics system incorporates a supply chain that has been redesigned to manage the flow of products or parts destined for remanufacturing, recycling, or disposal and to use resources effectively. Reverse logistics has received a great deal of attention from operations managers and company executives.

Waste management is about efficiently collecting and processing waste (products for which there are no new use). RL is concerned with products that have some value to be recovered as a new one (D.S. Rogers, R.S. Tibben-Lembke, 1999).

The main reverse logistic processes are (1) collection; (2) inspection, selection, and sorting; (3) reprocessing (including repair, refurbishing, remanufacturing, retrieval, recycling, and incineration) or direct recovery; and (4) redistribution.

Following are brief discussion of each functional elements of SWM and reverse Logistics processes: Waste Generation and Composition, Collection, Sorting, Storage, Recycling and Reuse, incineration, Composting and Disposal

2.1. Waste Generation and Composition

The ever increasing world population has increased demand of raw materials globally hence increasing on the waste that is being produced. The major common waste generation streams worldwide are from households, offices, shops, markets, restaurants, public institutions, industrial installations, water works and sewage facilities, construction sites, and agricultural activities. Throughout the developing world, biodegradable waste is the highest because it is unprocessed, contains high moisture content, high organic matter content and is characteristic of heterogeneity that further obstructs source separation.

2.2. Collection

Methods of Solid Waste Collection

Waste collection service is one of the chief components of municipal solid waste management. The four methods of solid waste collection are stated in the following way.

A) Communal collection

Under the communal collection system, householders discharge their wastes at predetermined locations having some form of communal storage facility, and refuse collection vehicles collect the wastes at frequent intervals. The frequency with which communal storage facilities should be distributed is often dependent on the extent to which a community is willing to cooperate in its proper use. Accordingly, the containers should be spaced so that the distance between any two containers does not exceed 200 meters. In some studies, the recommended distance between two communal containers set is about 150 meters.

B) Block collection

Under block collection system, a collection vehicle travels a predetermined route at intervals that suit the capacity and schedules of the municipality, usually every two to three days, and stops at selected locations. Consequently, the householders bring their refuse containers upon hearing the bell, and hand them over to the sanitation crew.

C) Curbside (entrance) collection

Under this system, the crew collects containers of refuse which are deposited at the curbside at fixed intervals, usually on two specific days in the week. In effect, this system requires a very regular and well organized collection service, so that householders know when to leave out their wastes. Curbside collection could be mainly applicable in high-income areas of the developing world as it incurs a relatively high collection cost.

D) Door-to-door collection

In door-to-door collection system, the collection crew enters each premise, takes out the container and sets it back after emptying the waste into collection vehicles. The lack of householder involvement in the collection process is, however, offset by increased labor costs in entering all premises. The door-to-door collection method only proves productive when collection is infrequent, typically once a week.

2.3. Sorting

Sorting is an essential component of solid waste management. It is a kind of activity which is separating different types of wastes in their respective nature. It makes waste management easy and simple. However, it should not be a one-time activity, rather should be a habit for proper and sustainable solid waste management.

Waste can be separated at the household level: into organic and inorganic only. Inorganic wastes like cans are usually sorted for sale. In few households, organic wastes like plant origin are sorted for the purpose of reusing in their gardens and as fuel after the waste gets dried.

2.4. Storage

The major waste storage practices are mixed waste segregated waste, and the latter is more pronounced in the developed world while the former is seen in the developing world. Storage of waste before collection by municipal authorities for proper disposal has attracted importance as a policy problem. In many countries especially the developed world, legislation and policy schemes target not only the household waste but also focus on an economy-wide effort to minimize waste.

2.5. Recycling & Reuse

Recycling, which is the process of collecting used products, disassembling them (when necessary), separating them into categories of like materials (e.g., specific plastic types, steel, glass, paper, etc.), and processing them into recycled products, components, or materials. In addition to reuse, recycling is also an obvious treatment of solid waste problem. It is an important way of collecting solid waste materials and turning them in to useful products. Such materials can be reprocessed in two ways: primary and secondary. "Primary recycling is a process in which original waste material is made back into the same material for example, newspapers recycled to make newsprint. In secondary recycling, waste materials are made into

different products that may or may not be recyclable for instance, cardboard from waste to newspapers”.

Reuse determines whether products still have enough quality and are in good enough condition that they can be used again. Examples are reusable bottles, containers, and most rented facilities. In reprocessing, a used product is converted into a usable product. This can happen at different levels: material (recycling), component (remanufacturing), product (repair), selective part (retrieval), module (refurbishing), and energy (incineration).

Recycling is both environmental and economical issue. Many people's are motivated to recycle because of environmental concern i.e. it reduces pollution, it also save energy, space and resources, helps to protect biodiversity and reduce litter. Economically, it can save money for items like paper, metals and some plastics.

Increasing interest in product recovery and recycling is gaining attention due to the declining landfill capacities and rising real costs of disposal. A waste management system that contains a lot of recyclable materials requires more transport due to the separated waste stream that is avoided. This is not economically viable and environmentally friendly.

Reuse also involves cleaning and using materials over and over. In other words, it means the use of a product more than once in its original form for the same or a new purpose. It relays on items that can be used over and over instead of throw away items. This method is used to decrease the use of matter and energy resources, cuts pollution, creates local jobs, and saves money. “Reusing is more efficient and better than recycling and composting methods because cleaning and reusing materials in their present form avoids the cost of energy for remaking them in to something else”. It is the process of collecting used products from the field, and distributing or selling them used. Thus, although the ultimate value of the product is reduced from its original value, no additional processing is required. In recycling, product forms are changed into more basic forms such as scrap metal, glass, plastic, and paper. (Reza Zanjirani Farahani ,Shabnam Rezapour and Laleh Kardar ,2011)

2.6. Incineration (waste to Energy)

Incineration is one option for sustainable solid waste management. It is defined as the process of burning solid waste under controlled conditions to reduce weight and volume of solid waste, and often to produce energy. This process is really waste reduction, not waste disposal, though

following incineration ash must still be disposed. It is recognized as a practical method of disposing of certain hazardous waste materials (such as medical waste).

Incineration can be carried out both on a small scale by individuals and on a large scale by industry. This facility does not require much area so that it is common in countries like Japan where land is scarce.

There are considerations that we should keep in our mind when we want to choose incineration. These are: the necessary environmental controls are properly installed and maintained; the facility is properly sized and sited to fit well with other components of the MSWM and the material to be burned is combustible and has sufficient energy content.

2.7. Composting (Fertilizers)

It is a process of allowing biological decomposition of solid organic materials by bacteria, fungi, worms, insects and other organisms in to a soil for transforming large quantities of organic material to compost (humus like material). The organic material produced by composting can be added to soil to supply plant nutrients such as nitrogen, phosphorous, potassium, iron, sulfur and calcium, slow soil erosion, make clay soil more porous or increase water holding capacity of sandy soils. (Enger and Smith, 2008)

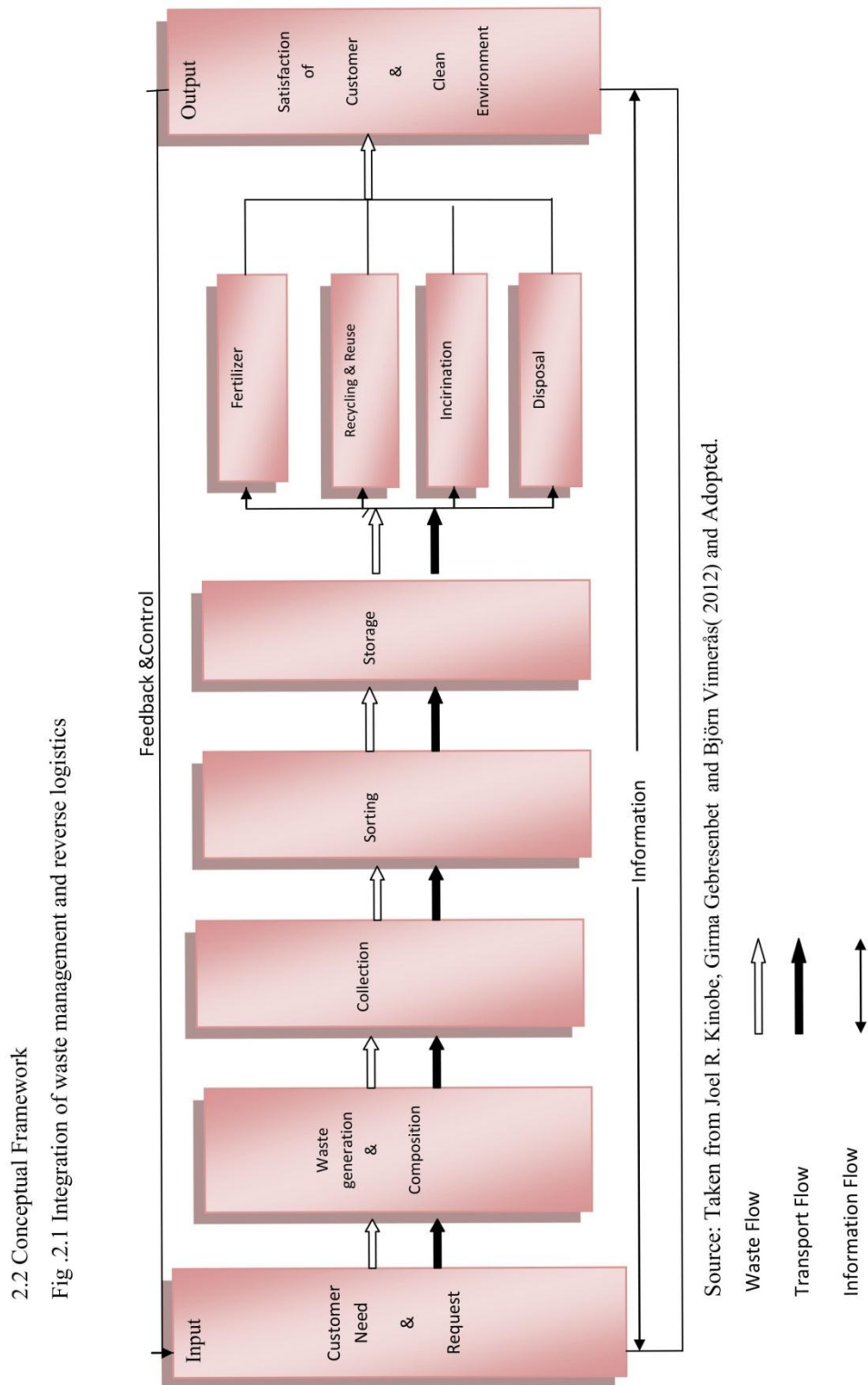
There are three scales at which composting has been implemented, residential level, decentralized community level and centralized and large scale municipality level. The larger the undertaking the more capital investment is required.

2.8. Disposal

This is final functional element in SWM system. Disposal activities are associated with final dump of solid wastes directly to a landfill site. Today disposal of wastes by land filling or land spreading is the ultimate fate of all solid wastes whether they are residential wastes, or residual materials from materials recovery facilities. "However, in most developed countries this method is officially banned allowing only sanitary landfill for final disposal. Because sanitary landfill is not a dump it is an engineered facility used for disposing of solid wastes on land without creating nuisances or hazards to public health and environment". "Though it is the most common technology around the world, conventional and environmental unfriendly methods such as open-burning, open-dumping, and non-sanitary landfill can still be used as disposal method".

2.1. Conceptual Framework

Figure 2.1. Integration of Waste management and Reverse logistics



. Waste composting, recycling & energy recovery potential

3.1. Waste composting potential.

Wastes are composed from a significant part of organic matter which could be composting. Rates of heavy metal in organic fraction allow it's composting. Moreover outlets are currently not identified for compost. And due to the mixed collection waste, quality of compost shall be altered with the presence of fine part of plastics, glass or other particles, difficult to sort in a composting process.

Recovery by composting could be considered in a long time if the collection organization allow to sort a part of the organic matter in the waste generated, for example with a new type of collection for some of big producers of organics waste.

3.2. Waste recycling potential

The waste material recycling mainly concern: Waste which the size is over 100 mm. plastic waste, cardboard, tetra pack, papers, metal and glass. Given these criteria, the maximum potential of waste recycling could be around 15% by weight at source. But due to the mixed collection, these materials are unclean because of the contamination by organic waste and recovery would require washing and drying before being recycled. Then less than 8% of waste from the city can be considered as potentially recyclable (without informal picking).

3.3. Waste energy recovery potential

Chemical analysis of the mixed waste from households shows that moisture content in waste is very important (more than 62% and 85% for low income areas). This value is direct in relationships with the rate of organic matter content in waste. Moisture is a limiting factor for treatment by energy recovery plants.

There is a relative homogeneity between the carbon elements and minerals. It has an impact on the waste treatment by composting or energy recovery, but with about 50% of volatile matter, a treatment by landfill would recover a significant amount of bio-gas.

According to the analysis made for the characterization study, the calorific value of the waste is relatively high on a dry product (between 9000 and 13,000 kJ / kg), which is very favorable for heat recovery.

A Logistics system is made up of a set of facilities linked by transportation services. Facilities are sites where materials are processed e.g. manufactured, stored, sold or consumed. They

include manufacturing and assembly centers, warehouses, distribution centers(DCs),transshipment points, transportation terminals, retail outlets, mail sorting centers, garbage incinerators, dump sites, etc. Transportation service moves materials between facilities using vehicles and equipments such as trucks, tractors, trailers, pallets, containers cars and trains.

4. Logistics Facilities in Solid Waste Management

4.1. Primary Storage Facilities

A variety of facilities are used for primary storage of solid wastes. Standardized containers can be used; the standardization of primary-storage facilities could maximize labor and transport productivity. This is especially true for waste collection methods that rely on the direct handling of primary refuse-storage equipments by municipal workers. No such advantage is derived in the case where municipal workers only handle secondary-storage facilities, such as communal bins.

In the separation at source scheme, the householder is either required to place recyclable materials into one container for sorting by the collectors (including informal sectors), or the recyclable materials are placed in separate containers.

4.2. Secondary Storage facilities

Secondary waste storage facilities may be either stationary or portable units. The stationary units are commonly uncovered, and the waste is often scattered around the facility where insects, rodents and animals are attracted to it. In portable storage facilities, the vehicle deposits an empty container and collects a full one. Vehicle productivity in general is maximized in portable units since time taken to set down an empty container and load a full one is very small (typically one minute), and with appropriate tipping gear fitted to the vehicle, the tipping operation also requires minimal time to complete

4.3. Landfill

The land fill is an ecologically sensitive area where groundwater supplies are threatened because it is located on a wetland. Koshe is an open and unlined landfill with no groundwater protection and limited leachate recovery. The landfill is encircled by settlements and housing, posing a health risk to the people living nearby. The waste pickers at the landfill burn the waste to reduce its capacity. The smell is a nuisance and discomfort to the people because the waste is not segregated. Burning of medical and industrial wastes produces gases that when inhaled cause health hazards to the surrounding community (Hu *et al.*, 2002, Jang *et al.*, 2006). The waste is heterogeneous in nature and is not segregated from the household to the disposal site. Waste

loaders who perform out the action of picking out recyclable products do sort these unsegregated wastes before it is loaded onto the vehicles, taking up a considerable amount of time (Wilson *et al.*, 2009, Wilson *et al.*, 2006).

4.4. Transfer Station

A transfer station is an interface between (short haul) waste collection vehicles and long hauls vehicles more appropriate for long distances to assist in disposal of waste more economically. The purpose is to reduce not only the transport unit cost of collection vehicles, and obtain more cost effective payloads, but also to allow quicker turnaround times on collection vehicles and therefore increased productivity. The need for a transfer station and the degree of required sophistication will be determined by the volume of waste generated, the collection systems implemented, and the distance to the disposal site. There no transfer station at the sub city level.

5. Equipments for Solid waste Logistics

5.1. Primary collection Equipments

5.1.1. Sacs(plastic Bags)

Waste is collected by plastic sacs which are emptying and/or replacing by another empty sac. Waste is carrying on back or shoulders to pushcart. Then, sacs are loading in a pushcart.

5.1.2. Pushcart

When the pushcart is full, after 4 to 10 houses collected, pushcarts are pushed manually to the designated temporary collection point. Carrying capacity of the pushcart varies from 150 to 400 kilograms. Standard specifications are not produced. Ownership of pushcarts is largely by the worda. Private primary collectors and some cooperatives also own pushcarts.

5.2. Secondary Collection Equipments

Waste collected by the primary collectors and street sweepers is transported until municipal collection points. Collection points are not used by private companies collecting institutional and commercial. These companies transport waste directly to the landfill. At collection points Skips are the main Equipment to store temporarily and transport waste to landfill.

5.2.1. Trucks

Addis Ababa, KirkosSub city disposes from 7 trucks for secondary collection. But according to the sanitation office the sub city, only 6 of these trucks are functional. One of them is often under maintenance because of the average age of the truck is more than 5 years, maintenance difficulties, negligence and frequent accidents during traffic jam are the main challenges.

5.2.2. Landfill equipments

In the active cells after being disposed on the floor by the trucks waste is compacted by compactors, then waste is spread and leveled with bulldozer, pushed to the side slopes. Then, waste is not covered with any other cover material. Resources for operation are: bulldozers, shovels, loaders and compactors.

5.2.3. Working materials for Waste collectors

Working materials like gloves, Uniforms, musk and plastic boots are important for the safety of waste collectors at the primary collection stage.

6. Solid Waste management Status in KirkosSub city

In Addis Ababa, Kirkos sub city the waste picked-up through curbside collection from each house hold goes directly to the main land fill at Repi (Koshe) site. It has no its own waste to energy facility, recycling facility, landfill, hazardous waste depot and transfer stations. The sub city uses all these facilities with other sub cities in common at the city level. Both the Transfer and the waste to energy facility are under construction so that the study will be conducted by taking in to account the completion and use of these facilities.

Reuse and recovery of materials and products is done by Micro and Small Enterprises who are engaged in Collection of waste at woreda level. They collect and sort out mainly used plastics bottles and scrap metal and to some extent papers and polythene bags.

In Kirkos Sub city, most waste is collected in two phases. The first phase is where waste is tried to be stored at the household and then when the need arises it is transported to the collection point, normally the temporary storage. The second phase is when waste is collected from temporary storage points and then transported to the final disposal site. Waste that is generated in the Sub city is not segregated. The uncollected waste is dumped in open spaces, on streets, in

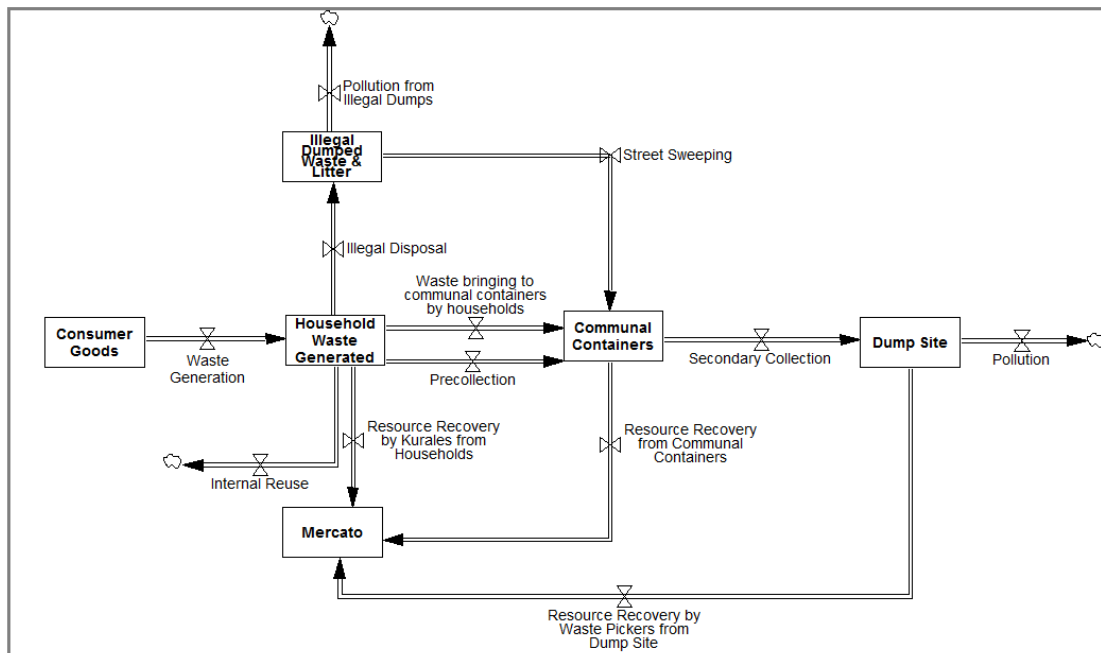
markets, and in drainage and storm waterchannels. These uncollected wastes create health risks, while the heapedgarbage on the streets becomes an impediment to traffic and an aestheticnuisance in the city streets. It is the mandate of the city Sanitation and Cleansing Agency of the City and the sub city tomanage waste generation.

The Sub city has trucks that are directed to collect waste in the city. The vehiclefleet used consists of vehicles with different size. Four of the vehicles are sophisticated, expensive and noteasy to operate or maintain.

Due to privatization in Ethiopia, there has been a limited participation in operation of transportation of solid waste, hence the private operators who obtain contracts from the Addis Ababa Cleansing Agency to participate in waste collection for a fee Contracts are awarded to those operators who are able to invest in the sector without any bid.

The Sub city uses (Koshe) is an open land fill to dumpedwaste directly onto the land. This is only the one recognized disposal site, known asKoshe. It is located about 15 kilometers from the sub city and is where collected waste from Addis Ababa is disposed of. Kosheis an open andunlined landfill with no groundwater protection and limited leachate recovery.

Fig.2.2.Solid Waste Materials flow in Addis Ababa (IGNIS,2013)



Source:Nicolás Escalante Mora, AgataRymkiewicz& Martin Kranert(2013)

7. Transportation of SW

Many sources of waste might only be reached by roads or alleys which may be inaccessible to certain methods of transport because of their width, slope, congestion or surface. This is especially critical in unplanned settlements such as slums or low income areas and thus largely affects the selection of equipment. Road conditions, traffic density, and overall haul distance will have a determining influence on vehicle choice. Besides motorized vehicles, non-motorized vehicles should be considered which are mainly used to transfer wastes to communal containers or to disposal sites (in small towns) that are found near the towns. The non-motorized vehicles are also recommendable in narrow and filthy roads, dense settlement areas and in inaccessible parts of large towns. In large towns or cities, the non-motorized vehicles should be used only to transfer wastes to communal containers.

Transportation is a key step in the management sequence of MSW. Transportation of MSW is defined as “the driving of the empty truck from the garage to the start of the collection route, driving of the full truck from the final stop on the collection route to the unloading point, and driving of the empty truck from that point either back to the garage or to a new collection area if more than one area is serviced on the same day”. Waste Transportation must be integrated systematically with other waste management activities to ensure smooth and efficient waste management.

MSW transport in Addis Ababa is currently based mainly on road transport. The Kirkos Sub city has 7 (seven) trucks that are directed to collect waste in the city. The vehicle fleet used consists of vehicles with different loading capacity.

7.1. Optimization of routing of waste

The application of route optimization in the field of waste management is still a new concept and very few urban authorities in developing countries consider having it in effective waste collection (Badran and El-Haggag, 2006). Collection of waste has posed a considerable number of operational problems for local authorities in many cities, involving tasks such as optimal fleet size, type and scheduled route (Torres and Anton, 1999). Added to the high costs of operating and maintaining vehicles, there is concern that these heavy trucks have a negative impact on the environment due to the quantity of miles driven, fuel type, engine inefficiency and exhaust gases emitted

The major shortfall during waste collection in Addis Ababa is that the collection vehicles are sent to collect waste from different areas in a random manner, making it ineffective. The fleet of vehicles is not optimized at all. Transport vehicles do not follow scheduled routes and sometimes double handling of waste becomes inevitable. The available vehicle types are designed to handle one type of waste stream, they lack compartments to collect different types of waste, and none of the waste is segregated. Waste loaders who perform out the action of picking out recyclable products do sort these unsegregated wastes before it is loaded onto the vehicles, taking up a considerable amount of time (Wilson, 2009).

Effective decision-making in the field of management systems requires the implementation of vehicle routing techniques capable of taking advantage of new technologies such as the geographic information system (GIS). Since routing models make extensive use of spatial data, GIS can provide effective handling, display and manipulation of such geographical and spatial information (Ghose., 2006, Bosona *et al.*, 2013). These tools eliminate hours spent on unplanned routing, maximize productivity, optimize equipment and staff allocations, and allow better control of waste collection operations.

Through the optimized routes it is possible to measure the efficiency of a management system, for instance generating an optimal route for a given vehicle will help minimize the cost. The optimal routes are then determined by comparing the different paths. These paths can be calculated by different types of algorithms such as Tabu search, ant colony optimization and genetic algorithm (Karadimas and Loumos, 2008).

Wastes from stationary units have to be removed by raking out on to the ground and collecting in baskets before being carried to the vehicle. This is often demeaning, unhealthy and time consuming task which limits productivity of both labor and vehicles. In portable storage facilities, the vehicle deposits an empty container and collects a full one. Vehicle productivity in general is maximized in portable units since time taken to set down an empty container and load a full one is very small (typically one minute), and with appropriate tipping gear fitted to the vehicle, the tipping operation also requires minimal time to complete. Hence, the overall round-trip time is essentially composed of travel time for shuttling back and forth to the disposal site. The requirement of labor is also minimal as compared to the stationary containers.

8. Empirical Studies

Waste collection in most countries accounts for a large proportion of the waste budget. For instance, in India, about 85% of the total expenditure on waste management is directed to waste collection and transportation, and an average of about 70% of the waste budget (M.K. Ghose, A.K. Dikshit, S.K. Sharma, 2006) as such proper design of the collection system would save funds. About 54.5% of the waste generated in low income areas was collected and disposed off while the rest was left to litter on the streets

Findings from a research project aimed at efficient household solid waste collection and transportation in Kuwait studied by Koushki, Al-Duaij, W. Al-Ghimlas (2004) indicated seven private companies as the main contractors for the collection and transportation of solid waste to the landfill disposal sites by the municipality. These private companies have been in the business for over 10 years and their contracts are always renewed because the waste collection and disposal is done. In cities of developing countries, most large mixed waste composted plants have failed or operate at less than 30% of capacity. The problems most often cited for such failure include high operation and management cost, high transport cost, poor quality of products as result of lack of sorting (especially plastic and glass fragments), poor understanding of composting process, and high competition from chemical fertilizers which are subsidized (UNEP 1996).

Waste reduction has become a prime concern in the industrialized countries. Waste reduction is the new trend that is being advocated due to government legislation addressing product recovery and proper disposal of end of life products, economic benefits gained from the returned products, and environmental concerns (T.J. Barker, Z.B. Zabinsky, 2008). Most industrialized countries are aiming at significantly cutting the amount of waste generated, through new waste prevention initiatives, better use of resources, and encouraging a shift to more sustainable consumption patterns. The primary objective is to decouple waste generation from economic activity, and there is evidence that this is beginning to happen (D. Zhang, T.S. Keat, R.M. Gersberg, 2010). These countries which have well developed economies and high GDP per capita do conduct high level research and development for environmentally sound mitigations for the waste problems. Based on this, fiscal policies in these countries are targeted to environmentally acceptable waste disposal avenues. Such approaches are missing out in the developing world and where they are, they remanufacture are not fully effective quotes.

Chapter Three

Research Design and Methodology

1. Description of the Research Area

Addis Ababa, the capital city of the country, is situated at the center of the country. The first census made in Addis Ababa by the Central Statistics Agency (CSA) of Ethiopia was made in 1984. Population of the city was estimated to 1.4 million inhabitants. According to the last census of 2007 made by the Central Statistics Agency of Ethiopia, population of Addis Ababa was estimated to 2.7 million inhabitants. The population doubled in 23 years. The city has Area 540 square kilometers(54000 hectare), includes ten (10) sub cities (Arada, lideta, kirkos, Akaki, Kolfekeranyo, Nifas silk lafto, Addis ketema, Gulele, and Yeka) . Every year, more than 200000 tons of residential and commercial waste produced in the city.

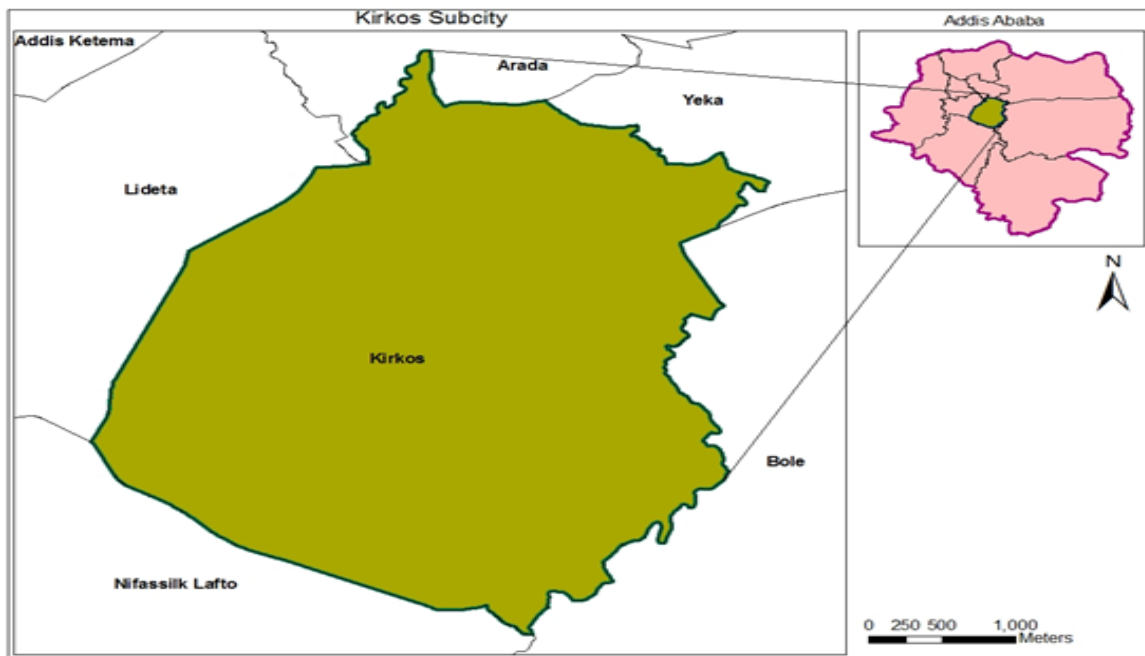
The KirkosSub citymunicipality is situated at the center of Addis Ababa City. The sub city includes 10 woredas. The report by CSA based on 2007 population census, the population of KirkosSub city was 220991.In 2013, it was projected to be 250615 in a total area of 16.26 km² with density of 154.3inhabitants/ha. The sub city hosts many different Governmental, Non-Governmental and Business Institutions.Every year many tones of residential,industrial&commercial and street sweeping wastes produced in the sub city.

Currently in KirkosSubcity, most waste is collected in two phases. The first phase is where waste is stored at the household and then when the need arises it is transported to the collection point, normally the temporary storage. The second phase is when waste is collected from temporary storage points and then transported to the final disposal site. Waste that is generated in the city is not segregated. Primary collection is done by micro and small enterprises there are 50 MESs waste collectors. The enterprises have a total of 509 members. (ARTELIA)

The study focuses on Addis Ababa Kirkos Sub city .The main rationales for selecting the sub city are : since

- It is one of the densely populated and smaller in size whereas produces large amount of solid wastes every year.
- It is located a city center and is one of the oldest part of the Addis Ababa city.
- The population comprises both low and high income inhabitants so that these reasons attract the researcher to conduct a study rather than other sub cities of Addis Ababa.

Fig.3.1 Map of Kirkos sub city



Source:Field Survey (Addis Ababa Rivers & River Side Development & Climate Change Adaptation Project Office)

2. Research Approach

In order to achieve the main research objectives this particular study has been adopted a cross sectional mixed methods approach (both quantitative and qualitative). The purpose of using such a mixed methods approach is to gather data that could not be obtained by adopting a single method.

The research design also has been use mixed approach of both descriptive and explanatory. It will be partly descriptive because to describes and interprets findings from primary and

secondary data. It has been partly explanatory as to tries to investigate and explain current practices of solid waste Logistics system.

3. Study populations

According to Donald et al, population consists of all the subjects you want to study. It comprises of all the possible cases (persons, objects, events) that constitute a known whole. Therefore, from this we can conclude that population consists of all the subjects the research envisaged to study. The population for this particular study has been multiple actors operating solid waste Logistics system in the Sub city.

The sampling frame that contains a list of experts in the Sub city, woreda administration sanitation office, MSEs and the service users (The community). Here the researcher has four strata's i.e. Kirkos sub city sanitation offices, Woreda sanitation offices, MSEs and the community (service users).

3.1. Major Solid Waste Logistics system Actors in Addis Ababa, Kirkos sub city

According to information obtained from Sub-city Cleaning Administration Office, there are different actors involved in solid waste Logistics System. Sub-city Cleaning Administration Office, the Woreda Administration, Micros and Small-scale Enterprises and the community are the main actors. The main chain actors play different functions along the reverse logistic chain /waste management chain

3.2. Sub-city Cleaning Administration Office

Sub-cities Cleansing Administration Office is responsible for transporting and disposing solid wastes, Provide advice and co-ordinate Woreda Cleaning Administrations to make the residents of the Sub-city clean their vicinity and follow-up the same, Provide sanitary services where emergency situation occurs make special preparation and provide efficient and speedy services in such exceptional times as holidays where large amount of waste is generated than ordinary activities.

3.3. Woreda Cleaning Administration Office

Woreda Cleansing Administration Offices are responsible for waste collection. The Woreda Cleaning Administration shall co-ordinate residents of the Woreda in their effort to keep their surrounding clean or shall co-ordinate the organization of the Woreda and village sanitary committee and their activities to conduct sanitation campaign. They perform also awareness

creation activities on Solid Waste Management and clean main roads, streets, ditches, drainages, etc.

3.4.Small-scale Enterprises, Micros and Association

Collect solid wastes from households using two wheel carts, Sort wastes (organic, inorganic, etc), clean their surroundings.

3.5. The Community(Service users)

The community is responsible for carrying out the necessary protection measures and actions to prevent the dumping of any waste materials within their vicinity. Participate in SWM matters, plans and programs, etc.

4. Sampling Technique and Sample Size

For this study, to collect data and from all woredas of the Sub city (the Second level administrative unit) random sampling has been employed. All Woredas comprises commercial center and residential areas. The woreda also contains residents of low, middle and high level income groups. Stratified sampling technique has been used due to the variability of the municipal solid waste generation sources and involvement in Solid Waste Management. Stratified random sampling has been employed based on the size of samples within each stratum

Determining sample size varies for various types of research designs and there are several approaches in practice. A general rule, one can say that the sample must be of an optimum size i.e., it should neither be excessively large nor too small (Kothari, 2004).

The researcher has taken Zikmund and Babin (2010) sampling technique by determining the sample proportion success and not success based on the experience from previous survey research response rate. Saunders, Lewis and Thornhill (2012) state that the likely response rate shall be reasonable 50% or moderately high, while Patrick (2003) referring Babie (1979), the return or success rate 50% is 'adequate'; 60% response rate is 'good' and 70% rate or higher is 'very good'. Having this experience, for this research purpose confidence of successfully collect or return rate is expected to 90% because the respondents are located on specific area and easy to collect questionnaires and the remaining might be defected or non-response, and sample size is determined at 95% confidence level. Determine the size of the sample size for population (Kothari, 2004): sample size of Service users & MSEs determined as follows

Where;

$$n = \frac{NZ^2 PQ}{e^2(N-1) + Z^2 PQ}$$

- z = z score level of confidence of the estimate (in the case of 95% = 1.96);
- e = marginal error, 5%
- P = proportion of the sample successfully collected (p=0.9)
- q = failure of sample (1-0.9= 0.1)

Sample size of Service users

N = population of the sample (1333)

$$n = \frac{1333(1.96)^2 0.9*0.1}{0.05^2(1333-1) + (1.96)^2 0.9*0.1} = 125$$

Sample size of MSEs

N = population of the sample (50)

The $n = \frac{NZ^2 PQ}{d^2(N-1) + Z^2 PQ}$

$$n = \frac{50(1.96)^2 0.9*0.1}{0.05^2(50-1) + (1.96)^2 0.9*0.1} = 37$$

The overall sample size for the study that has been taken from each stratum as summarized in the following Table

Table 3.1. Summary of the Sample size of the Study

No.	Target population	Number of population	Sample size
1	Service users (Households)	133	125
2	Experts and Officials from Sub city Administration sanitation office	18	18
3	Experts and Officials from Woreda Administration sanitation office	88	88
4	Micro and Small Enterprises	50	37
		Total	268

Source: Own Survey

Therefore, the total number of the sample size the researcher used was **268 Respondents**.

5. Data Collection Procedure, Source and Type

In this study, the researcher has been used primary and secondary data. All required data for this study has been collected both from primary and secondary sources. The primary data has been obtained from target populations (Kirkos sub city administration sanitation branch office, Woreda Administration sanitation branch office, Micro and Small Enterprises and the community) respondents, researchers' observation and key informants. Similarly, secondary data has been obtained through review of all available published and unpublished documents of relevant organizations.

6. Survey Instrument

6.1. Instrument Development

As tried to be mentioned on the preceding part, questionnaire has been employed as the instrument of data collection. Multi-item scales namely Waste collection, recycling, composting and disposal operation, waste transport system, waste facilities and equipment has been developed on the basis of an extensive review of the extant literature. The items has been measured on five point Likert scale that range from strongly disagree to strongly agree and also some additional qualitative questions related to the study objective and questions. Respondents were requested to allocate/select scores for each of the items on the instrument by taking their knowledge and actual situation in mind.

Basically, the instrument has been developed by the researcher based on the objectives of the study, research questions and the literature. The principles of questionnaires such as, use simple and clear languages, statements should not be too long and use of appropriate punctuations also has been considered when developing the instrument.

6.2. Validity Test

Validity defined as the accuracy and meaningfulness of the inferences which are based on the research results. It is the degree to which results obtained from the analysis of the data actually represents the phenomena under study. He contends that the validity of the questionnaire data depends on a crucial way the ability and willingness of the respondents to provide the information requested.

A pilot study has been conducted to refine the methodology and test instrument such as a questionnaire before administering the final phase. Questionnaires was tested on potential respondents to make the data collecting instruments objective, relevant, suitable to the problem and reliable as recommended by (John Adams et al., 2007). Issues raised by respondents have been gathered and questionnaires have been refined accordingly. Besides, proper detection by an advisor and subject matter expert has been taken to ensure the content validity of the instruments. Finally, the improved version of the questionnaires has been translated in Amharic, printed, duplicated and dispatched.

7. Ethical Consideration

All the research participants included in this study have been appropriately informed about the purpose of the research and their willingness and consent has been secured before the commencement of administering of questionnaire and asking interview questions, at the time of data collection the researcher has been given a respect to the participants and ask permission about their voluntariness for response. Regarding the right to privacy of the respondents, the study has been maintained the confidentiality of the identity of each participant. In all cases, names have been kept confidential thus collective names like ‘respondents’ have been used. In addition, the researcher has given full acknowledgements to all the reference materials used in the study.

8. Data Analysis.

This study has been employed a combination of quantitative and qualitative data collection methods. The quantitative data has been checked for completeness then the data entry has begun. Descriptive statistics is used to describe the data collected in research study. Then, the data exported into Statistical Package for the Social Sciences version 16.00 software (SPSS V.16.0) for analysis. SPSS is used to produce preliminary frequency tables, and tabulations. Data also obtained from observation is used during analysis

The Key Informant has been developed, piloted and finalized before conducting the interviews. The interview has been carried out. Then, the collected and analyzed data was presented by using the following data presentation tools: tables and a histogram along with interpretations.

9. Instrument Reliability Test

Cornbach’s alpha is a coefficient of reliability used to measure the internal consistency of a scale; represented as a number between 0 and 1. The researcher conducted the Cornbach’s alpha reliability test by using SPSS (Statistical Package for the Social Sciences) and found that 86% of the responses from the target population

Table 4.1: Reliability Statistics

Cronbach's Alpha	N of Items
.864	32

Source: SPSS Result

CHAPTER FOUR: DATA ANALYSIS, RESULTS AND DISCUSSION OF THE STUDY

1. Introduction

The previous chapter had presented the design of research methods and ways including the rationale for undertaking the research using a mixed approach and data collection tools used. Thus, the quantitative as well as the qualitative analysis of data was incorporated to this chapter, the qualitative part was supposed to be complementary to the quantitative analysis.

Hence the qualitative data gathered through interviews and open ended questions. In this study the following three research instruments were used namely, questionnaire, interviews, and observation. Where necessary, two or more instruments were used jointly to ensure that all the important information had been elicited.

Interview – a semi-structured interview schedules were developed and administered with (3) experts that who have knowledgeable and experienced on the issue under this study. Thus, the selected interviewees were communicated by the researcher himself to be interviewed face-to-face to get further and reliable information, opinion, and attitudes of the respondents to enrich or help the data gathered by questionnaire.

Including 10% non response rates, 268 questionnaires were distributed, 248(90%) was returned, out of which 6(2%) were not correctly filled and rejected. Therefore 242 (97%) questionnaires were correctly filled and used for the study analysis.

The chapter presents the analysis and discussion of qualitative and quantitative main data.

2. Descriptive Statistics

As, pointed out in the methodology part, the research design of this study was descriptive statistics. Descriptive statistics entail transformation of raw data into a form that would provide information to a set of factors in a situation. Thus, the profile of the respondents together with their perception about the topic of the study were presented, analyzed and interpreted under this section through descriptive statistics relating the objective of the study.

3. Data analysis, discussion and results

3.1. Data Collection and Analysis

The data collection was done using checklists which were pre-tested prior to the actual field work. The bulk of the data generated for this study were qualitative. Structured questionnaire, interview guideline and field observation were used to obtain data and information for the study. The structured questionnaire was used for the selected households (users), officials and experts at sub city and Woreda sanitation office and to the MSEs those engaged in solid waste collection at the sub city. Beside this, checklist was also provided for the Sub city Sanitation Department (SD) office to gather information on their current solid waste management. Collection of information about solid waste management and Logistics system was done by myself. Equipment like a digital camera was used for photographing by the researchers during field observations. Waste Collection sites where containers are placed, market places where waste handling is expected to be difficult and open dumping sites, were also purposely used as sample units to collect qualitative information. The data were analyzed combining the information collected from secondary sources, qualitative and quantitative survey.

The Sanitation department at the Sub city level was assigned the responsibility for the solid waste management in 2009 E.C. The office is also struggling with tight budgets, lack of qualified manpower, and experience in waste management.

3.2. Result and Discussion

3.2.1. Solid Waste Generation Rates

With regard to solid waste generation rate, even though the solid waste trend is expected to increase in general, recent and up to date data were not available. However, as per the data obtained from the sub city about 433 tones/week of waste were collected every day from about 1333 households (Source: the sub city Sanitation office).

Table 4.2: Solid Waste generated rate

Weekly generated	Monthly generated	Yearly generated
433 tones	1732 tones	20784 tones

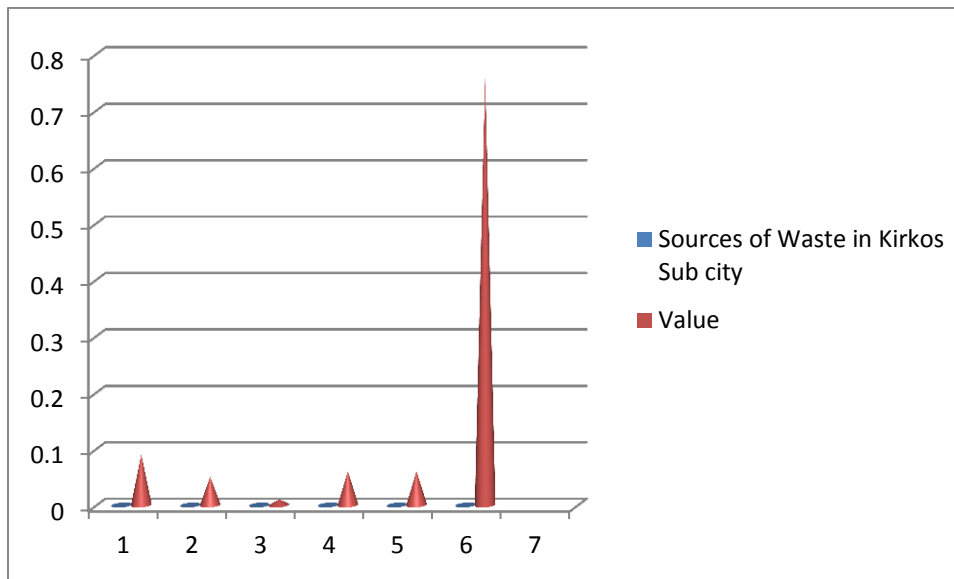
Source: Own survey result, 2017

3.2.2. Solid waste Source

The result from the surveyed households reveals that MSW generation by source and type in Kirkos sub city Addis Ababa City. The composition of municipal waste varies greatly from country to country and changes significantly with time. Waste can be classified into several types. However, the following list represents a typical classification of municipal solid wastes: (1) Biodegradable waste: (like; food and kitchen waste, green waste, paper), (2) Recyclable material: (paper, glass, bottles, metals, certain plastics, batteries etc.) and (3) medical wastes.

When considering the solid waste production across different sources (residential and commercial, in this study), the residential origin was found to be higher (76%) while the remaining (24%) accounts for commercial and other origin. Sources of Waste Generated specifically are commercial 9%, Industrial 5%, Hospital 1%, others 3%, Street sweeping 6% and 76% households.

Fig. 4.1: Solid Waste sources in Kirkos Sub city



Source: own survey result, 2017

3.2.3. Physical Composition of waste in kirkos Sub city

The result of the survey in the study area showed that municipal waste is an aggregate of all substances ready for disposal. The composition of the solid organic waste was almost homogenous in nature across the study households.

As it was observed in this study, majority of the waste was of plastic origin while the animal and the industrial origin was almost none in most of the households. Of the plastic source, residues of festal (known locally as Mika) and liquid containers take the greatest portion. Overall composition includes paper, vegetable peelings, onion seed coats, broken plastic and festal, soil and dust, animal dung, grasses, used shoes, pieces of cloth, small bottles, soot, etc. The waste aggregate more frequent in the whole mass of household waste was house sweeping, which is composed of soil and dust followed by pieces of paper and vegetable peelings.

Table 4.3. Physical composition of waste

1	Vegetable	4.20%
2	Paper	2.5%,
3	rubber/plastics	2.9%,
4	Wood	2.3%,
5	Bone	1.1%,
6	Textiles	2.4 %,
7	Metals	0.90%
8	Glass	0.5%,
9	combustible leaves	15.10%
10	Non-combustible stone	2.50%
11	All fine	65%

Source: the sub city Sanitation Administration office, 2017

Out of the whole composition of waste depicted on table 4.8, it is estimated 60% to be organic, 15 % recyclables and 25% other type of wastes

Table 4.8 shows percentage of municipal solid waste composition in Kirkos sub city, Addis Ababa. It has been revealed that the largest constituent of residential solid waste is organic 60 % and recyclable wastes 15 % and the remaining 25% waste that are neither organic nor recyclable waste.

3.2.4. Collection

Waste collection service is one of the chief components of municipal SWM practices. The survey showed that containers are placed in some neighborhoods. However, a number of containers are not enough with respect to waste generated and a portion of the neighborhoods are obliged to throw their refuse into an open area. Some of the households, who are not enjoying municipal services, have their own way of household waste disposal. The tools that are used for solid waste collection in both residential and commercial area are shown below in table 4.4.

Table 4.4: Tools that are being in use to Store waste at households

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	metallic containers	12	5.0	5.0	5.0
	baskets	40	16.5	16.7	21.7
	plastic bags	39	16.1	16.2	37.9
	empty sacks	149	61.6	62.1	100.0
	Total	240	99.2	100.0	
Missing	System	2	.8		
Total		242	100.0		

Source: own survey result, 2017

Table 4.4 Shows majority of the respondents 149(62.1%) stated that the bulk of primary waste collection equipments are sacks whereas a few said that they use metallic containers 15(5%) & 16(16.5%) baskets. Most of the areas in the city are inaccessible for motorized collection; therefore, the human powered collection system is mostly used. Generally, there are three basic types of collection equipments. These are: human powered, animal powered, and engine powered. Under the sub city situation, both human and to some extent motorized collection equipment are being used. Majority of the respondents 159 (65.7%) reveal the main power to collect waste from households is human power.

Table 4.5. Collection Equipments used to collect waste in the sub city

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	human powered	159	65.7	66.5	66.5
	animal powered	29	12.0	12.1	78.7
	engine powered	51	21.1	21.3	100.0
	Total	239	98.8	100.0	
Missing	System	3	1.2		
Total		242	100.0		

Source: own survey result, 2017

The current trend of storage bins reveals in the sub city of that dust bins are located in Main roads of the Sub city. But there observed improper usage of the dust bins. Only 75% of the MSW generated in the Sub City is collected and disposed off by the sub city with little recycled and a little composted. The rest about 25% is dumped in uncontrolled environment like on/in streets, empty spaces, and river banks.

There are different waste collection services given in the study area. Of these services, the majority use door-to-door collection services while others don't receive any services rather they dispose wastes into river systems, burn and reuse for their gardens even though they didn't mention

Table 4.6: Disposal of waste at household level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	by burning	30	12.4	12.6	12.6
	throwing to the nearby river	68	28.1	28.5	41.0
	reuse	9	3.7	3.8	44.8
	delivering all waste to collectors	132	54.5	55.2	100.0
	Total	239	98.8	100.0	
Missing	System	3	1.2		
Total		242	100.0		

Source: own survey result, 2017

But the table 4.6 shows that 132 (54.5%), disposal is conducted by delivering all waste to collectors and 68 (28%) of the respondents indicate significant amount of waste disposed by throwing to the nearby river, there are a lot of solid waste rivers banks in the sub city, however, any person while walking in the sub city from any corner all public spaces like road sides and open spaces attest eye catching piles of garbage, flying 'festal' which is increasingly used for packaging, rubbish, construction demolition and moved earth from new construction sites littering the urban space indefinitely. The reply is contrary to the reality on the ground.

Fig 4.2.Solid Waste Dump in a small River (Around Beklobet behind Rift Valley University)



Table 4.7: The frequency of solid waste collection at household level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	daily	38	15.7	16.3	16.3
	weekly	162	66.9	69.5	85.8
	monthly	6	2.5	2.6	88.4
	and above	27	11.2	11.6	100.0
	Total	233	96.3	100.0	
Missing	System	9	3.7		
Total		242	100.0		

Source: own survey result, 2017

As far as waste transfer both the municipality and private few trucks are used to transfer wastes from the source to the destination. In an interview with sanitation office, one of the offices experts reveals that the trucks collect wastes each weekly from residential households but From Table 4.7 it can be realized that majority of wastes from residential households are collected

using door to door service weekly 162 (66.9 %) while the rest 15.7 %, 2.5% & 11.2% revealed collection done daily, monthly and above respectively

Fig4.3. Illegal Dumpsite nearby St. Joseph School (behind Meskel Square)



3.2.5. Sorting Practice

Table 4.8: Sorting practice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No extent	95	39.3	39.3	39.3
	little extent	92	38.0	38.0	77.3
	moderate extent	43	17.8	17.8	95.0
	great extent	11	4.5	4.5	99.6
	Avery great extent	1	.4	.4	100.0
	Total	242	100.0	100.0	

Source: own survey result, 2017

Sorting is an essential component of solid waste management. It is a kind of activity which is separating different types of wastes in their respective nature. It makes waste management easy and simple. However, it should not be a one-time activity, rather should be a habit for proper and

sustainable solid waste management. Separating different types of waste components helps to sort recyclable materials from non-recyclable and identify decomposable (organic) materials from non-decomposable. The process is also efficient in reducing the problem of landfill sites and expenses. However, as to the respondents, there is no/little separation of solid wastes in Kirkossub city whereby over 77.3 % of the respondents, invariably confirmed the absence of solid wastes separation practices during both collection and disposal periods. The remaining few households or 22.7% of the respondents replied that solid wastes were sorted into organic and inorganic wastes. Inorganic wastes like cans are usually sorted for sale. In few households, organic wastes like plant origin are sorted for the purpose of reusing in their gardens and as fuel after the waste gets dried; this is seen in residential households. Animal source (meat and bone) is used to feed domestic animals like dogs. Some households give the waste away to their neighbors who use it for different purposes like for animal feed.

Table 4.9: Sorting practice at collection and disposal period

		Frequency	Percent	Valid Percent	Cumulative Percent
Sorting of waste is being conducted at collection period	highly disagree	78	32.2	33.5	33.5
	disagree	86	35.5	36.9	70.4
	neutral	50	20.7	21.5	91.8
	agree	8	3.3	3.4	95.3
	highly disagree	11	4.5	4.7	100.0
	highly disagree	233	96.3	100.0	
	Total	9	3.7		
	Missing System	242	100.0		
Sorting of waste is being conducted at disposal period	highly disagree	101	41.7	41.9	41.9
	disagree	81	33.5	33.6	75.5

	neutral	24	9.9	10.0	85.5
	agree	23	9.5	9.5	95.0
	highly disagree	12	5.0	5.0	100.0
	Total	241	99.6	100.0	
	Missing System	1	.4		
	Total	242	100.0		

Source: own survey result, 2017

Table 4.9 depicts that 164 (67.7%) disagree that sorting do not conducted during waste collection period and also 182(74.5%) respondents believe that sorting not carried out during disposal period.

3.2.6. Recycling practice

Table 4.10: Practice of Recycling

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no extent	45	18.6	19.5	19.5
	little extent	110	45.5	47.6	67.1
	moderate extent	47	19.4	20.3	87.4
	great extent	26	10.7	11.3	98.7
	a very great extent	3	1.2	1.3	100.0
	Total	231	95.5	100.0	
Missing	System	11	4.5		
Total		242	100.0		

Source: own survey result, 2017

Reuse(Recycling) is an important factor to reduce the amount of waste to be dumped at the final disposal site. The studyresult indicates that there is little practice of waste reusefor different purposes like industrial waste like can for sale,plant origin waste for fuel, animal source (meat and bone)waste for domestic animals feed. However, if we see the wastes from the recycling point of view, many of the constituents are compostable andrecyclable materials, and hence it

indicates that recycling practices are effective SWM practice. Unfortunately, it was so far not practiced in the subcity, and this is why we see a lot of paper and plastic substances thrown out in river banks, ditches and open areas

In general, as far as waste reuse is concerned, there is no formal practice in the city except some people called “*Korales*” who move through the city to buy recyclable items such as glass, plastic, tin cans, metals, shoes etc. from different houses, hotels, restaurants, repairs services and sell them to small recyclers and industries. There are also people engaged in similar types of job known locally as “*Liwach*” who go around the city and exchange used clothes and shoes with new household utensils and sell them to low-income people 118(64%) of the respondents reveals the absence of formal recycling practice .

Table 4.11: Formal Practice of Recycling

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	highly disagree	70	28.9	28.9	28.9
	disagree	111	45.9	45.9	74.8
	neutral	34	14.0	14.0	88.8
	agree	19	7.9	7.9	96.7
	highly agree	8	3.3	3.3	100.0
	Total	242	100.0	100.0	

Source: own survey result, 2017

Table 4.11. Depicts that 181 (74.8%) disagree about the existence of formal recycling practice so that respondents believe the formal recycling practice is at low level at the sub city.

Fig.4.4. Stockpile of plastic bottles to be recycled



3.2.7. Composting practice

Table 4.12: composting Practice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no extent	50	20.7	21.1	21.1
	little extent	118	48.8	49.8	70.9
	moderate extent	44	18.2	18.6	89.5
	great extent	24	9.9	10.1	99.6
	a very great	1	.4	.4	100.0
	Total	237	97.9	100.0	
Missing	System	5	2.1		
Total		242	100.0		

Source: own survey result, 2017

With regard to composting, the households practicing composting are very few, while a significant amount of this refuse is largely of plant origin /biodegradable/ organic waste.(Gardner 2001) and (Bezaye 2008), argued that composting is an ancient practice where more cities in the world nowadays are reclaiming the benefits of reusing solid organic waste material. It is a natural way to prepare the waste for reuse.

During the study, it was recognized that Majority of the respondents 168 (69.5%) replied the absence of the practice of composting that there are people who know at least the use of organic waste for soil fertility improvement. There are also some people who have training in composting, but are not practicing. The major limitation for not practicing compost as indicated by the respondent is lack of market and a piece of land for urban agriculture

Table 4.13: Formal Practice of composting

	Frequency	Percent	Valid Percent	Cumulative Percent
highly disagree	70	28.9	28.9	28.9
disagree	115	47.5	47.5	76.4
neutral	19	7.9	7.9	84.3
agree	31	12.8	12.8	97.1
highly agree	7	2.9	2.9	100.0
Total	242	100.0	100.0	

Source: own survey result, 2017

Table 4.13 Shows majority of the respondents 185 (76.4%) disagree about formal composting of organic waste at the sub city level

3.2.8. Incineration Practice

Table 4.14: Practice of incineration

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid no extent	147	60.7	61.0	61.0
little extent	65	26.9	27.0	88.0
moderate extent	19	7.9	7.9	95.9
great extent	10	4.1	4.1	100.0
Total	241	99.6	100.0	
Missing System	1	.4		
Total	242	100.0		

Source: own survey result, 2017

The key respondents were interviewed whether incineration has been practiced at secured places or not. Accordingly, as the informants, practice of incineration at secured places is confined to health institutions typically to manage medical wastes even though the practice takes place only sometimes. So far, no incineration taking place in or near the compound of households. Also 212 (87.6%) responds no or little extent of solid waste incineration practice in the sub city.

Table 4.15. Use of containers

		Frequency	Percent	Valid Percent	Cumulative Percent
There is appropriate use and care for containers so that there is no scattering of waste around the containers	highly disagree	54	22.3	22.3	22.3
	disagree	107	44.2	44.2	66.5
	neutral	43	17.8	17.8	84.3
	agree	38	15.7	15.7	100.0
	highly disagree	242	100.0	100.0	
The containers placed are enough with respect to the waste generated	highly disagree	39	16.1	17.4	17.4
	disagree	106	43.8	47.3	64.7
	neutral	46	19.0	20.5	85.3
	agree	29	12.0	12.9	98.2
	highly disagree	4	1.7	1.8	100.0
	Total	224	92.6	100.0	
	Missing System	18	7.4		
	Total	242	100.0		

Source :Own Survey

Respondents asked if there is appropriate use and care for containers so that there is no scattering of waste around the containers and the containers placed are enough with respect to the waste generated or not. The finding revealed that majority of the respondents 161 (66.5%) revealed there is no appropriate use and care for containers so that there is scattering of waste around the containers also among the respondents 145 (59%) replied that the insufficiency of containers with respect to the waste generated.

3.2.9. Solid Waste Transport System

4.7. Waste Transport system in Kirkos Subcity

4. Waste Transport System

Table 4.16: Transport system in Kirkos sub city

		Frequency	Percent	Valid Percent	
1	The Waste Transport system is integrated systematically with other waste management activities.	highly disagree	65	26.8	27.4
		disagree	89	36.7	37.5
		neutral	23	9.5	9.7
		agree	59	24.3	24.8
		highly agree	1	0.4	0.4
		Total	237	97.9	100
		Missing System	5	2	
		Total	242	100	
2	The participation of private sector in transportation service of waste is satisfactory	highly disagree	70	28.9	29.6
		disagree	88	36.3	37.2
		neutral	32	13.2	13.5
		agree	44	18.1	18.6
		highly agree	2	0.8	0.8
		Total	236	97.5	100
		Missing System	6	2.4	
		Total	242	100	
3	Optimal route has been determined and applied using different algorithms	highly disagree	76	31.4	32.0
		disagree	80	33.0	33.7
		neutral	44	18.1	18.5
		agree	35	14.4	14.7
		highly agree	2	0.8	0.8
		Total	237	97.9	100
		Missing System	5	2	
		Total	242	100	
4	There are Specialized trucks deployed for Hazardous wastes used	highly disagree	89	36.7	37.5
		disagree	58	23.9	24.4
		neutral	53	21.9	22.3
		agree	31	12.8	13.0
		highly agree	6	2.4	2.5
		Total	237	97.9	100
		Missing System	5	2.0	
		Total	242	100	
5	There is proper preventive maintenance of Vehicles therefore minimum out of service periods of trucks	highly disagree	63	26	26.5
		disagree	77	31.8	32.4
		neutral	57	23.5	24.0
		agree	40	16.5	16.8
		Total	237	97.9	100

		Missing System	5	2	
		Total	242	100	
6	The available truck types designed to handle different types of waste stream with different compartment for different types of waste.	highly disagree	65	26.8	27.4
		disagree	77	31.8	32.4
		neutral	40	16.5	16.8
		agree	55	22.7	23.2
		Total	237	97.9	100
		Missing System	5	2.0	
		Total	242	100	
7	There is an application of technologies to routing such as GIS to optimize routing is applied	highly disagree	88	36.3	37.1
		disagree	64	26.4	27.0
		neutral	32	13.2	13.5
		agree	51	21.0	21.5
		highly agree	2	0.8	0.8
		Total	237	97.9	100
		Missing System	5	2.0	
		Total	242	100	
8	There is a scheduled plan for collection by trucks .Drivers haul waste before need arise	highly disagree	56	23.1	23.1
		disagree	82	33.9	33.9
		neutral	51	21.1	21.1
		agree	44	18.2	18.2
		highly agree	9	3.7	3.7
9	Trucks with different size used for collection and haul SW from transfer station to dumpsite	highly disagree	99	40.9	41.1
		disagree	74	30.6	30.7
		neutral	21	8.7	8.7
		agree	28	11.6	11.6
		highly agree	19	7.9	7.9
		Total	241	99.6	100.0
		Missing System	1	.4	
10	The existing numbers of trucks are sufficient for the current SW generation and collection	highly disagree	43	17.7	17.7
		disagree	108	44.6	44.6
		neutral	1	0.4	0.4
		agree	86	35.5	35.5
		highly agree	4	1.6	1.6
		Total	242	100	100
11	The frequency of waste collection by drivers is High (time travel time for shuttling back and forth to disposal site)	highly disagree	72	29.7	29.7
		disagree	93	38.4	38.4
		neutral	57	23.5	23.5
		agree	17	7.0	7.02
		highly agree	3	1.2	1.2
		Total	242	100	100

Source: own survey result, 2017

As far as solid waste transportation is concerned each sub-city is responsible for transporting site to the final dump site “Rapi” by means of trucks. According to the interview held with the office, the main challenge in this regard include trucks that are very old, maintenance difficulties, negligence of drivers, and frequent accidents. The vehicles carry only a single container at a time to disposal site with maximum Capacity of 8m³ or 2160kgs. Private institutions which have capital of up to 10,000 are obliged to transport their refuses to the landfill site using their own trucks

Fig.4.5. Waste that is ready to be transported (Around Kirkos Area)



Table 4.16 depicts that 154(63.5%) of the respondents disagree the existence of solid waste transport integration with other waste management activities such as recycling, composting, collection and disposal. 65.2 % doesn't believe satisfactory participation of private sector in solid waste logistics system. It is necessary to involve a third party logistics in order to alleviate the

shortage of resources the sub city faces . effective decision-making in the field of management systems requires the implementation of vehicle routing techniques capable of taking advantage of new technologies such as the geographic information system (GIS). Since routing models make extensive use of spatial data, GIS can provide effective handling, display and manipulation of such geographical and spatial information. These tools eliminate hours spent on unplanned routing, maximize productivity, optimize equipment and staff allocations, and allow better control of waste collection operations. Among the respondents 152(62.7%) disagree the application of GIS and other technologies to improve optimize routing.

These tools work with a computer software application that generates efficient vehicle routes for solid waste collection over a road network and can be used for recycling collection services. There is an increasing awareness and need for municipal authorities to reduce their overall operational costs. The use of GIS technology is one aspect that cost-conscious decision makers implement to keep costs down. This is because GIS provides a powerful resource for identifying cost savings in an efficient way. One of the main aims of optimized routing is to minimize travel distances and reduce the fleet size through the design of the optimal and cheapest distribution pattern to serve scattered customers.

Through the optimized routes it is possible to measure the efficiency of a management system, for instance generating an optimal route for a given vehicle will help minimize the cost. The optimal routes are then determined by comparing the different paths. These paths can be calculated by different types of algorithms such as Tabu search, ant colony optimization and genetic algorithm (Karadimas and Loumos, 2008) so that The Addis Ababa cleansing agency sanitation service giving standard manual 2006/7 E.C article number 3 discloses routing to be applied by drivers but 155(65.7%) respondents reveal the absence of routing techniques in the sub city.

In order to optimize the available Vehicles should be scheduled to the vehicles. With regard to scheduling, respondents were asked. 84(63%) of the respondents disagree about the existence of scheduled plan for collection by trucks and they don't believe that drivers haul waste before need arise. 142(58.6) of the respondents disagree the available truck types designed to handle different types of waste stream with different compartment for different types of waste.

A municipal waste collection poses high cost of operating and maintenance cost of vehicles .It is necessary to maintain timely the vehicles .Old trucks have negative impact on the environment due to the quality of miles driven, fuel type, engine inefficiency and exusted gasses emitted.

Among the respondents 140(57.8%) of the respondents replied that the absence of proper preventive maintenance for the vehicles in Kirkos sub city.

There are temporary stations for secondary waste collection and use as transfer stations but they are not standardized one and there so that 173 (71.5%) of the respondents believe that appropriate types of vehicles do not inuse for collection and haul SW from these transfer station to dumpsite.62.3% of the respondents replied that the number of vehicles being under operation in kirkos sub city are not sufficient compared to the amount of waste generated.During the study majority of respondents (68%) disagree that the frequency of waste collection by drivers to be High.

5. Solid Waste Logistics Equipments and Facilities in Kirkossub city

Table 4.17: Solid waste Logistics Equipments and Facilities

		Frequency	Percent	Valid Percent	
1	Storage Equipments at house level, the Dust bins and the push carts are properly designed (Standardized) and in sufficient number with respect to the waste generated	highly disagree	69	28.5	28.6
		disagree	113	46.7	46.9
		neutral	12	5.0	5.0
		agree	44	18.2	18.3
		highly agree	3	1.2	1.2
		Total	241	99.6	100.0
		System	1	.4	
		Total	242	100.0	
2	Transfer station is available to unload collection vehicles, and to load solid waste to dumpsite	highly disagree	69	28.5	28.6
		highly disagree	66	27.3	27.3
		disagree	75	31.0	31.0
		neutral	56	23.1	23.1
		agree	34	14.0	14.0
		highly disagree	11	4.5	4.5
		Total	242	100.0	100.0
		highly disagree	66	27.3	27.3
3	There is Material Recovery Facility(MRF) to separate recyclable materials	disagree	75	31.0	31.0
		highly disagree	70	28.9	29.3
		disagree	95	39.3	39.7
		neutral	42	17.4	17.6
		agree	29	12.0	12.1
		highly agree	3	1.2	1.3
		Total	239	98.8	100.0
System	3	1.2			

		Total	242	100	
4	The sub city has a call center to reach customers regarding Solid Waste Management	highly disagree	70	28.9	29.3
		disagree	95	39.3	39.7
		neutral	42	17.4	17.6
		agree	29	12.0	12.1
		highly agree	3	1.2	1.3
		Total	239	98.8	100.0
		System	3	1.2	
		Total	242	100.0	
5	The necessary Safety materials (Plastic bags, push carts, gloves, musks, uniforms, plastic boots and others) sufficiently provided for solid waste collectors at primary collection stage	highly disagree	29	12.0	12.0
		disagree	105	43.4	43.6
		neutral	24	9.9	10.0
		agree	76	31.4	31.5
		highly agree	7	2.9	2.9
		Total	241	99.6	100.0
		System	1	.4	
		Total	242	100.0	

Source: own survey result, 2017

Table 4.18: The distance that people travel to reach the nearest container

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	100 meters	18	9.2	9.5	9.5
	200 meters	18	9.2	9.5	18.9
	300 meters	60	30.6	31.6	50.5
	and above	94	48.0	49.5	100.0
	Total	190	96.9	100.0	
Missing	System	6	3.1		
Total		196	100.0		

Source: own survey result, 2017

Respondent were asked to assess whether Storage Equipments at house level, the Dust bins and the push carts are properly designed (Standardized) and in sufficient number with respect to the waste generated or not. The finding revealed that majority of the respondents 182 (75.2%) revealed the storage equipments are not standardized and need improvement also currently the

available equipments at the sub city are not sufficient with respect to the amount of waste generated and 154(78.6%) of the respondents replied users travel 300m and above meter to reach the nearest container (skips)

A transfer station is an interface between (short haul) waste collection vehicles and long hauls vehicles more appropriate for long distances to assist in disposal of waste more economically. The purpose is to reduce not only the transport unit cost of collection vehicles, and obtain more cost effective payloads, but also to allow quicker turnaround times on collection vehicles and therefore increased productivity. The need for a transfer station and the degree of required sophistication will be determined by the volume of waste generated, the collection systems implemented, and the distance to the disposal site. The finding from this research also revealed the absence of formal transfer station at the sub city .Majority of the respondents 141(58.3%) confirmed this. Also,in this survey168 (68.2%) of the respondents revealed unavailability of Material Recovery Facility (MRF) to separate recyclable materials in the sub city.

An important part of the collection activities involves customer service with both the frontline interaction of the office’s crews with customers and the handling of customer call requests. The office currently does not have a customer call center or a single number for people to call for information. 165(68.2%) of the respondents replied that no call center related to solid waste management in the sub city. With the recommended call center, a trained customer call technician could process calls for all services provided by the office. .

The necessary Safety materials such as Plastic bags, push carts, gloves, masks, uniforms, plastic boots and others) should be provided sufficiently for solid waste collectors at primary collection stage.134(55%) of the respondents indicated that the safety materials do not sufficiently provided by the sub city.

Different types materials of uses to store at households. Containers, baskets,plastic bags and empty bags are among these materials. Majority of Respondants166 (75.80%) use empty sacks are the most used material. This shows that storage bin for degradable and for non degradable wastes not identified separately.

Table 4.19: Tools in use to store waste at household level

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid metallic containers	12	5.5	5.6	5.6
baskets	28	12.8	13.0	18.6

	plastic bags	9	4.1	4.2	22.8
	empty sacks	166	75.8	77.2	100.0
	Total	215	98.2	100.0	
Missing	System	4	1.8		
Total		219	100.0		

Source: own survey result, 2017

Table 4.20: The rate of SWM service

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	highly satisfactory	30	15.3	15.6	15.6
	average	43	21.9	22.4	38.0
	dissatisfaction	25	12.8	13.0	51.0
	highly dissatisfaction	94	48.0	49.0	100.0
	Total	192	98.0	100.0	
Missing	System	4	2.0		
Total		196	100.0		

Source: own survey result, 2017

Table 4.20 shows that the level of rate given by the respondents for the solid waste logistics service that is being rendered by the sub city highly Satisfied respondents =30 (15.3%), average 43=21.6%, dissatisfied=25 (12.8% and highly dissatisfied =94 (48%). This data shows most of the service users are not satisfied by the service level. So that improvement measures has to be taken.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

1. Conclusion and Recommendation

1.1. Conclusion

SWM and SWL are the important compulsory functions of not only urban local authorities but also of rural local bodies. However, this essential service is not efficiently and properly performed by the concerned bodies of Kirkos Sub city resulting in sanitation, social and environmental problems. Waste management and Solid waste logistics problem is complex because it involves a multitude of scientific, technical, economic and social factors. Similarly, it is observed that lack of financial resources, institutional weakness, improper selection of technology, transportation systems and disposal options, social problem associated with lethargy towards environmental cleanliness and sanitation have made this service unsatisfactory and inefficient in the study area.

1.2. Recommendations

The experiences from some developed countries indicated that reverse logistics related to waste Management, if fully incorporated, is a promising solution for developing countries. The potential for reverse logistic activities such as coordination, route optimization, and innovative materials handling will solve the urban waste problem if applied.

Though there is no single readymade solution to control the waste problems, the researcher found it important to indicate issues requiring serious attention of concerned bodies. The data on generation rate and the percentage contribution of each solid waste source might have changed through time due to the change in demographic and socio-economic conditions of the residencies. Therefore, further study is needed to generate more valid data for current and future planning. Due to the complexity of the situation, cooperation among different parties/citizens should be methods of choice and industries and individuals should work as partners rather than adversary to find a long-term sustainable SWM & SWL system.

Empower the sub city to be in charge of its own Curbside collection; using either its own workforce or contracted service. The sub city should be responsible for the treatment and disposal of the collected waste. The primary reason for this is existence of economies of scale in reuse transportation and disposal.

Based on the research findings, the integrated SWM and SWLS system which combines a range of solid waste treatment options like reusing, recycling, composting, and waste to energy transformation is recommended by building its own at least one transfer facility, recycling facility, composting facilities and Customer call centers. For waste to energy and disposal utilize

the facilities that already built at the city level. Try to fulfilling the necessary logistics equipments at collection and disposal stage.

The estimates indicate that over 12470 tones (60%) of the refuse from most households is biodegradable organic waste which has a potential for replacing inorganic fertilizer to save foreign exchanges earning, also strengthening and implying rural-urban-linkage.

Composting has to also be promoted by all actors who have the concern in poverty alleviation's and environmental protection. Therefore, attention should be given to reusable household wastes. So that out of 12470 tones, 7482 (60%) tones and 4988 (40%) should go to composting and waste to energy facilities respectively.

And 3118 (15%) tones of the waste generated estimated to be recyclable. Recycling should have been given great concern. Therefore, this 3118 should transport to recycling facility. The rest 5196 (25%) tones have been transported to Repilandfill.

Waste needs proper management. The first priority should be to segregation of wastes, preferably at the point of generation, into re-usable and non-reusable for waste reduction and changing in to financially viable material; hazardous and non-hazardous components for avoidance of hazardous containing products and waste workers safety.

Effective and efficient logistic systems, if fully incorporated into proper waste management and better and cheap transport routing system, will help in resource recovery.

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QUESTIONNAIRE
ADDIS ABABA UNIVERSITY

**COLLEGE OF BUSINESS AND ECONOMICS SCHOOL OF
COMMERCE DEPARTMENT OF LOGISTICS AND SUPPLY CHAIN
MANAGEMENT**

Dear respondents:

The intent of this questionnaire is gathering information to a thesis to be conducted with regard to the **Assessment of the Current Solid waste logistics system Related to Solid Waste management: The case of KirkosSub city, Addis Ababa** in partial fulfillment of the requirements for the Master of Logistics and Supply Chain Management Degree and; to be submitted to Addis Ababa University College of Business and Economics School of Commerce, Logistics and Supply chain Department. Therefore, I humbly request you to consider your participation in responding the questionnaire is in high importance so as to give the researcher a great deal of clarity about the issue.

Also, I can assure you that the information to be collected from you are solely for academic purpose and will be treated with strict confidentiality. Once again, I demand your valuable support in filling the questionnaire as patiently and frankly as possible.

Thank you for your time and consideration!

Tamiru Admassu

Contact Address +251911638927

Instruction: Please, put a tick (✓) mark in which you want to select.

Part I: Questions related with Background Information

1. Gender?

Male Female

2. Age: 18-25 years 26-35 years 36-45 years above 45 years

3. Educational Qualification:

Below college diploma College diploma First Degree (BSc, BA)

Second Degree (MSc, MA) PhD and above

4. Current Position.....

5. Year of service in the current position:

Below 1 year 1 to 5 years 5 to 10 years above 10 years

Part II: Question Directly Related to the Study

Section A:To what extent the practice of solid waste logistics practices (Sorting, Recycling,Composting and incineration) at the Sub city. The five Likert Scale points denote: 1=No extent, 2=little extent, 3= moderate extent 4=great extent and 5= a very great extent.

1.	Waste Logistics practices	1 (No extent)	2 (Little extent)	3 (Moderate extent)	4 (Great extent)	5 (Very great extent)
1.1	Sorting					
1.2	Recycling					
1.3	Composting					
1.4	Incineration					

Section B: Questions related with SWLS. To be answered by circling the number.

The five Likert Scale points denote: 1=Highly Disagree, 2=Disagree, 3=Neutral 4=Agree and 5= Highly Agree

2. Waste collection, storage, recycling, and composting and disposal process.		1 (Highly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Highly Agree)
2.1	There is appropriate use and care for containers so that there is no scattering of waste around the containers					
2.2	The containers placed are enough with respect to the waste generated					
2.3	Sorting of waste is being conducted at collection period					
2.4	Sorting of waste is being conducted at disposal period.					
2.5	There is a practice of Institutional composting of organic waste.					
2.6	The formal practice of waste recycling is high.					

Any other, Please State

.....

.....

3.Waste transport System		1 (Highly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Highly Agree)
3.1	The existing numbers of trucks are sufficient for the current SW generation and collection.					
3.2	Trucks with different size used for collection and haul SW from transfer station to dumpsite.					
3.3	The frequency of waste collection by drivers is High (time travel time for shuttling back and forth to disposal site)					
3.4	There is a scheduled plan for collection by trucks. Drivers haul waste before need arise.					
3.5	There is an application of technologies to routing such as GIS to optimize routing is applied					
3.6	The available truck types designed to handle different types of waste stream with different compartment for different types of waste.					
3.7	There is proper preventive maintenance of Vehicles therefore minimum out of service periods of trucks					
3.8	There are Specialized trucks deployed for Hazardous wastes used					
3.9	Optimal route has been determined and applied using different algorithms.					
3.10	The participation of private sector in transportation of waste is satisfactory					

3.11	Waste Transport is integrated systematically with other waste management activities.					
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Any other, Please State

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4.Logistics Equipments and Facilities		1 (Highly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Highly Agree)
4.1	Storage Equipments at house level, the Dust bins and the push carts are properly designed (Standardized) and in sufficient number with respect to the waste generated					
4.2	Transfer station is available to unload collection vehicles, and to load solid waste to dumpsite.					
4.3	There is Material Recovery Facility(MRF) to separate recyclable materials					
4.4	The sub city has a call center to reach customers regarding Solid Waste Management					
4.5	The necessary Safety materials (Plastic bags, push carts, gloves, musks, uniforms, plastic boots and others) sufficiently provided for solid waste collectors at primary collection stage.					

Any other, Please State.....

Section C: Questions related with SWLS. To be answered by putting a tick (✓) mark

1. The frequency of solid waste collection at household level
 Daily Weekly Monthly And above
2. To reach the nearest Containers people travel at least
 100 meters 200 meters 300 meters And above
3. At household level waste disposes
 by burning Throwing to the nearby river Reuse Delivering all waste to collectors
4. Tools that should use to Store waste at households are
 Metallic containers Basins Plastic bags Empty sacks
5. Collection Equipments used to collect waste in the sub city are
 Human powered Animal powered Engine powered
6. Please rate the level of service .The SWM service that is being rendered by the sub city is
 Highly satisfactory Average Dissatisfactory Highly dissatisfactory

Thank you so much!