ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
INSTITUTE OF REGIONAL AND LOCAL DEVELOPMENT STUDIES

ASSESSMENT OF POTENTIALS OF BIO-RECYCLING AS AN ALTERNATIVE TO SOLID WASTE MANAGEMENT IN ADDIS ABABA

BY: DIRIBA WELTEJI

FEBRUARY 2009
ADDIS ABABA, ETHIOPIA

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Approved by Board of Examiners:

Chair person, school of Graduate Committee	Signature
Advisor	Signature
General Examiner	Signature

ACKNOWLEGEMENTS

First and foremost Almighty deserves the fruit of my praise as He is my comforter through out my life time in general and during stay in the University in particular.

Heartedly, I would like to thank my advisor Dr. Aklilu Amsalu for his valuable comments and constructive suggestions without which the completion of this research could be turned to dismay.

My thank goes to my brother, Gebissa Welteji, for his financial, material and moral support. I hope with his absence, I doubt I could precede the challenges.

My gratitude also goes to my colleagues Jonse Gedefa, Damtew Yadeta, Ayalew Abera, Wasihun Gebru, Abebe Alemu and Getachew Gonfa for their moral and material assistance during this research work.

I am indebted to thank institutions with whom I carried out this research such as SBPDA, EPA, BIO-FARM, ENDA and BCBS for their unreserved cooperation in the provision of necessary information and data sources. I would also thank AAU Institute of Regional and Local Development Studies and all its staffs for its material and financial support for this research.

My thank also goes to the ECA Library and its staffs for their cooperation to supply me with necessary and relevant materials.

I am highly indebted to thank Desalegn Chalchissa and his family for their moral support and willingness to provide me with their LAP-TOP computer.

Finally, more others deserve my heart felt thanks that it is difficult for me to list down all of them.

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ACRONYMS

AAHB	Addis Ababa Health Bureau
AAU	Addis Ababa University
BA	Bachelor of Arts
BCBS	Birhan Cleaning and Beautification Service
CBO	Community Based Organization
CSA	Central Statistical Authority
EC	Ethiopian Calendar
ECA	Economic Commission for Africa
EIA	Environmental Impact Assessment
ENDA	Environmental Developmental Action
EPA	Environmental Protection Authority
ETB	Ethiopian Birr
FAO	Food Aid Organization
FBO	Faith Based Organization
FDRE	Federal Democratic Republic of Ethiopia
FSS	Forum for Social Studies
GDP	Gross Domestic Product
GHG	Green House Gas
GO	Government Organization
ICIPE	International Center for Insect Physiology and Ecology
IRLI	International Livestock Research Institute
ISO	International Standard Organization
ITU	International Trade Union
KAP	Knowledge, Attitude and Practice
KG	Kilo Gram
KM	Kilo Meter
M2	Square Meter

M3	Cubic Meter
MHUD	Ministry of Housing and Urban Development
MSC	Master of Science
MSE	Micro and Small Enterprise
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NGO	Non-Governmental Organization
NUPI	National Urban Planning Institute
NRDEB	Natural Resource Development and Environment Bureau
OAU	Organization of African Union
ORAAMP	Office of Review of Addis Ababa Master Plan/ Project
PH	Percent of Hydrogen
SBPDA	Sanitation, Beautification and Parks Development Agency
UDP	Urban Development Planning
UK	United Kingdom
UNDP	United Nations Development Program
UNHCR	United Nations Higher Commission for Refugees
UNICEF	United Nations International Children Emergency Fund
USA	United State of America
USSR	Union of Soviet Socialist Republic
WB	World Bank

ABSTRACT

Municipal solid waste management (MSWM) in Addis Ababa has been the exclusive responsibility of the city administration with minimal participation of the public and other stakeholders. However, inappropriate handling and disposal of MSW is the most visible cause of environmental pollution and bad aesthetic feature in Addis Ababa. This research is mainly aimed at the assessment of existing MSWM method with especial emphasis to bio-recycling/composting activities undertaken by NGOs and private organizations. In order to achieve this objective, qualitative data collection methods were employed. The primary data was collected through in-depth interview with team leaders, experts, project coordinators and owner of private organizations while secondary data was also drawn from documentation units of respective organizations to supplement the primary data. The data was presented by description, tabulation and percentages accordingly.

The research showed that household (yard) composting and decentralized community composting designs and windrow composting process alone are being promoted by the organizations considered in this research as to fit the situation of Addis Ababa because of their technological simplicity and costs. The finding of the research also strongly revealed that the composition of organic waste generated in Addis Ababa exceeds 80 percent out of all solid wastes. Similarly, the laboratory analysis for essential nutrient composition of the produced compost confirmed that it exceeds the essential nutrient in chemical fertilizers. Yet, national compost quality assurance and standard is not well established in the city. Moreover, compost is demanded for forestry, land scaping, rehabilitation of eroded area, park greening and a forestation.

Further more, the research has revealed that absence of sorting waste at source, acute shortage of finance, physical space scarcity, lack of institutional capacity, disposal to ecologically sensitive area, lack of community awareness, poor legal enforcement, lack involvement of research institutions, infrastructure, are some of the areas that intensify the problems of MSWM in Addis Ababa. Moreover, bureaucratic bottlenecks, shortage of means of transport, lack of maintenance are among the indicated factors that call for intervention by government and concerned entities.

CHAPTER ONE

INTRODUCTION

1.1. Background

Municipal solid waste management is one of the major services provided by the municipal government in metropolitan areas. In the face of rapid population growth and industrial boom solid waste management plays a critical role in protecting the urban environment and improving health of urban community. In terms of expenses it consumes about 20 to 50 percents of available operational budget of the municipality (Bartone, et.al 1990). In many developed countries about 70 percent of the municipal solid waste is disposed off in sanitary land fill. But, in Africa, the prevalent methods of solid waste disposal sites are open dumps, some of which are situated in ecologically sensitive areas. Recently, however, some countries have moved towards improved landfill practice. Egypt and South Africa have considered policy changes to promote upgraded landfills for their major cities (Fisseha, 2005).

As in most cities of developing countries, inappropriate handling and disposal of solid municipal waste is the most serious cause of environmental pollution in Addis Ababa (ORAAMP, 2002). When it was established in 1887 by Emperor Minilike II and Empress Taytu, there was no a mental set up for a disciplined hand of urban planning to incorporate such services. However, the importance of municipal solid waste disposal was felt in 1968 and the dumping site nick named "*Repi*" or "*Koshe*", commissioned well outside the city perimeter at the time. It is located 13km away south west from the center. All the collected waste is indiscriminately relegated to this fenceless site. The site has already been filled up by an estimated two million tons of waste and an extension of about 25 hectares was commissioned currently (SBPDA 2005). The method of disposal is crude open dumping, hauling the wastes by truck, spreading and leveling by bulldozer,

and compacting by compactor. The spreading and leveling by bulldozer, and compacting by compactor enable the waste to be collected in a pre-defined area, enhance reduction of fly and rodent breeding, and reduce internal heat generation through times which destroys combustible materials. Its management has been the task of Addis Ababa Health Bureau since 1980s. This includes the provision of collection containers, collection, transportation, and disposal in the landfills, street sweeping and management of public toilets (AAHB, 1997).

Based on the constitution of the country that grants its citizens to live in a healthy environment, the city administration has accorded highest priority for environmental sanitation and waste management. As a commitment for clean and green environment, it has established Sanitation, Beautification, and Park Development Agency of Addis Ababa (SBPDA) and Addis Ababa Environmental Protection Authority (EPA) in 2002, respectively. SBPDA has endorsed comprehensive waste management sectoral policy. As per the sectoral policy formulated by SBPDA, local NGOs like Bio-Farm Ethiopia, Environmental Development Action (ENDA) Ethiopia, and other formal Micro and Small Enterprises (MSES) are engaging in various ways in handling Municipal Solid Waste (MSW) in Addis Ababa. They are introducing new methods of Municipal Solid Waste Management (MSWM) for the city such as bio-recycling, urban agriculture and recycling of recyclable materials from waste streams. Currently, only 60-70 percent of the solid waste is estimated to be collected and disposed off (SBPDA, 2007). The remaining waste is left unattended. This aggravates the city's poor environmental conditions and affects the overall health status of the population in general and the poor in particular. Therefore, it is important to look for an alternative ways of waste management such as bio-recycling which is an important area of investigation in this research.

1.2. Statements of the Problem

Solid waste management in many of the world's largest urban areas is in crisis as populations attracted to cities continue to grow. This has led to ever increasing quantities of domestic solid waste while space for disposal decreases. Municipal managers are looking to the development of sanitary landfills, which requires large areas around the peripheries of the cities as well as good day to day operation to minimize negative environmental impacts (Rand et al, 2000). However, capital and operational requirements for these plants are greater than required for landfill. In Addis Ababa, a total amount of 75,100 tons of organic material is estimated to be disposed every year without further recycling process and utilization (Greiling et al 2000). Similarly, estimates of Sanitation, Beautification and Park Development Agency of Addis Ababa city (SBPDA 2003), indicated that the daily solid waste generation of the city is 2,297M^3 or 851 tones, out of which the municipality collects about 70 percent as a solid waste. The remaining 30 percent is disposed off through informal means with the exception of smaller percentages going into incineration on open sites.

In addition to high cost incurred on the city administration to transport the waste material to "*Reppi*", a locality at the outskirt of the city, improperly disposed waste is greatly affecting the health of the people and aesthetic features of the area. Each *kebeles* in Addis Ababa has no more than two or three solid waste collection containers. Besides containers are not protected from rain and sun that makes the garbage to cause bad smell, unsightly urban scene, deterioration of aesthetic feature of the neighborhoods, and disturbance to human activities. The sites where containers kept are also exposed to animals like dogs, cats and others during scavenging and scatter the waste in the surrounding area (Tadese, 2004). In the squatter settlements which occupy a substantial area of city, garbage collection is often non existent or inefficient either due to unpaved street or the settlement fall out side of the official service perimeter (Zenebework, 2000).

The Problems are further accelerated by rapid growth of population with its growth rate of over 3.8 percent per annum and expected to double every 20 years (ORAAMP, 2002). The funds allocated by the municipality for collection, handling and disposal are insufficient to meet the requirements of handling the increasing volume of municipal solid waste. The organization responsible for the collection and disposal is inefficient or poor. This is due to among other factors, the shortage of funds and partly because of its type. Yet solid waste management in Addis Ababa relies entirely on municipal services, which is expected to provide the full range of collection and disposal. The majority of the population of Addis Ababa fall under low-income category and their capacity for financial contributions in sustainable solid waste management is insignificant. In addition, sound municipal solid waste management is a complex task which demands the organization and cooperation among all stakeholders such as households, communities and other concerned entities, as it is an essential task for public health and sustainable quality of urban environment. The organic content of the municipal solid waste in the typical African cities exceed 70 percent on wet bases, even though centralized composting, anaerobic digestion, and gas recovery are not significant components of Africans' municipal solid waste management practices. This fact is also true in Addis Ababa where the organic content of the green waste exceeds 60 percent (Fisseha, 2005).

For proper planning and handling of the problems of municipal solid waste, the real picture and magnitude of the problems should be well studied. To this end, the government had commissioned few consultants from abroad in the early 1980s and 1990s. For instance, the research conducted by ORAAMP in 2002, suggested increasing the number of landfill by commissioning other four sites: Filidoro; North West, Dertu; South West, Yeka Abado; North East, and Bole Arabsa; South East. Similarly, the study conducted by consultant in collaboration with NUPI and MHUD in 1989 proposed additional new landfill sites for waste disposal for Addis Ababa at the quarry between Gafersa and Burayou, at the divide between Entoto and Gojam road, and south of Bole. It was timely given to the concerned bureaus for approval in line with Environmental Impact Assessment, land fill design and the like but there is no response for the request.

Furthermore, to give a little solution, the previous landfill is closed and an extension to the south east of it was commissioned on 25 hectares. It is this extension part that is functioning now. The scavengers who are continuously working at the landfill are causing operational problems, fire and pose a threat to labor and property.

However, the emphasis have been given to the improvement of the efficiencies of existing open dumping method rather than options of waste reduction at source, reuse, recycling and composting. The municipality also did not develop clear regulations and policies until then. Moreover, in order to curb these environmental problems, alternative solid waste management such as bio-recycling option play a significant role. This work will contribute in filling the gap in research on the area and will be valuable for the practitioners, planners and policy makers; due to its relevance in Addis Ababa's situation through the assessment of potential alternative municipal solid waste management activities by formal institutions in Addis Ababa.

1.3. Objectives of the Study

1.3.1. General Objective

- To assess and describe the situation and potentials of bio-recycling activities of the formal institutions as alternatives to solid waste management in Addis Ababa.

1.3.2. Specific Objectives

- To assess major activities of the formal organizations working on bio-recycling in Addis Ababa.
- To explore and describe potential benefits of bio-recycling/composting as an alternative solid waste management in Addis Ababa.
- To explore options of skill transfer and replication of bio-recycling /composting technology else where to the community and other stakeholders.
- To indicate constraints and prospects of bio-recycling/composting activities in Addis Ababa

1.4. Methodology

1.4.1. Research Design

Waste management activity is in a changing situation due to rapid population growth and industrialization which requires longitudinal study design. However, since these institutions are few in number, short in duration of engagement, costly and time taking, the study employed is a case study design.

1.4.2. Sources of Data

The study employed both primary and secondary sources. Primary data is collected from two experts of SBPDA, one team leader of environmental pollution control department and one coordinator of composting demonstration site of Addis Ababa EPA, one farm manager and one coordinator of demonstration site of integrated Bio-Farm Ethiopia, one waste management expert and one project coordinator of ENDA Ethiopia, owner and manager of Birhan Cleaning and Beautification Service through in depth interview. Secondary informations were obtained from different reference books, publications of international organizations, reports, Journals, archives, Central Statistical Authority (CSA) documentations, published and unpublished sources and different internet websites.

1.4.3. Methods of Data Collection

In this thesis qualitative data collection method was used. Subjects of qualitative data were mainly team leaders, experts and owners of the five purposively selected formal institutions. To collect data ten enumerators were trained for two days in order to understand the questions properly. Data collection was conducted from May 26 - June 3, 2008 and November 2008.

In-depth Interview

Qualitatively, through guidelines or checklist two experts each from SBPDA, EPA, ENDA Ethiopia, Bio-Farm Ethiopia and an owner of Birhan Cleaning and Beautification

Services, with a total of 9 individuals are involved. Due to face to face interaction rich information was generated. At the same time the experts enriched the data out of their rich experience on the area. This tool also helped to generate detailed information on generation, collection, disposal and processing of solid wastes. The rationale behind the decision to use this tool was that the number of purposively selected formal institutions involved in bio-recycling/composting in Addis Ababa is few in quantity and unique in their involvement in bio-recycling activity. Moreover, it is believed that team leaders and experts better understand about bio-recycling/composting activities and other methods of municipal solid waste management in Addis Ababa.

Personal Observation

Personal observation was employed by the researcher to validate and compare the informations generated through other tools with the reality on the ground. The researcher observed the demonstration sites of Bio-Farm Ethiopia, Addis Ababa EPA, the collection sites at Piazza fruit market area where the workers of Birhan Cleaning and Beautification Service were collecting, sorting and loading the waste according to the intended destination of the garbage by their types. Some pictures are also attached to supplement with facts gained from other sources.

1.4.4. Method of Data Analysis

Careful collection of appropriate primary data was drown from the experts of the five institutions by administration of unstructured questionnaires for in-depth interview and followed by describing, editing, arranging in tabular, and percentage presentation. The issues explored through in-depth interviews with eight experts, two from each organization and an owner of a business organization on major aspects of MSWM were descriptively presented in line with specific objectives, sub-checklist and the specific activities of each organizations.

1.5. Significance of the Study

The performance of solid waste management system is poor, inefficient and insufficient. The sole dumping site commissioned in 1968 is now getting full and it is partly surrounded by legally constituted residents. At the same time it does not have gas control and liners in order to prevent air pollution and ground water contamination. It is also impossible to continue with single landfill, having rapid population growth due to natural increase and net migration as well as rapid growth of diverse economic activities. Limited previous studies emphasized the existing methods and gave less focus to bio-recycling/composting. This research, however, emphasizes solid waste management approach through bio-recycling/composting based on the assessment of the potential benefits, constraints and prospects of bio-recycling activities in Addis Ababa. Therefore, the research output in the assessment of the potential of alternatives to solid waste management activities as bio-recycling helps abate the problems on the one hand and enhance planners and policy makers on the other in order to exploit this untapped cost effective socially and environmentally friendly option.

1.6. Scope of the Study and limitation

The scope of the study was limited only to formal organizations that are currently engaged in composting in Addis Ababa and SBPDA, the municipal agency in charge of municipal solid waste management regardless of the fact that there are large proportions of informal itinerant waste collectors, recyclers and processors, scavengers and compost dealers, door-to door collectors, incinerators of various kinds and the like. Even if bio-recycling/ composting is an ancient or traditional informal activity in Ethiopia, the formal ones are recent and scarce in engagement in this activity. At the same time organized information sources, researches and source of compiled data is limited. Furthermore, financial resources and time are also very much limited to deal with this research at depth it requires.

1.7. Organization of the Thesis

This study is organized into five main chapters. The first deals with introduction that includes backgrounds, problem statements, methodology and scope. The second chapter is concerned with related theoretical and empirical literatures while the third deals with overviews of the profile of the institutions and the study area. Chapter four deals with presentation, analysis of data and discussion. The fifth chapter is about the conclusion of the research and policy implication

1.8. Definition of terms

Aerobic Composting: a method of Composting organic wastes using bacteria that need oxygen. This requires that the waste be exposed to air, either via turning or by forcing air through pipes that pass through the material.

Composting: biological decomposition of solid organic materials by bacteria, fungi, and other organisms into a soil-like product.

.**Commercial waste**: waste from shops, offices, restaurants, hotels, and similar commercial establishments typically consisting of packaging materials, office supplies and food waste. In lower-income countries, food markets may contribute a larger proportion of the commercial waste. It may also include hazardous components such as contaminated packaging materials.

Controlled dump: a planned landfill that incorporate to some extent some of the features of a sanitary landfill sitting with respect to hydro geological suitability, grading, compaction in some cases, leachate control, partial gas management, regular (not usually daily) cover, access control, basic record-keeping, and controlled waste picking.

Industrial waste: waste components similar to domestic and commercial source waste including food wastes from kitchens and canteens, packaging materials, plastics, paper and metal items. Some production processes however, utilize or generate hazardous (chemical or infectious) substances. Disposal routes for hazardous wastes are usually

different from those for non-hazardous wastes. The composition of industrial waste depends on the kind of industries involved.

Institutional waste: waste from schools, hospitals, clinics, government offices, military bases, and so on. It is similar to both domestic and commercial wastes, although there is more packaging materials than food waste. Hospital and clinical waste include potentially infectious and hazardous materials.

Incineration: the process of burning solid waste under controlled conditions to reduce its weight and volume, and often to produce energy.

Municipal solid waste management: planning and implementation of systems to handle municipal solid wastes.

Open dump: an unplanned landfill that incorporates few if any of the characteristics of controlled landfill. There is typically no leachaate control, no access control, no cover, no management, and many waste pickers.

Organic waste: technically, waste containing carbon, including paper, plastics, wood, food wastes, and yard wastes. In practice in MSWM, the term is often used in more restricted sense to mean material that is more directly derived from plant or animal sources, and which can generally be decomposed by microorganisms.

Recyclables: items that can be reprocessed into feedstock for new products. Common examples are paper, glass, aluminum, corrugated card board, and plastic containers.

Recycling: the process of transforming materials into raw materials for manufacturing new products, which may or may not be similar to the original product

Sanitary landfill: an engineered method of disposing of solid waste on land, in a manner that meets most of the standard specifications, including sound sitting, extensive site preparation, proper leachate and gas management and monitoring, compaction, daily and final cover, complete access control and record keeping.

Solid waste: organic and inorganic waste materials that have lost their value in the eyes of the first owner and which are produced by house holds, commercial, institutional and industrial activities.

CHAPTER TWO
LITERATURE REVIEW

This chapter is concerned with relevant works that deal with the topic under investigation. This include different concepts of municipal solid waste management, empirical evidences, types of waste managements methods developed and their positive or negative social, economical, and ecological effects. Similarly, experiences of different countries in choice of methods are viewed and special attention is given to bio-recycling. Besides, the existing municipal solid waste management conditions, some aspects of its mishandling and available legal frame work in Addis Ababa is reviewed.

2.1. Review of Theoretical Literature

Solid waste arises from human activities; domestic, industrial, agricultural, waste water treatment and so on. Waste management usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetic. It is also carried out to reduce resources from them. It involves solid, liquid, gaseous or radioactive substances with different methods. At the same time waste management practices differ for developed and developing nations, for urban and rural areas, for residential and industrial producers (Wikipedia Encyclopedia, 2008). Urbanization and rapid growth of cities increase the amount of waste generated. If it is not properly handled and treated it will have negative impact on the hygienic conditions in urban areas and pollute air, surface water, ground water, soil and crops every where whether in developed or developing world. Hence, an efficient collection system and an environmentally sound sanitary landfill is the backbone of any waste management (Rand et al 2000).

Accordingly there are a number of concepts about waste management which vary in their usage between countries or regions. These include (1) ***waste hierarchy*** which refers to

reduce, reuse and recycle and classify waste management strategies according to their desirability in terms of waste minimization, to extract the maximum practical benefits from products and to generate the minimum amount of waste. (2) ***Extended producer responsibility*** is a strategy designed to promote the integration of all costs associated with products through out their life cycles into the market price of the product. It is meant to impose accountability over the entire life cycle of products and packaging introduced to the market. Firms which manufacture, import and /or sell products are required to be responsible for the products after their useful life as well as during manufacture.(3) ***Polluters pay principle*** is where the polluting party pays for the impact caused to the natural environment. This refers to the requirement for a waste generator to pay for appropriate disposal of the waste. Accordingly, general waste management or treatment methods all over the world are schematically summarized here under:

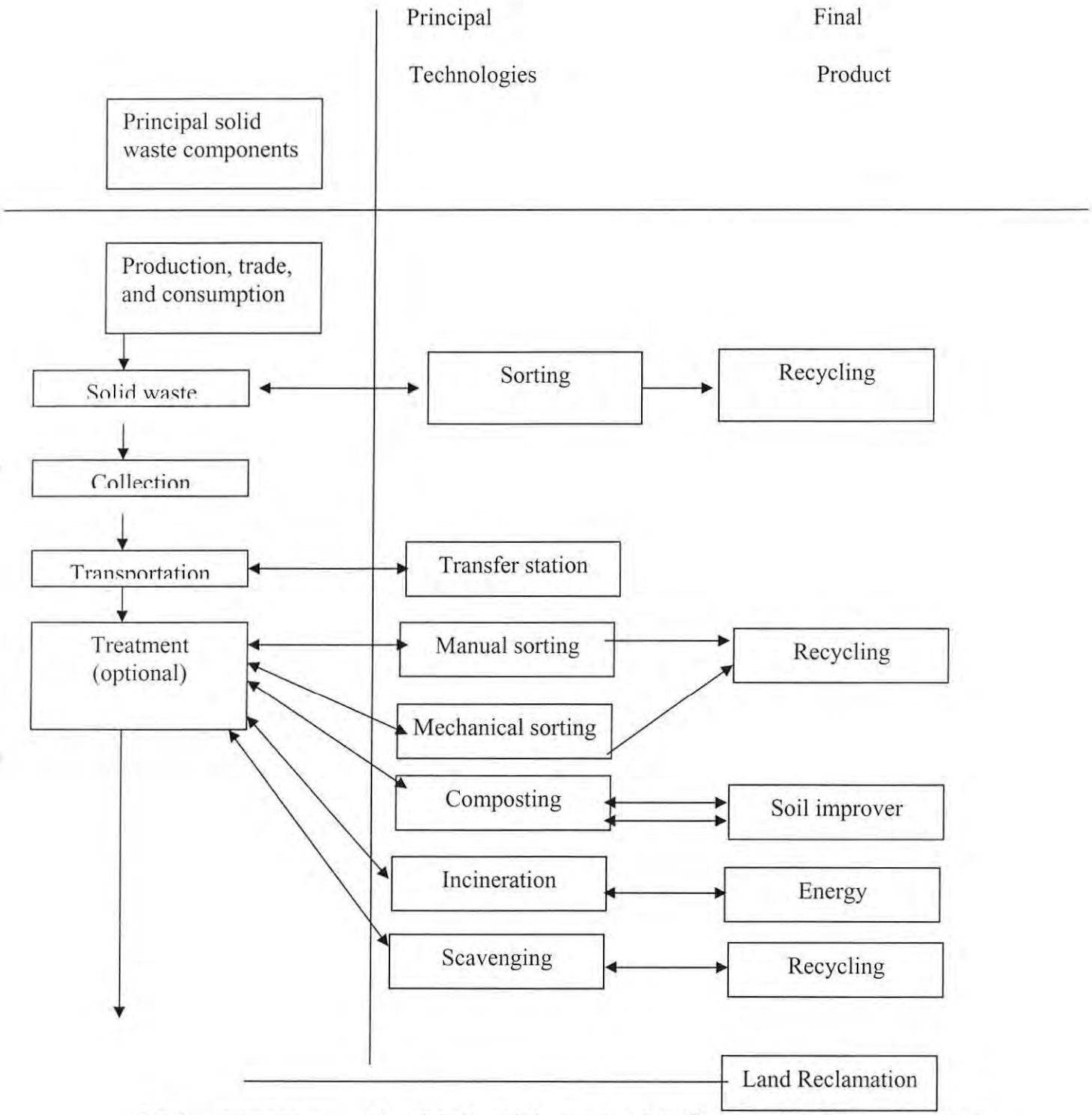

Fig.1. Components of global solid waste handling and treatment system.

Source: Adopted from Rand et al (2000)

2.2. Review of Empirical Literature in MSWM

2.2.1 The Experience of Developed Countries

As a matter of fact cities in developed nations produce huge municipal solid waste. In average, a person living in an industrialized country produces as much as 695kg of solid waste per annum. Estimated generation of domestic solid waste per person equivalent in some industrialized countries is summarized as follows.

Table 2. 1: Per-capita waste generation per year in selected developed countries.

Country	Kilograms	Pounds
Australia	690	1520
Canada	630	1390
France	590	1300
Germany	400	880
Japan	400	880
Mexico	300	660
South Korea	400	1880
UK	440	970
USA	720	1590

Source: Organization for Economic Cooperation and Development, Environmental data 1999, cited in Stevenson (2006).

According to Stevenson (2006), each year, North Americans alone throw out enough office and writing paper to build a 12-foot wall from Los Angeles to New York city; every two weeks they dispose off enough glass of bottles and Jars to fill up the 110-story twin towers of new York's world trade center; every hour they throw out 2.5 million plastic bottles, only about one-fifth of which are recycled. As the population of the United States of America and other countries rises, so too do the mountains of garbage including toxic and hazardous wastes that people throw away day after day.

Similarly municipal solid waste management statistical source of USA as indicated in journal of composting and organic waste recycling in 2006; annual MSW generation is 388 million tons, MSW land filled 248.6 million tons, recycled or composted 110.3 million tons, MSW combusted 28.9 million tons per year and per capita waste generation was 1.3 tons per year per person. When this is converted to percentages 64.1percent of MSW is land filled, 28.5 percent of MSW is recycled and 7.4 percent of MSW is combusted or incinerated (BioCycle, 2006).

The Sanitary Landfill: The most common destination for ordinary garbage is a sanitary landfill, a dump where dirt is used to cover the garbage, so as to prevent it from blowing away and keep down odors. According to Franklin associates (2006), a consulting firm that studies solid waste issues for the EPA, as cited in Stevenson (2006), in 1990; 66.6 percent of the country's ordinary garbage ended up in landfills in USA and 82 percent in Canada. In USA, most garbage is deposited in landfills; talk of a garbage crisis focuses on their dwindling numbers. In early 1970s sanitary landfills from a high of about 20,000 dropped to about 6,600. Most of the landfills closed in recent years have been small operations, many of which were poorly run and lacked environmentally protective features such as thick liners to prevent toxic liquids from leaking out. In the United States, tougher federal landfill regulations, which EPA issued in 1991, are expected to cause even more of these kinds of dumps to shut down by 1995 (Stevenson,2006).

People object to landfills for a number of reasons; they anticipate blowing garbage, foul odors, rodent infestations, increased truck traffic in the neighborhood, and lowered property values. From an environmental and public health stand point, probably the most legitimate concern about a landfill are its potential to pollute the underlying groundwater with leaking liquid, called leachate. The federal government now requires landfills to have thick liners to prevent leachates from escaping and a system of pipes to collect leachate within the landfill and carry it to a treatment facility. Other pipes can draw off the methane gas that rotting garbage gives off, which can be purified and burned to create electricity. Some landfills also have monitoring wells outside the landfill that will allow the early detection of a leak (Ibid).

***Incineration*:** Municipal incineration is found at the most advanced level of the waste disposal or treatment hierarchy; dumping, land filling, sanitary land filling, medical treatment (composting and incineration). Opposition to landfills, however, has led some garbage haulers and municipalities to invest instead in incinerators. In the USA these have more than tripled in number since 1985, when some 50 incinerators burned nearly 8 million tons of trash. In 1992 more than 175 incinerators received over 32 million tons of garbage (Rand et al 2000; Stevenson, 2006).

According to the same author, waste officials and bureaucrats prefer to call incinerators "waste-to-energy or resource recovery," facilities. The steam which does not come into contact with the garbage can be sold to local industries that use steam in their manufacturing process, and the electricity which is generated by turbines driven by steam from incinerator, is fed to the local electric utility, reducing the utility's consumption of coal or natural gas. These beneficial uses of the energy stored in garbage are one reason the EPA favor incineration with energy recovery over the use of landfills. Incinerators also require less land than garbage dumps, and they do not pose the potential threat to ground water that land fills do.

Furthermore, in the mid 1980's a number of Eastern European and Asian cities jumped directly from simple dumping to incineration. In the former Soviet Union, for instance, several plants were commissioned in the 1970s and early 1980's. Unfortunately, some of these plants were never completed, others were discontinued, and the rest are operating at reduced capacity because of financial, managerial, and operational shortcomings. Moreover, in Asia, there is limited experience with waste incineration outside the industrialized countries of Japan, Singapore, and Taiwan. A few plants in other places have experienced managerial or operational problems inducing low calorific value of the waste due to scavenging, precipitation, or the basic composition of the generated waste. Unfortunately, oppositions to incinerators usually revolve around the issues like toxic air pollution and disposal of the ash that is left after garbage has been burned. States require specialized equipments equipped with complicated mechanical systems, they are expensive than landfills (Stevenson, 2006; Rand et al 2000).

Hazardous Waste Management: Hazardous waste in the United States is regulated under the 1976 Federal Resource Conservation and Recovery Act, which holds waste producers responsible for the proper handling, treatment, and disposal of materials classified as hazardous. The majority of hazardous waste-over 95 percent in the United States and over 80 percent in Canada is treated where it is produced. For instance, **on-site** waste water treatment facilities extract chemicals from water used by the industry. **Off-site** treatment options are either incineration or land filling, but the facilities for hazardous waste are smaller and more tightly regulated than those for regular garbage so as to reduce the chance of accidental release to the environment (Stevenson 2006).

***Recycling*:** The practice of recycling solid waste is ancient one. Metal implements were melted down and recast in prehistoric times. Today, recyclable materials are recovered from municipal refuse by a number of methods including shredding, magnetic separation of metals, air classification that separates light and heavy fractions, screening, and washing. Increasingly, municipalities and private refuse-collection organizations are requiring those who generate solid waste to keep bottles, cans, newspapers, cardboards, and other recyclable items separate from other waste. Special trucks pickup this waste and cart it to transfer stations or directly to recycling facilities, thus lessening the load at incinerators and land fills (Jerry and Huang, 2006).

As to Stevenson (2006) an early model for this kind of enterprise was the Ontario "blue box" system, which won the United Nations Environmental award in 1989. Some 2.8 million Ontario households recycle through the program since 1983. In European cities, also there are complex plants which process municipal solid wastes and produce different out puts such as energy, glass equipments, metals, woods and paper. To facilitate recycling in urban areas, however large containers of the various types of recyclables can be set up in convenient locations, so that apartment dwellers can drop off recyclables regularly. Buy-back centers can also be established, giving the poor an incentive to recycle by paying them for their recyclables. The search for technological solution is driven by the relatively high cost of labor versus capital. In case of developing countries

resource scarcity particularly that involve foreign exchange expenditures, may be the driving force. Even then, a labor intensive approach is preferred to capital intensive (James, 1985; Stevenson, 2006).

However, investment in recovery technology will bear certain level of risk whether done in developed country or developing country. For instance, inefficient collection method and the collapse of price for discarded newspapers have sent the cost of the blue box program soaring. Moreover, opportunities that recycling creates include; recycling saves landfill space, reduces the cost of waste disposal, saves energy ,saves natural resources ,reduces air pollution, and creates jobs (USA 's EPA,2006; James, 1985)

2.2.2. The Experience of Developing Countries

According to Abebe, 2006 in most of the developing Latin American, Asian, and African countries solid waste management is carried out by micro and small enterprises run by private sector and the destination of bulk of collected municipal waste is open dump. The majority of them are involved in cleaning of public areas, collection and some waste recovery such as recycling and composting which is driven by economic motives for survival.

For instance, the private enterprises in Latin America are organized and initiated by different actors such as small entrepreneurs, in the cities of Guatemala, El Salvador and Costa Rica, offer waste collection services directly to the population with municipal approval. Informal recovery workers (waste pickers and itinerant waste buyers) initiate an organization and undertake entrepreneurial work. They receive support from churches. Cooperatives in Brazil and Colombia are examples of this type of initiative. The other actors are community based organizations formed by the community to respond to its own needs. Examples are found in Costa Rica, El-Salvador and found in Guatemala. These cooperatives basically respond to community interests and usually have very limited relationship with the municipalities. NGOS are also some types of initiative that

have close links with the communities and which generally work in waste collection in low income areas and prevail in Bolivia, Peru and Colombia (Abebe, 2006).

In a similar manner Asia, for example in 1987, Bangkok contracted three districts for services. The cost for the contract service appears to have been lower for each ton than the costs for public services. The private service was also considered to be of adequate quality. In 1988, Jakarta began to experiment with the private contracting for collection in 261 sub districts (10 percent of the city's waste generating area), which were comprised of middle-to-high income residents in relatively laid out development (Cointreau, 1994).

There were two types of enterprises participate in solid waste management activities in south Asia:1) Community-Based enterprises and 2) Labor contracted by community leaders or social organization. Community participation is supported by an international NGO. For instance, EXNORA is an international NGO, which is active in many Indian Cities such as Chennai (Madras). Labor contracted by community leaders or social organizations in south Asia mainly refers to the provision of waste services by direct labor contracting by a group of residents, community leaders, CBOs, NGOs or another organization. In Indonesia for instance, many local leaders, especially of low-income neighborhoods, organize the community to deliver household refuse to a communal depot, or hire and manage workers from the neighborhood for door-to door waste collection using handicrafts (Ibid).

Accordingly African cities follow the same pattern. For instance, private solid waste entrepreneurs are spread all over the city of Dare-Salaam. Most of their activity is concentrated in residential neighborhoods and is biased towards the middle and higher income areas .There is no private solid waste collection sector in low income areas. In a recent survey about 70 percent of the small firms mainly serve middle-income and some lower-middle income areas. On average each of these small firms serves about 500 clients (Abebe, 2006).

In Nairobi, organized and commercial private sector companies such as Bins and Disposal service Limited is registered to manage, collect, and dispose solid waste from industries, institutions, commercial establishments and high-income residential areas. By 1996, the combined daily collection capacity of the two private companies was 400 and 100 tons respectively. In Nigeria (Lagos), there are nearly 100 private contractors; most with only 1or 2 vehicles and less than 10 with more than 5 vehicles participate in solid waste collection and disposal where a number of workers earn their subsistence income (Cointreau, 1994; Abebe, 2006).

2.3. Composting, Composting processes and design

2.3.1. Global composting process

Depending on available labor, level of technology, input, market and weather condition the prevailing composting processes include windrow composting where organic matter is built into large piles which is physically turned on a regular basis, relatively simple technology, labor intensive and cost effective; in-vessel composting occurs inside an enclosed container or vessel and relies on various methods of aeration and mechanical turning to control the process, where a plug flow system operates on first-in first out or a dynamic mix of material mechanically throughout the process; and vermi-composting also known as vermi-culture, is a simple technology using the natural digestion process of red worms and earth worms to break down organic materials. Worms multiply fast under optimum conditions eight worms can produce 1,500 new worms within six months and from the time it hatches a worm can consume daily its body weight and its casting contains high concentration of nitrates, potassium, calcium, phosphorous, and magnesium can be applied instead of chemical fertilizers in agriculture (Daniel et al, 1999; Bartone et al, 1990)

2.3.2. Types of Global Composting Design

Composting occurs whenever there is sufficient oxygen, water and ambient temperature. Designing a composting system usually involves optimization between: transportation, labor, capital costs, feed stock (inputs) and markets (Lardinois and van de Klundert, 1995; Daniel et al, 1999). Based on their intake capacity and available inputs, the three popular composting designs are residential (yard) composting, decentralized community composting and centralized large scale composting. Residential Composting (Yard composting) is promoted when a significant number of homes have individual or collective yards, gardens, and sufficient space and generate less than 5 tones. Similarly decentralized community composting is a community or neighborhood scale composting that can be practiced by households or commercial establishments in an area generating between 5 and 50 tones of organic waste per day, while centralized composting is a significantly large-scale which can be practiced by generators of waste ranging from 10 tones to more than 500 tones per day (Daniel et al, 1999).

2.3.3 Global Physical Parameters of Composting Process

The physical ingredients of composting process include: oxygen, moisture, nutrients, and temperature. Composting is an aerobic process that by definition requires oxygen. Physically turning the compost or providing forced aeration maintains aerobic conditions and limits odors. Excessive temperatures also indicate that the materials are not receiving adequate flow of air (Daniel et al, 1999).The preferred moisture content for composting is between 50 and 60 percent. At low moisture content below 40 percent will slow the composting process where as high moisture content over 65 percent will restrict air movement through the pore spaces and anaerobic conditions (Lardinois and van de Klundert, 1993).

Carbon and nitrogen are the most important nutrients in the composting process. A carbon to nitrogen ratio ranging from 20:1 to 25:1 is optimum for composting organic wastes, but higher ratios may be possible. This can be attained by combining various

organic wastes as leaves (high in carbon, low in nitrogen) and food waste (high in nitrogen) to balance the carbon to nitrogen ratio (Tchobanoglous et al, 1993). Moreover, the activities of micro organisms release energy in the form of heat which is dissipated by water evaporation. Temperature rapidly rises in the initial composting stages and eventually decreases as the biodegradable organic carbon is consumed. However, temperature regulation by turning the pile is very important weekly or bi-weekly. As smaller particle size will increase the rate of aerobic decomposition due to increasing surface area, wood chips, recycled compost, crop residues, bark, leaves, waste paper, and shredded tires are some bulking agents added to the raw materials to maintain adequate porosity within the compost pile (Daniel et al, 1999; Bartone et al, 1990).

2.3.4 Chemical parameters of composting process

According to (WB, 1997a), compost should meet the following chemical parameters to ensure a safe product that it is stable. F**irstly** carbon to nitrogen ratio of less than 22 to be safe for agricultural use, **secondly**, mature compost should not re-heat over 20^{O}_{C} upon standing: **thirdly**, mature compost should reduce the volume of raw material by at least 60 percent. **Fourthly,** manual or mechanical screening (sieving) is an effective method to remove unwanted objects, recover bulking agents and separate organics that are completely decomposed. **Screening** also provides different grades of compost based on the particle size; usually coarse compost is returned back to the process to be further refined. Furthermore, heavy metals such as cadmium, lead and mercury are found in MSW because of discarded objects like batteries, lighting fixtures, paints, and inks. Even if heavy metals in compost pose very little health threats to workers, a public health hazard exists when poor quality compost is used for agricultural purposes because heavy metals can accumulate in soils and enter the food chain through plant uptake (Daniel et al 1999; Favoino, 1999).

Table-2.2: Global compost standard of heavy metals as April 1996

	(mg/kg dried matter)							
Country	**AS**	**Cd**	**Cr**	**Cu**	**Pb**	**Hg**	**Ni**	**Zn**
USA(s)	41	39	1200	1500	300	17	420	2800
Canada (MO)	13	2.6	210	128	83	0.83	32	315
Ontario (SSMO)	10	3	50	60	150	0.15	60	500
Austria (MO)	-	4	150	400	500	4	100	1000
Belgium (SSMO)	-	1	70	90	120	0.7	20	280
Denmark	-	1.2	-	-	120	1.2	45	-
France (MO)	-	8	-	-	800	8	200	-
Germany	-	1	100	75	100	1	50	300
Switzerland	-	3	150	150	150	3	50	-
Spain	-	40	750	1750	1200	25	400	4000
Indonesia (Proposed)	10	3	50	80	150	1	50	300

Source: (Daniel et al, 1999)

Due to the fact that the standards of composts are site specific, developing countries should be cautious in applying industrialized country compost standards. It is also suggested that the standards be re-evaluated after five years of experience with MSW composting in different communities (Daniel et al, 1999).

2.3.5: Compost Quality Assurance and market Conditions

Testing of composts through the application of quality assurance system proves to be a crucial point in the overall development of composting strategies. This is because quality assurance is a good tool for sales promotion and positive image for the compost product. It is also the basis for the product marketing and declaration for which quality compost is marketable on a large scale. Quality assurance systems for composted products have already long been playing a central role in the composting framework in central Europe. As a matter of fact, a quality assessment links the quality of the end products to all the elements of the process management (Favoino, 1999).

Table-2.3: status of quality assurance at composting plants in central Europe in 1999

Country	Plants with quality assurance	Plants with quality sign
Austria	18	2
Belgium (Flanders)	21	5
Germany	340	300
Netherlands	22	2

Source: Favoino, 1999.

Theoretically, there is unlimited market for good quality compost. However, effective marketing framework and strategies have been the fundamental tools to overcome initial worries about lack of demand for the product. In all countries, hobby gardening, horticulture and landscaping are a successful market in Europe and generally constitute major marketing basis for composted products. However, the cost of production, transportation and application can exceed the benefits. Therefore, good marketing program and strategies should be designed to be successful in municipal composting projects. It is also important to adapt the marketing strategy to meet the local requirements by considering soil characteristics, agricultural practices, social customs, transportation costs, climate and seasonal variations (Favoino, 1999; Daniel et al, 1999)

Table 2.4: Market share in selected European countries in % in 1998/9.

	Austria (1998)	Flanders (1999)	Germany (1998)	Denmark (1998)	Italy (1999)	Netherlands (1998)	Market size
Landscaping	30	24	25	19	30	30	Large
Landfill restoration	5	5	25	13	-	-	Small
Agriculture	35	5	43	10	20	40	Very big
Horticulture	5	6	5	3	-	-	Medium
Earth work	5	33	10	-	50	-	Medium
Hobby gardening	20	20	14	48	50	20	Large
Export	-	4	-	-	-	-	Very small
Miscellaneous	-	11	3	7	-	10	?

Source: Favoino, (1999)

2.3.6. Cost, benefits and constraints of Composting

The cost of composting includes raw materials, production, marketing, and hidden environmental costs whereas traditional cost accounting systems usually do not include the hidden costs and benefits of environmental and social externalities that are difficult to quantify. Some of the environmental costs which are rarely accounted for are potential odor emissions and improper disposal of rejects (Daniel et al, 1999).

It produces beneficial end product with unlimited marketing potential, and recycles organic materials back to the topsoil from where it is mined. The benefits include the market value of the compost, saving from availed waste disposal costs as well as various positive environmental impacts. Composting increases overall waste diversion from final disposal, produces valuable soil additives, promotes environmentally sound practices such as reduction of methane generation at landfill, reduces transportation cost, requires little capital ,creates excellent opportunity to improve a city's overall waste collection program. Furthermore, it integrates existing informal sectors involved in the collection, separation and recycling wastes. Compost improves the movement of water, dissolved

nutrients, and oxygen through the soil, making it easier for plant roots to absorb these vital substances (Lardinois and van de Klundert, 1995; Daniel et al, 1999).

The most prominent problems cited by many studies include; over-emphasis placed on mechanized process than labor intensive operations, lack of vision and marketing plans for the final compost product, contamination with heavy metals, financial problems since the revenue generated from the sale of compost will rarely cover processing, transportation and application costs, nuisance potential such as odors, rats, poor marketing experience, and poor integration with agricultural community (Jerry and Huang, 2006 ; Daniel et al, 1999).

2.3.7: Composting Related Health problems and Safety measures

Waste management related environmental pollution through out the cities of developing countries have created serious health risks. In Bangkok, excessive exposure to lead causes 200,000-500,000 cases of hypertension resulting in 400 deaths a year. Rough estimates suggested that children with lead poisoning lose an average of four or more IQ points by the age of seven. In Mexico City annual health costs from air pollution are estimated to exceed $1.5 billion. High levels of suspended particulates have caused an average of 2.4 lost work days per person each year and 6,400 deaths every year. Lead exposure may contribute to as much as 20 percent of the incidence of hypertension in adults and 29 percent of all children have unhealthy lead level (Daniel et al, 1992, USA's EPA, 1990; and Bartone et al, 1994)

Open dumping of municipal wastes in urban areas attracts rats, flies, and other insects which can transmit pathogens to humans. Compost workers tend to be more exposed as they are directly handling the waste for an extended period of time. Health risks are also influenced by the composting technology and the raw organic materials used as feed stock. Precautions to mitigate environmental and public health effects can be implemented in the design and facility of operations (Daniel et al, 1999).

Furthermore workers and facility managers should receive ongoing training and education about health and safety issues to reduce occupational injuries. They should also be encouraged to maintain high standard of personal hygiene and protect themselves by wearing gloves, masks, gowns and safety boots during processes such as sieving or turning, when the spores can be dispersed. During hot and dry weather conditions the composting area should be periodically sprinkled with water to reduce dust and the workers should be encouraged to wear safety tools. Household source separation of the waste before it is brought to the composting facility is recommended to reduce worker injury and compost contamination (Daniel et al, 1999; Bartone et al, 1994).

2.4. Stakeholders, their role and involvement in waste management

In the waste management scheme a number of stakeholders are involved. These include the private informal sector (the scavengers and waste pickers), the community based organizations (CBOs), the NGOS and the formal sector (the municipality and legalized entrepreneurs). These stake holders work synergically or alone in the waste collection and resource recovery system (Lardinois and van de Klundert, 1995; Abebe, 2006).

2.4.1: Job opportunities created by waste management activities in developing countries

In Latin America and East Asia the private enterprises are found to have significant employment opportunities. It was learnt that about 10,000 jobs were created in Guatemala, Columbia, and Peru out of the total of 500 enterprises. For example, Jakarta had a daily waste production of over 21,000m3; 25 percent of which was recovered by an estimated 37,000 scavengers. These activities save the city about 270,000 to 300,000 US dollars per month. The recycling rates for glass and paper are as high as 60 to 80 percent. The waste paper collected by scavengers comprises 90 percent of the secondary raw material in this sector. By delivering 378,000 tons of waste paper per year to paper factories for recycling purposes, the scavengers save 6 million trees from being cut down. In Metro Manila, an estimated number of 17,000 people make their living as dumpsite

scavengers and over 80,0000 women work as paper pickers in Ahmedabad in 1988 (Abebe,2006).

In Seoul (Korea) approximately 35 percent of the solid waste is collected by 85 private contractors, each of which is a relatively small firm with an average of 6 vehicles (Cointreau 1994). In addition, in Indonesia and India vermi-composting is a successful method to process organic waste in densely populated low income neighborhoods. Every one or two months 20kg of compost is produced and locally sold to supplement income for low-income families. In 1990, with a support from the local municipality in Indonesia, 3,000 families participate in composting and the product was marketed to a nursery selling plants and fertilizer to middle and high-income households for landscaping. The managers and workers were trained in compost technology, environmental controls, health issues and business management (Daniel et al, 1999).

The settlement of landless family groups known as the Zableen, located on the outskirt of Cairo rely on the collection and sorting of urban solid waste as source of income. In early 1980's, Zableen community in Maqattam with population of 17,000 engage in garbage composting and the final product is sold to local farmers to improve quality of existing agricultural soil. They also feed organic waste to pigs, which they raise and then sell to supplement their home. For instance, they collect by donkey cart about 45percent of all house hold waste (1,800 ton/day) at no cost to the government (Daniel et al, 1999; Bartone et al, 1990).

2.4.2: Operational arrangements in solid waste management schemes

In literature, at least five operational designs and institutional arrangements could be identified. These include the informal arrangement, concessions, joint ventures, contractual agreements and the purchase of garbage (ENDA, 1991; Cointreau, 1994).

2.5: Solid waste Management in Addis Ababa

According to Nor consult (1982), the municipal solid waste generated is about 76 percent by households, 9 percent by commercial institutions, 6 percent by street sweeping, 5 percent by industries, 3 percent by hotels and 1percent by hospitals. According to Beyene (1993), the per-capita solid waste generation per annum was estimated to be 0.168567m^3. Similarly as a study made by a consultant (UDP, 1994), the amount generated per day is as high as 2165m3 (ENDA: 1999). The density is unusually high as it varies from 205 to 270kg/m3, and the average being 333kg/m3. In different studies the share of compost-able in MSW varies from 50 to 60 percent by weight and from 60 to 90 percent by volume or average 70 percent (AAHB, 1997; SBPDA, 2007). The major house hold solid waste comprises of organic matter (Kitchen waste, vegetable peels, organic fines and grass). Ashes and fines or smokes are also the ones that is contributing to the high density of the refuse. Various studies conducted to determine the waste generation rate of Addis Ababa provide variable results that follow.

Table-2.5: Waste generation per capita per day in Addis Ababa, 1982-1986

		Weighted mean per capita per day		Weighted mean density Kg/M^3	Year
		Liters	Grams		
1	Nor-consult	0.40	150	370	1982 wet season
2	Sturdy Gordon	0.65	221	336	`994 wet season
3	A.A University	0.48	111	230	1993 wet season
4	Sturdy Gordon	1.23	252	205	1995 dry season
5	French mission	0.65	200	308	1986 wet season

Source: A.A. Health bureau 1997

Studies commissioned by the City Administration to determine the relationship between the amounts of waste generated by a household in relation to the level of income had indicated that high income groups generate more waste than their low income counterparts.

Table-2.6: Waste generation per capita per day by income group in Addis Ababa from 1982-1995

Income groups	Nor consult 1982	sturdy Gordon 1994	Sturdy Gordon 1995
High income			
gm/capita/day	280	350	477
Lit/capita/day	1.0	1.08	2.226
Density (kg/m^3	280	322	220
Middle Income			
gm/capita/day	110	280	236
lit/capita/day	0.28	0.7	1.246
Density (kg/m^3)	390	395	196
Lowincome			
gm/capita/day	150	170	260
lit/capita/day	0.4	0.55	1.316
density(kg/m^3)	280	310	206
General population			
gm/capita/day	150	221	252
lit/capita/d	0.4	0.65	1.23
density (kgm/m^3)	370	336	205

Source: Addis Ababa Health Bureau (1997)

The composition of waste also differs not only from country to country but also within a country, depending on income levels, residential and administrative areas. About 60-70 percent of waste by weight in Addis Ababa can be considered as organic matter (Kitchen waste, vegetables, organic fines and grass). On the other hand 90 percent of the volume constitutes grass, leaves, organic fines and used vegetables making up the organic waste that may potentially undergo composting and incineration (AAHB, 1997). Accordingly household survey conducted by SBPDA (2007) on composition of household waste summarized in the following table indicates that 91.7 percent is organic and 8.3 are inorganic.

Table-2.7: Composition of household wastes in Addis Ababa in 2007/8.

No	Type of waste	Percent composition
	Organic	
1	House rubbish	24.1
2	Vegetable refuse	12.1
3	Fruits refuse	10.6
4	Food refuse	9.2
5	Ashes	10.3
6	Grasses	8.1
7	Papers	8.1
8	"chat" leaves	2.7
9	Wood	1.1
10	Bones	3.2
11	Textile	1.4
	Total	**91.7**
	Inorganic	
12	Glass and mirror	1.9
13	Broken pottery	1.4
14	Tin	1.1
15	Plastics	3.0
16	Metal	0.7
17	Others	0.2
	Total	**8.3**

Source: SBPDA and own computation (2008).

Waste is collected in three ways in Addis Ababa: door to door, block collection and container system. In the door-to-door collection system, which covers less than 15 percent of total amount of waste collected in the city, households living along accessible streets dump their waste in the trucks at a specific time in the day. It is used in accessible areas where $8m^3$ transfer stations are lacking (AAHB, 1997). In block collection, the municipality provides large $8m^3$ refuse containers or 1.1m3 to clients upon request. These clients dump their waste in the containers and call the municipal office when the container is full. Clients are charged 11 *Birr/m^3* for the service. However, the municipality is always capable of responding promptly for few privileged clients as ECA,

Hilton, and Ethiopian Airlines (ORAAMP, 2002). As of container system, large 8 m3 refuse containers are placed at accessible sites in the *kebeles*. Residents are expected to carry and dump their waste in the containers. Approximately 85 percent the waste collected is through this system free of charges (AAHB, 1997). With regards to transporting, the collection vehicles are generally of the 6-7 cubic meter capacity and go directly from their point of last pickup to the disposal site. According to (SBPDA,2003), only 35-40 percent of trucks work daily because of the average age (more than 5 years), maintenance problems, negligence of drivers, lack of maintenance, and high vehicle accidents during traffic congestion.

Municipal solid waste management services in Addis Ababa is dominated by collection and disposal of household, commercial, institutional, industrial, street cleaning wastes to landfill and running public toilets (NUPI and MHUD, 1989). However, pathogenic wastes such as surgery and operation wastes are either incinerated or buried within a hospital compound. Even if the inefficiency of the single landfill site was proposed by Norconsult (1982), reduce traveling times that requires over 25km distance from eastern sub-urbs to present landfill, yet it is not put into practice. Moreover, the dumpsite is getting full and it is partly surrounded by institutions, legally constituted settlements and it has no gas emission control. It enormously contributes to the emission of green house gases to the atmosphere. The scavengers continuously working at the landfill are causing operational problem, fire, threat to labor and property (ORAAMP, 2002).They are also an additional source of nuisance and trouble when they browse through the heap of waste looking for recyclables.

Recycling (Inorganic solid wastes): The proportion of recyclable wastes in the waste streams of Addis Ababa city is estimated to be 15 percent of the volume of MSW. However, 5 percent of the waste is informally recycled. Recyclable materials with direct commercial value are widely separated from the waste stream at the household. According to (SBPDA, 2007) the collection of these recyclable materials is highly organized through the informal networks of dealers and wholesalers through out the city with their nucleus at Merkato. Even if it is semi-formal or informal it provides a

significant proportion of work forces with good opportunity of employment. The recyclable materials with out direct commercial value or immediate reuse are usually not separated from waste stream. In Repi land fill, there are more than 600 scavengers who practice waste recovery for collecting salvageable materials (SBPDA, 2007). Those items with the direct commercial values are sold directly to informal itinerant waste pickers or collectors moving around the city called "Korales". This recycling activity forms part of the actual family subsistence in the poorest families.

2.6. Legal framework and policy environment

The Federal constitution of Ethiopia on article 44(1) allows the right to a clean and healthy environment. The regulation issued by Addis Ababa city government proclamation 13/2004 expresses that it is appropriate to manage, collect, transport, and dispose waste generated from the city of Addis Ababa in a manner that does not pollute the environment and harm health. In this regulation on its article 3(6) it indicates that any person is responsible to keep the area clean up to 20 meters away from his household and institution on which he has a possession. Its article 4 prohibits disposing wastes on unauthorized place. Its article 17(1) and 18(1) allows the participation and involvement of stakeholders taking appropriate measures to protect health of the community and preserve the welfare of the environment.

Article 21(6) of the regulation states about the responsibility and function of SBPDA to encourage private investors and other actors engage into solid waste management activities. In addition, any person residing in Addis Ababa should pay sanitation fee and any person who committed fault shall be penalized. The small enterprises engage in sanitary services shall obtain, for a limited period of time, services of landfill free of charge as an incentive.

As a summary, different studies conducted on SWM world wide have revealed several aspects of alternative SWM. However, the real situation in the case of Addis Ababa is scarce on this area and very few particularly, when we come to bio-recycling. Therefore, the current study has tried to give emphasis for this untouched area and gave emphasis for bio-recycling in order to contribute for appropriate practice of the method by avoiding the existing problems of MSW mishandling in Addis Ababa..

CHAPTER THREE

STUDY AREA AND ORGANIZATIONAL PROFILE

This section deals with descriptive overview of physical topography of the study area, administrative structure, demographic condition and the organizational profile of case institutions with brief description of their major activities in relation to municipal solid waste management in general and bio-recycling activities in particular.

3.1. Description of the Study Area

Addis Ababa is the capital city of Ethiopia, Oromia Regional State, a diplomatic capital for Africa, (OAU, ECA), regional headquarters like UNDP, UNICEF, UNHCR and ITU. It has an area of 540km^2 or 54,000 hectares of which 18Km^2 is rural. Addis Ababa is located between 8^0 55" and 9^0 05" North latitude, and 38^0 40" and 38^0 50" East longitude. Situated on the foothills and South East slopes of Entoto, it lies between 2000m and 2800m above sea level (Tadese, 2004). Due to the rugged steep slope topography, all drainage systems have steep sided valleys. This makes the areas susceptible to soil erosion and land slide which often causes extensive damages to property and the existing infrastructures. The Entoto ridge that prohibits the city's further expansion to North forms the divide between the Blue Nile basin in the North and the Awash basin in the south.

Numerous streams and rivers, which starts from Entoto run North- South within city's boundary and drain into Awash. The most important ones are Kebena, Ginfile, Bantyiketu, Buhe belu and little Akaki. These water systems serve the purpose of open drainage and in some places are used for horticultural activities. Addis Ababa enjoys mid Afro-alpine climate and the climate is divided into three distinct seasons. The period of

heavy rain (*Kiremt*) occurs between June and September in which 70 percent of the mean annual rainfall (1,240mm) is recorded. The dry period (*Bega)* is between October and January and (*Belg)* is a period of small rain which occurs between March and May. The high altitude has a cooling effect, and the temperature does not vary much through out the year. The city has a maximum and minimum temperature of 26^0 and 6^0C respectively, and an average temperature of 16^0C (NUPI &MHUD, 1989).

The municipality of Addis Ababa forms a self-governing administration governed by municipal council. It is recently sub-divided in to ten sub- cities, 305 urban and 23 rural Kebeles respectively for administrative purpose (SBPDA, 2007). However, the number today is further reduced to 90 neighborhoods by merging three or two Kebeles gradually. The population is composed of 51.6 percent female and 48.4 percent male with annual growth rate of 3.8 percent. This assumes the natural increase and annual net migration. Accordingly, the population projection for the year 1998, 1999 and 2000 was 2.43, 3.52 and 3.62 respectively (CSA, 1995). The vast majority of the population is poor, and lacks adequate access to basic needs.

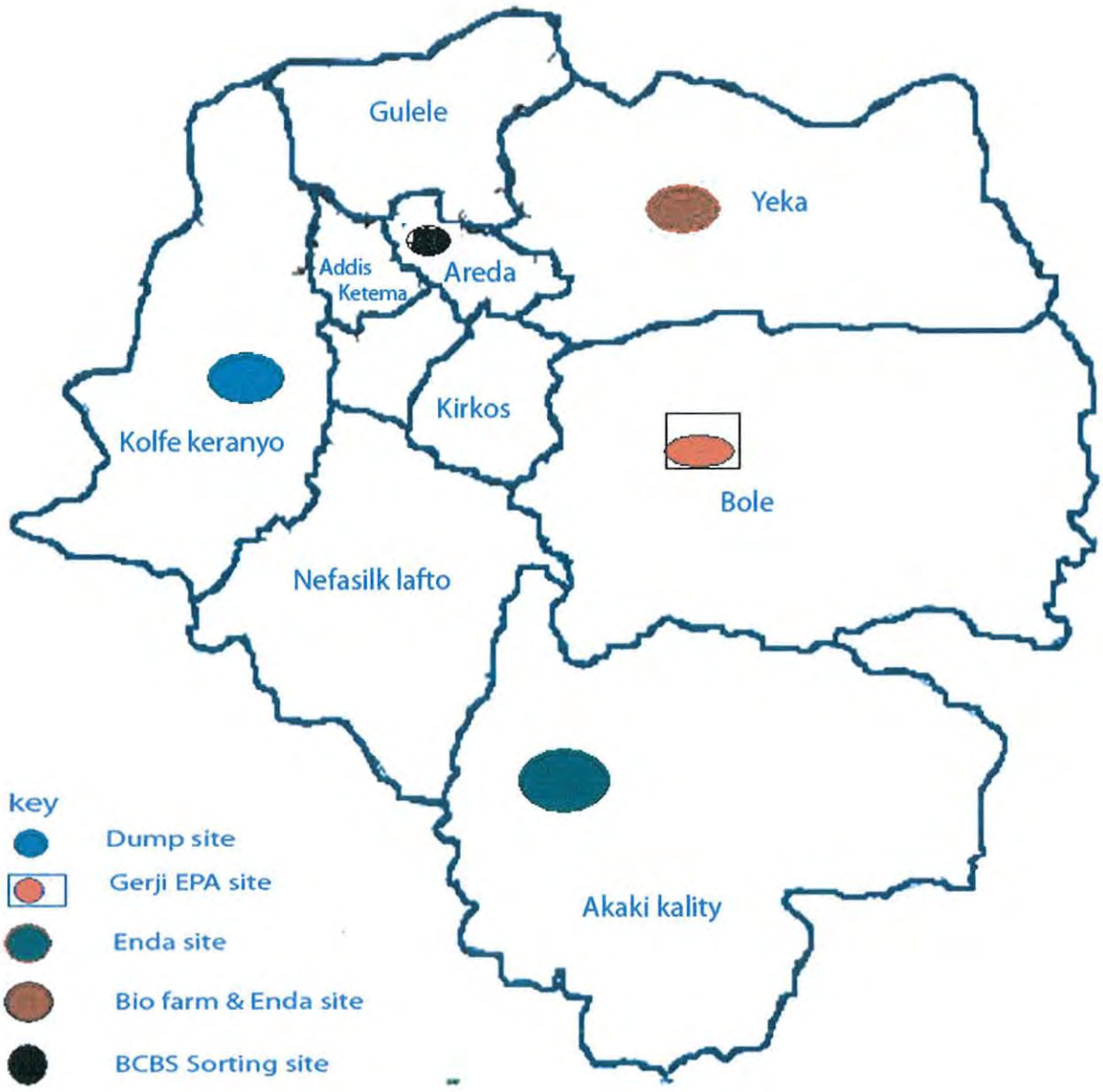

Fig.2: Addis Ababa city map.

3.2. Profile of the case study organizations

3.2.1 Bio-Farm Ethiopia

The Bio-farm Ethiopia demonstrates an integrated, nature based resource management, and concepts of environmental restoration. It is combining an international and indigenous knowledge for the purpose of targeting poor communities with emphasis given to poverty reduction, environmental rehabilitation and sustainable development through technology and skill transfer (Kifle, 2007). Added to it, the center has huge facility serving both as a model for integrating bio-farming system serving as bio-intensive farming training for farmers and other relevant actors coming from different parts of the country. Accordingly, the bio-farming system consists of many interrelated components as dairy farm linked with bio-gas technology for cooking and lighting purpose, vegetable and fruit tree seedling production linked with the bio-gas slurry as organic fertilizer, bee keeping, poultry, urban solid waste management and recycling, horticulture and pest management. As it was explained by head of farm manager, it has branches in Asela, Gambela, Mekele, Sebeta, and Gurage zone country wide. Similarly, all the posts of its organizational structure are well occupied by properly qualified staff. Since its establishment in 1988 E.C. Bio-Farm has its head office and demonstration model site at North East of Addis Ababa, 6 km away from the organic waste source area; Piazza, in Yeka sub-city (Kifle, 2007).

3.2.2. Sanitation, Beautification and Park Development Agency (SBPDA)

Addis Ababa Sanitation Beautification and Parks Development Agency is one of the municipal administrative agencies with duties and responsibilities related to the city's solid waste management and park development. It is established in 2002 based on the Charter of the city Administration and the constitution of the country that grants for the residents of the city, the right to live in a clean and healthy environment (SBPDA, 2007).

As it is explained by team leader of solid waste department of SBPDA the human resource required by the organizational structure for execution of its activities in the sub

cities is about 1810 out of ,which 1580 posts are accordingly placed by appropriate manpower and accounts for 87.3% of all the posts. However about 230 posts are vacant. The over all placement of human power seems satisfactory but sub-cities with excessive vacant posts are in a problem. As a commitment, it has endorsed different waste management regulations and solid waste management policy that realizes the city to be clean, green, and naturally balance through environmental sanitation (SBPDA, 2007). To this end, private formal organizations are engaging in solid waste activity in Addis Ababa. These organizations are introducing new methods of waste management methods, such as bio-recycling of wastes with recyclable entity.

According to informant experts of SBPDA's solid waste department, the agency has established its structure from top to bottom at the kebele level and most of the organizational structure is staffed by required man power. Accordingly appropriate activities are being undertaken as much as possible even at the grass root level. Moreover it has delegated its responsibilities and resources down through sub-city to kebele level based on the new decentralization process of the city. Above all it has set its goals and targets in the near future to realize the set objectives not itself alone but mobilizing all the stakeholders of the city. The agency is structured in such a way that clear responsibility and accountability will be realized through tier of hierarchy. As per city's decentralization power delegation, solid waste management team was established in all sub-cities. The experts of SBPDA further explained that all garbage vehicles, equipments and materials are distributed to all sub-cities with established criteria. With this decentralization process, full support and appropriate capacity building interventions have been underway and service delivery improvements in terms of collection, transportation, optimizing rotations, container sitting, truck maintenance and the like are in the process of implementation.

3.2.3. Addis Ababa EPA

In the History of Ethiopia, constitutionally established EPA is a recent phenomenon. Addis Ababa EPA is one of the outcomes. It is established in 2002, by the proclamation

No 300/2002 with a duty and responsibility to protect the environment and safeguard human health and biota from being inflicted through social and economic development endeavor. It is well structured and its offices are staffed up to sub-cities. However, the agency has no administrative structure at kebele level. For the purpose of training and demonstration of composting at the household level, it has established a composting project site at Bole sub-city *kebele* 10/11 since 2006. As a pilot project, the sixty households purposively selected were given two plastic waste collection containers of different colors so that household wastes that are decomposable are collected/ sorted in one container and non-decomposable wastes in the other one. The containers are collected at least every three day and brought to the project site by workers of an MSE called Rehoboth. Both waste containers from a given household is weighed at the site, recorded and organic waste is stored for composting purpose while the non decomposable ones are weighed, recorded and sent for disposal to communal collection containers. The household members are also composed of different income groups (Getaneh and Tesfaye, 2006)

3.2.4. ENDA Ethiopia

ENDA Ethiopia, an International NGO, is the branch of Environmental Development Action in the third world based in Dakar Senegal. It started its activities in Addis Ababa in 2001 and obtained its legal status in 2004 from ministry of Justice. Its branches are united by a common vision and work to help people realize they can change things through their own actions and efforts, getting organized and using their resources. Accordingly it believes that actions conducted at grass root level serve not only to solve specific problems to meet specific needs but also to strengthen people's confidence that they have the ability to make changes. In a similar manner ENDA'S work in Ethiopia concentrates in the Urban Environment on two sectors; solid waste management and urban agriculture with a potential to be integrated in to urban development. However emphasis in this thesis is given to sustainable waste management system that integrates community based collection systems, traditional waste recovery practices, the informal waste recycling activities, and the services rendered by the city administration (ENDA, 1999; ENDA, 2007).

Its office is situated in kirkos sub-city and staffed with qualified manpower as per the structure of the organization. Its project targets are in three sub-cities of Addis Ababa Lideta, Yeka and Akaki Kality sub-cities. It has no branch offices of its own in sub-cities but works in collaboration with government offices and community based organizations to empower the already established institutions. Within the last seven years ENDA-Ethiopia has launched its "living healthily in a clean and green city" under its urban development program towards the efforts being made to minimize environmental pollutions due to solid waste mishandling in Addis Ababa. The programs were implemented in two phases; the first phase was from 2001-2003 and the second phase was from 2004 on wards. The major activities of these projects include: awareness creation, environmental education, information and communication at all levels, initiating community based waste management schemes and minimization of waste at different levels through promotion of various techniques conducted in three sub-cities of Addis Ababa(ENDA, 20007).

3.2.5. Birhane Cleaning and Beautification Service

Birhane Cleaning and Beautification Service is a micro and small enterprise private formal organization established legally in 2001. According to responses of the owner it has received a license from SBPDA to involve in waste collection activity at the initial phase. It operates this activity in Arada sub-city *Kebele* 01/02, Piazza, where huge amount of organic waste is generated in the city due to high concentration of fruit and vegetable market centers and other business organization. The organization is established on legal business as family owned organization. Its office is rented from kebele and well organized for its level of activity. The individual owner explained that he was motivated to involve in this venture due to the experience he gained from his previous job with government health institution. He had an opportunity of being inspired to engage in to untapped opportunity of income it can generate, and to contribute his part to the efforts being made to curb low level of environmental hygiene of the city. Since then the enterprise is running cleaning and beautification services as a pre-collector MSE in Arada sub-city *Kebele* 01/02 and bio-recycling/composting. The owner further replied that the

enterprise engaged initially in pre-collection of solid waste based on personal initiative with little own saving and few working equipments as pushcarts, wheel barrow, pitchforks, spades and few workers as daily laborers. At the time the manpower were 4 males and 3 females. However, the number of workers today is more than 85 out of which 30 people are strictly working on sorting decomposable and non decomposable waste on the road side near the station of the communal collection containers of the municipality at piazza fruit and vegetable market center of kebels 01/02 of Arada sub-city.

Plate1. Traditional method of feeding waste to animals at piazza

Source: own field observation 2008

CHAPTER FOUR
RESULTS AND DISCUSIONS

4.1. Results

The results of data collected from 5 organizations on solid waste management activities in Addis Ababa, with special emphasis on bio-recycling/composting because of high volume of organic waste generation is presented in this part accordingly.

4.1.1. Assessment of existing MSWM situation in Addis Ababa (SBPDA)

According to the experts of SBPDA and previous baseline studies, out of the total waste generated in Addis Ababa; 76 percent is from household, 9 percent from commercial areas, 6 percent from street sweeping, 5 percent from industries, 3 percent from hotels and 1 percent from hospital. The waste generation rate per person is estimated to be 0.221 kg/day and the average estimated density is 333kg/m3. If the current estimated population of Addis Ababa is about 2,738,248 the daily total solid waste generation will be:

- Daily generation per capita=0.221kgg/day.
- Total population of Addis Ababa= 2,738,248.
- Total daily waste generation= 2,738,248 x 0.221kg/day = 605,153.808 kg/day.

Means of MSW Collection and Transportation: The equipments used for waste collection in Addis Ababa are engine-powered and human powered. Human powered collection equipments are pushcarts and wheel barrows made of wood and metals and utilized by MSE'S. The engine powered equipments are vehicles, which are imported while all human powered ones are indigenous technologies. On top of this there is no sufficient quantity of equipments and efficient means of transport available. According to the owner of BCBS, the means of transports of their MSE'S are simple and manual type of equipment driven by human labor. These are push carts, wheel barrows and different used buckets made of plastics and metals.

Distribution of available means of transportations by sub-cities: To further improve the efficiency of collection of waste all the material resources are decentralized and distributed to sub-cities based on established criteria even if it is still insufficient in quantity. Table-4.1 indicates the distribution of vehicles based on the set criteria in all sub-cities by type and their functional level.

Table-4.1: Distribution of vehicles by types in the sub-city in 2008

No	Sub-city	Type of Vehicles and Quantity						
		Functional	Lift loader	Side Loaders				
				"*Shifne*" Mercedes	Hino	Renault	Non functional	Total
1	Addis Ketema	6	4	2	1	1	2	8
2	Arada	7	4	2	1	1	1	8
3	Ledeta	4	2	1	1	1	1	5
4	Kirkos	8	4	2	1	1	-	8
5	Yeka	2	1	2	1	1	3	5
6	Bole	6	4	1	1	1	1	7
7	N.silk L	3	2	1	1	1	2	5
8	K.karanyo	4	2	1	1	1	1	5
9	Akaki-K	3	2	1	1	-	1	4
10	Gulele	3	1	2	1	1	2	5
	Total	46	26	15	10	9	14	60

Source: SBPDA record unit and own computation (2008)

Types of Containers in use and their distributions by sub-city: From Table-4.2, one can understand that Akaki and Ledeta sub-cities are out of stock in 1.1.m^3 functional containers .Conversely in Kolfe Keranyo and Yeka sub-cities, their 1.1.m^3 containers are 100 percent functional and the efficiency of the collection is likely in a better position

than their counter parts while Ledeta and Akaki Kality are in serious shortage of these items. Similarly, 8m2 containers in Bole, Yeka, and Arada sub-cities are high in non-functional containers when compared with other sub-cities.

Table 4.2: Distribution of 8m3 and 1.1m3 container by sub-city in 2008

		$8m^3$			**$1.1m^3$**		
No	Sub-city	Functional	Non-functional	Total	Functional	Non functional	Total
1	Add K	40	-	40	29	-	29
2	Arada	82	4	86	59	22	81
3	Ledeta	52	2	54	-	27	27
4	Kirikos	54	2	56	10	25	35
5	Yeka	53	4	57	15	-	15
6	Bole	51	6	57	5	16	21
7	N Silk	62	1	63	8	24	32
8	Kolfe	55	-	55	5	-	5
9	Akaki	47	1	48	-	60	60
10	Gulele	91	2	93	6	16	22
	Total	587	22	609	137	190	327

Source: SBPDA record unit and own computation (2008)

Sub-cities like Arada, Ledeta, Yeka and Bole where the population concentration is high are in high non-functional rate of dust bins. This shows serious shortage of the items needed. Similarly the overall percent functional dust bins are 55.74 percent and non-functional dust bins 44.26 percent, which indicates the overall shortage of the dust bin in the city as a whole (Table 4.3).

Table 4.3: Distribution of dust bins by sub-city in 2008

No	Sub-city	Functional	Non-functional	Total
1	Addis Ketema	244	-	244
2	Arada	63	300	363
3	Ledeta	22	134	156
4	Kirikos	326	104	430
5	Yeka	85	185	270
6	Bole	183	97	280
7	N Silk L.	97	16	113
8	Kolfe K	21	-	21
9	Akaki K	13	3	16
10	Gulele	9	-	9
	Total	1063	839	1,902

Source: SBPDA record unit and own computation (2008)

As to the responses of the experts of SBPDA, bulk of municipal solid waste in Addis Ababa goes to land fill at "Repi" irrespective of segregating the solid waste by physical or chemical means. Due to serious financial, technological and logistic problems the dominant method of disposal is open dumping in Addis Ababa. However, as it is explained by SBPDA informant experts;

"*Even if sanitary landfill is the best method of disposal it is not practiced due to high capital cost, skilled man power and sophisticated technology it requires operating. It is also well engineered in such a way that it has heat sealed internal lining to control leachate with a potential of contamination of ground water. More over, due to low capacity, developing countries in general and Addis Ababa in particular fails to practice sanitary landfill method of waste treatment.*"

Similarly another problem of landfill in Addis Ababa is that even the existing open dumping method is fenceless, surrounded by legally constituted residential area and institutions.

4.1.2. Composting design, process and procedure

The sorted organic waste is piled in a volume of one cubic meter in such a way that the structure can get optimum air during decomposition. The volume of pile less than one cubic meter can not retain the heat to be released during the breakdown of organic

materials by aerobic bacteria. This size can facilitate to maintain optimum temperature of the pile. On the other hand when the volume of the pile is greater than one cubic meter air fails to reach the innermost of the pile and this affects the activities of the microorganisms. In Addis Ababa, the experts of EPA, ENDA Ethiopia and Bio-Farm recommend decentralized community composting and yard or household composting designs to be appropriate. The reason behind their recommendation is that as opposed to large scale centralized composting enterprises small scale decentralized and yard or household composting are labor intensive, cost effective, requires less space, low technology, less capital requirement and easily cope with small market available in Addis Ababa. Furthermore, to be successful in composting activity selecting appropriate process is necessary. However, in Addis Ababa, the experts of EPA, Bio-Farm Ethiopia, and ENDA Ethiopia prefer windrow composting process as it is simple, less complicated process to adapt and can be constructed using locally available resources and done by any person at any place at local setting than importing costly materials produced abroad. It is easily prepared on open spaces above the ground, favorable to control temperature and moisture, comfortable for fluffing and free from over saturation by water.

Plate2a. windrow compost pile at Gerji in 2008 **plate2b. windrow compost pile at Bio-farm 2008**

Source: own field picture 2008

However, vermi-composting process (compost prepared through decomposition of organic waste by earth worms) and in-vessel composting process(mechanical mixing drum with an enclosed vessel) are very difficult for developing countries in general and

Addis Ababa in particular due to high capital, skilled man power it requires and hard currency or high foreign loan to import equipments. Given that all the above procedures fulfilled the key informants of Bio-Farm and EPA compost site coordinators responded that: "*the cured compost is obtained within 2-3 months depending on type of waste, time, and weather condition.*"

4.1.2.1: Source and Quantity of solid waste for Preparation of Compost at Bio-Farm.

Bio-farm Ethiopia usually initiates those technologies that are nature based such as compost in a natural way of reusing waste. It is a huge resource, which is economically attainable and environmentally sound for farm inputs. Producing compost as fertilizer is widely used here to produce nutrient rich soil additives. The technology used here to process the wastes is extremely elementary (manual) and can be replicated easily elsewhere at the household level. The major source of raw material of organic solid waste is generated from the central fruit and vegetable market place/piazza kebele 01/02 of Arada sub-city in Addis Ababa. The market center is a nodal point for distribution of vegetables and fruits that comes from large fruit farms of the country. The micro-and small enterprise called Birhan Clean and Environmental Sanitation Service in negotiation with the fruit whole sellers, retailers, restaurants, hotels, business organization and residents of the area collects the heterogeneous solid wastes. The owner of BCBS explains constituents of MSW collected from the surrounding areas of fruit market of *kebele* 01/02 as:

"The bulk of the physical composition of the generated solid waste at the area is vegetables; damaged and discarded fruits, grasses, food leftovers that are mostly generated from hotels and households; broken glasses, bottles from hotels and other shops; plastics, paper, iron wires, and the like. Some of the ashes, fine dusts from house sweepings, cans and some times iron bars and corrugated iron sheets from construction demolishing are few of the composition of the waste."

Terms of Agreement with potential clients: As explained by manager and owner of BCBS, from the very beginning there were about 200 private business organizations with whom BCBS agreed to take away the wastes generated in their work place to the communal collection points per informal negotiation. According to the informant owner of BCBS, they used to pay 10ETB per pushcart. In addition, there is no difference in amount of charge per pushcart whether the waste is generated by the household, business organization or governmental institution. This days the number of its clients in kebele 01/02 of Arada sub-city are about 200 households, and 600 private business institutions such as fruit and vegetable shops, hotels, restaurants and retail shops of various kind.

Plate3: organic waste sorted at piazza fruit market area in 2008

Source: own fieldwork picture 2008

Similarly playing an intermediary role between the generators, city Administration and Bio-Farm Ethiopia it entered in to the agreement to separate organic and inorganic wastes before dumping the heterogeneous wastes to the near by collection garbage tanks. The farm manager of Bio-Farm explained about the role that BCBS plays as partner:

"The solid waste with high organic constituent is sorted, loaded and sent to Bio-Farm project by the workers of BCBS. Since then Bio-Farm found this MSE as resourceful for its own activities in illustrating huge resources used to be abused previously and entered negotiation with BCBS to sort the organic one's from the inorganic and in agreement also with Arada sub-city, thousands of kilograms of waste was sorted and taken to their demonstration site located at Gurara, away from France legation in Yeka sub-city."

Quantity of organic waste and Processing Capacity at Bio-Farm:

Total waste processing capacity by Bio-Farm as explained by project coordinator is:

- *Estimated daily intake and processing capacity = 2trucks of total weight of 1400kg/day = 1.4tons/day.*
- *Estimated monthly processing capacity = 1.4tons/day x 30= 42tons/month.*
- *Estimated dry season intake capacity = 1.4tons x 30days x 9months= 378tons.*

The implication is that bio-recycling can minimize a significant amount of organic solid waste going to landfill without any economic benefits. On the other way extracting organic fertilizer as farm input is an opportunity in boosting productivity. Moreover, out of all weights of sorted organic wastes and transported to the project site, about 50 percent is being lost during the composting process through evaporation and when it dries.

4.1.2.2: Sorting of Household Solid Wastes by Addis Ababa EPA.

According to the response of the experts at EPA, all households sort their waste at household. The waste they produce and sort may vary depending on their income group or level. Sorting waste at source for reuse is promoted by low income, middle income and higher income respectively in rank order. Additionally, as the in depth informant experts

of EPA, "*Total heterogeneous solid waste generated by the recruited 60 households of residential area of the project site is primarily sorted at the selected households and stored in the provided containers of different color for each type of waste per day by the household. The transportation of solid wastes generated is effected by the workers of micro and small enterprise called Rehoboth.*"

Plate 4: Colored containers distributed to households for sorting waste at source by EPA
Source: own field picture in 2008

The physical composition of household solid wastes collected at the site includes organic compostable wastes, plastics, bones, broken glasses, and worn-out clothes. The EPA project site coordinator of compost at Gerji *kebele* 10/11 indicated about the constituents of MSW generated by households of the locality as:

"The major constituents of decomposable organic wastes collected were vegetable wastes, food leftovers, fruit peels, "chat", and ashes. The second phase of sorting/separation takes place at the project site by the workers of EPA. After separation each type of waste is weighed and recorded on appropriate format. The compostable portion of solid waste is taken to composting site and the non-compostable ones are taken away by an MSE, called Rehoboth sanitation services workers to be dumped in to communal waste collecting bin."

Table4.4: Composted organic and discarded inorganic solid waste sorted at Gerji project site from 2006-2008.

Waste type	Years			Total	Percent weight (dry)
	2006	2007	2008		
Organic waste in kg	60328	12830	16450	89,608	81.16
Inorganic wastes in kg	6003	5590	9210	20,803	18.84

Source: EPA record unit and own computation (2008).

As it can be depicted from the Table-4.4 above, a total amount of **89,608kg** of organic and **20,803kg** inorganic household wastes were transported to Gerji composting demonstration site in three years.

According to the key informants of EPA, ingredients of composting process are water or moisture and air or oxygen, in order to sustain the life of micro organisms that carryout the decomposition. Hence turning or fluffing the compost pile can fulfill the requirement of air by the micro organisms. Increasing of the frequency of compost turning can speed up the time period required for the process of composting. Lack of adequate amount of oxygen from the system on the other hand prolongs the time required. Moreover, the experts argue that anaerobic composting process produces bad smell.

Responses of the experts of ENDA also indicated that, although, it does not involve itself in composting activity, due support is made in the construction of demonstration site for compost preparation and vegetable production at Kebele 01/02 for Addis Hiwot Volunteers Association to train community and help the association to generate income from the sale of organically produced vegetables in Yeka sub city. Similarly, public bio-latrine construction for Tesfa-Ethiopia Youth Association at Akaki-Kality Kebele 01/03 was also accomplished to demonstrate how latrines can be used to generate energy from methane gas and the out-flows from the bio-digester that can be used with other bio-degradable household wastes as compost.

4.1.2.3. Composting quality and standard parameters

Another important issue in the composting activity is about the quality of the product, standard for the ingredients, and parameters. These factors can affect the demand of the product for marketing either positively or negatively. However, according to the responses given by the experts of the SBPDA, the quality issue is expressed as follows:

"*The agency is not given the responsibility to set compost standard and assure quality. But, quality assurance obviously can positively contribute in raising the market demand of the product. Furthermore, the experts believe that there are some ingredients of solid waste that can possibly contaminate and deteriorate the quality of compost on the one hand and pose health risks to human being on the other.*"

In light of this, identifying quality of compost is vitally important. In order to determine the quality of compost the two methods are either to test in the field experiment or to test in the laboratory. Here at Gerji EPA and Bio-Farm demonstration sites compost quality is tested through both methods.

Field experiment of bio-compost on plant growth at EPA and Bio-Farm demonstration sites.

In terms of its suitability for plant growth, comparison of vegetable growth status on the nursery site on local cabbage seedling was observed using different plots or seedbeds supplied with different soil types; organic compost produced, organic soil mixed with local soil, cattle manure mixed with local soil and only local soil respectively. Project demonstration site coordinator of Bio-Farm specifically described the effect:

"A continuous observation, measurement and recording for 45 consecutive days indicated that a vigorous plant growth was observed on the seedling produced on organic soil/compost/ mixed with local soil. "

Nutrient Analysis: Bio-farm Ethiopia has tested the nutrient content of compost conducted by International Livestock Research Institute (IRLI) laboratory by comparing the chemical composition of essential elements for plant growth in local soil, a produced compost, chemical (artificial fertilizer) and the following results have been obtained. The Table 4.5 below indicates that the produced compost is by far richer than chemical fertilizer in composition of essential nutrients for plant growth. For instance; UREA contain nitrogen and DAP contain potassium only while other nutrients are totally absent. In contrast, compost is rich in all essential nutrients than inorganic fertilizers.

Table 4.5: The nutrient Analysis of the compost at Bio-Farm 2007/8

Analysis parameter	Average demand for plant growth	Available nutrient based on laboratory test			
		Local soil	Organic soil (compost)	Inorganic fertilizer	
		-	-	DAP	UREA
PH:H_2O	5.5-7.5	-	10.16%	-	-
Total N2	>0.15%	0.22%	0.60%	-	46%
Organic matter	>2%	3.95%	11.16%	-	-
Available p.	25PPM		257.60%	10-20	-
Exchangeable K	5%	-	10.86meq/100g	-	-

Source: Bio-Farm documentation unit (2008)

Similarly, at EPA experts indicated that a sample of prepared compost was given to National Soil Research Center and the following compost result analysis was obtained.

Table-4.6. Laboratory test of compost and finding at EPA

Lab. No	Total Nitrogen %	Organic carbon%	C/N	P(ppm)	K(ppm)
88/05	0.918	8.778	10	-	1052

Source: EPA record unit 2008.

Accordingly, the laboratory test on nutrient analysis at EPA revealed that the prepared compost does not have phosphorus which is one of the important elements for plant

growth, but it is rich in other essential elements and has a sufficient plant nutrient to apply in farm activities.

4.1.2.4. Screening (sieving):

Screening is done by using chicken wire mesh to separate the fine and coarse fraction of compost to pack the compost into different size plastic bags or sacks. The impure coarsest decomposable organic wastes are again used as raw material for composting and the non-decomposable ones are dumped into communal containers for disposal to landfill. Plate 5 below demonstrates the practice of screening at Addis Ababa EPA project *kebele* 10/11 of Bole sub city.

Plate5-seiving at EPA Gerji project 2008
Source: own field observation in 2008

4.1.2.5. Packing: At Bio-Farm Ethiopia the produced compost is packed and sealed by plastic bags having a logo of bio-compost in two versions, English and Amharic, sealed on the bags describing the name (bio-compost), ingredients, available nutrients,

instruction of use and contact address and packed in three different weights: 2kg, 5kg and 25kg .

Plate6. Packed compost at Bio-Farm 2008

Source: own field picture 2008

4.1.2.6. Benefits of Compost and demand potential in Addis Ababa

As it is confirmed by interviewed experts' of SBPDA, Bio-Farm Ethiopia, ENDA Ethiopia, and Addis Ababa EPA compost as a natural fertilizer is socially, economically and ecologically friendly as opposed to chemical fertilizer. It reduces emission of GHG from dump sites and protects atmospheric pollution and easy to start with small capital. Furthermore; green areas, urban forest areas, parks, road squares, river basins and botanical gardens are potential developmental areas with high demand of compost in Addis Ababa. Furthermore, when this huge resource is converted to organic fertilizer and distributed to peri-urban and urban farmers with quality assurance, it will help boosting productivity without any negative environmental consequences.

Overall, the interviewed compost site coordinator explained that over the last three years alone, EPA has produced about **310,000 seedlings** and planted in the aforementioned

areas by using compost on seedbeds (nursery) at Gerji demonstration site of Bole sub city *kebele* 10/11 while some are distributed to local community in low price.

4.1.3. Water harvesting

Water security is important for proper composting activities as shortage of water supply is one of the major obstacles to the development of this economic sector. Rather than promoting large scale irrigation scheme, which is often inefficient and socially disruptive, Bio-Farm is a primary example in promoting small scale water harvesting, which is a localized supply of water in artificial ponds to use in time of emergency. At the same time water harvesting by accumulating rain water can avoid water shortage in dry season where compost is at a peak demand for water.

Plate 7. Artificial pond at Bio-Farm 2008

Source: own field picture 2008

4.1.4. Integrated PEST Management

Pesticides and chemical fertilizers are believed to be a panacea for high yield and food security by third world farmers on the one hand and fail to afford its cost on the other hand. In fact, chemical fertilizers may boost immediate yield, but their long term effects

are ecologically detrimental. Declining human health, increased pest resistance, soil pollution and the like may result from using pesticide and fertilizer. Many such chemicals have been banned in developed countries for these consequences, but not yet in Africa. As a result, chemical companies have turned their face to the third world for potential market without due regard for human and environmental health. Conversely, pests can be naturally kept in check by natural enemies like parasite wasps, birds etc, which are attracted to varied plant life. This method controls outbreak of pests while improving the quality of the environment. It is for these reasons that Bio-Farm Ethiopia is promoting and demonstrating nature based pest management methods. Rather than treating plants with chemicals, it relies on ever-increasing bio-diversity and sensible crop design to control pest infestation. Specifically, biological (non-chemical) pesticide often termed as biocides made of Neem tree seeds and pyrethrum flowers are being developed and tested. Because these come from a natural source, they are not detrimental to the ecosystem or human health in the same way that chemically based pesticides are.

The end results of integrated pest management are threefold; farmers can naturally produce bio-pesticides, human health is improved through the use of natural methods rather than chemical pest control agents, and food security is ensured due to high yield. The other method of pest control system is using tse tse fly trap which is indicated below.

Plate 8: Tse tse fly trap at Bio-Farm 2008

Source: own field picture 2008

4.1.5. Transfer of Skill, Technology and trainings

4.1.5.1. Some Component activities of Bio-Farm

In addition to integrated activities in the demonstration site and expansion of these technologies through out the country via different branches, Bio-Farm launched an urban project benefiting about 200 women and their families around the project from local community. It undertook different trainings in fruit production, vegetable production, composting, seedbed preparation and environmental rehabilitation. As project's target group, Gurara Women cooperative has got technical assistance on strengthening periodical meetings, horticultural crop production, harvesting, marketing and process of legalization of the cooperatives and restaurant and hotel management. To establish better customer handling and marketing system for organized women, basic information on vegetable product marketing was collected from Oromiya marketing department and other known supper markets. Remarkable accomplishments have been performed on the area of marketing, promotion and other businesses. Similarly technical assistance is being given on land preparation, soil fertility improvements and techniques of planting various vegetables and trees in their demonstration site.

To transfer bio-intensive farming technologies to beneficiaries through practical and theoretical approaches; trainings to participants on a variety of intensive bio-farm systems in accordance with the local needs and conditions is being promoted at Bio-farm. The approaches to the training was a balanced mix of some farming techniques that incorporate traditional and specific issues to augment their knowledge and understanding of the environmental, economic and social implications of bio-intensive farming. Predominantly, trainings on the topics such as compost preparation and utilization, fruit production and marketing, vegetable production and harvesting, and nature based pest management was given for different trainees from Addis Ababa, Oromiya, Amhara and Gurage regions.

As explained by farm manager of Bio-Farm:

"*Since 2003, about 26,000 people, from different Regional States of the country and different segments of the society such as farmers, volunteers, and local community members have participated in different components of intensive bio-farming systems such as composting, seed bed preparation and ornamental plant production in collaboration with local governments ,local and international NGOS.*"

Similarly, Bio-farm Ethiopia assist researchers coming from different Universities and Colleges of the country to conduct their research and in a way introduce intensive bio-farming system through out institutions of higher learning. Furthermore workers of different pre-collector MSES such as BCBS were given occasional on job trainings about waste work related health risks, the methods of prevention and environmental or personal hygiene. It is then being recognized that the waste we used to dump at "Repi" is a good resource that can save a foreign expenditure in the purchase of farm inputs.

4.1.5.2. Some Components of activities of ENDA

General Awareness Raising Activities: The interviewed respondents said that ENDA planned to conduct training on environmental sanitation in general and waste management in particular with 15 selected schools and publication of IEC materials. The program was highly appreciated by the schools especially after the office has given training on compost preparation and vegetable production. In this activity it is reported that **1286** people (of which **506** were female from students, teachers, and association leaders, known individuals) participated. Accordingly, the interviewees indicated that ENDA had published 1000 copies of training manuals, 6000 copies of leaflets, 4000 copies of broachers, 800 copies of posters and have distributed the materials to schools, NGOs, kebele administrations, trainees and youth association. Due to the increased demand the plan was further revised to increase the copies of the materials and as a result the accomplishment exceeded the quantity planned.

Community Based Waste Management Scheme in the target sub-cities: According to responses of interviewed experts, ENDA promotes the training on issues that are very important in waste management schemes as sorting of solid waste at household level, techniques of recycling, composting and bio-intensive gardening and using organic inputs for households' vegetable production. Its training methods employ theoretical and practical illustrations through teaching aids as manuals, leaflets, brochures and posters. The rationale behind community initiated support and training is to stimulate communities to organize themselves and design projects that will alleviate the problems in line with ENDA'S objectives. According to the respondents, the activities with community based waste management projects and accomplishments are summarized as: training in school, iddirs, training for solid waste pre-collectors, training code executors, training sanitation committee, and purchasing materials for compost preparation and capacity building in the three sub-cities. The identified problems as respondents include poor financial management, lack of skill in preparing monthly, quarterly and annual action plan, poor property handling and poor assessment of market niches. The training given was then to bring about new ways of thinking, enhance their entrepreneurial competences and scale up their management skills.

Research: According to the respondents, ENDA-Ethiopia undertook research on the physical composition of solid wastes, generation and recycling practices by income group in Arada sub-city *Zebegna Sefer* and Akaki-Kality sub-cities. The finding indicated that all income groups recycle wastes they generate with different preference in the type of wastes to be recycled due to the variation of composition of waste generated by income. It also showed that MSW related problems in Addis Ababa are improper disposal, surface water and ground water contamination, low level of participation of stakeholders and awareness.

4.1.6. Stakeholders and Partners

While undertaking a solid waste management through bio-recycling, Bio-Farm entered a partnership with local institutions such as Bio-economy association (NGO), SBPDA

(GO), Arada- sub city (G0) and Birhan Clean and Environment Sanitation Service (MSE), a private business organization. The responses of experts of ENDA also showed that waste management committee was established by the staff of line bureau and local authorities, representatives of youth associations, and urban agriculture led vegetable growers, who were given capacity building training in the sub-cities where ENDA-Ethiopia is working as partner. Moreover, the International funding organization ENDA, Addis Ababa EPA, local formal and informal pre-collector MSES, Iddirs, Addis Ababa University Faculty of IRLDS and Technology Faculty and Schools in concerned sub-cities are some of ENDA'S partners. The most significant MSES are Addis Hiowt volunteers association of Yeka Sub City *kebele* 01/02 and Tesfa Ethiopia youth association of Akaki-Kality Sub City *kebele* 01/03.

4.1.7. Market for products and Promotion

The experts of Bio-Farm explained that the significance of market has been realized to increase access for consumers to organic vegetable produced. An urban project benefiting women group and their families has initiated a shop and communal restaurant to maximize their opportunity of selling nutritious food to low cost for the needy community in the area. In addition, market assessment is done to distribute organic vegetables to supermarkets and other retailers and hence all the out puts of Bio-Farm and those groups who work with Bio Farm are in good market condition. According to the respondents, Bio-Farm has reached potential buyers and promoters of bio-compost. It has found five supper markets and known agricultural input suppliers. It has provided them with sample products. Some of the clients are small scale producers while others are larger ones. After getting feedback, Bio-Farm will advertise the product for large scale marketing. The price of bio-compost is set at 2.5 birr /kg, which is reasonable compared to artificial inorganic fertilizer.

4.1.8. Recycling

Now a days SBPDA believes that landfill alone is not a panacea or a magic solution to solid municipal waste management in Addis Ababa and in a position to involve in other options as alternatives to waste management as recycling. In this context it has launched pilot projects in the ten sub-cities in collaboration with Ethio-French urban development program. The construction, development and organizing works are implemented by sub-cities and kebeles. The project is based on the assumption that the public has willingness to participate in the project implementation.

ENDA-Ethiopia also promotes recycling activities to minimize the usage and production of plastic bags due to the threat it poses to the environment. According to the informants, to materialize this objective repeated discussions were held with government decision makers, owners of factories producing plastic bags, relevant institutions and the community at large. Fortunately, federal EPA supported ENDA'S programs and have submitted a draft policy on plastic bags for approval to the parliament. As a result, the parliament has passed laws that govern the production and imports of plastic bags. The interviewees replied that in collaboration with Government offices and Institutions during the celebrations like world Habitat day, World Environment day; ENDA is positively responding through its flexible funds for costs incurred on these events. It developed culture of involving different bodies from the highest level to the grass root to develop sense of ownership in order to keep the projects sustainable.

4.1.9. Financial sources

The major source of finance of SBPDA is government budget from the general revenue, but to execute some urgent activities different projects are funded either by NGOS, international funding organizations and the like. The responses of the SBPDA experts indicated that the amount of money allocated is not fully utilized on the one hand and in relation to the annual revenue of the city the allocation of less than 1% is insufficient on the other hand. The reason for inefficient utilization of the allocated budget is due to high

turnover of the employees on the one hand and the problem of the organizational structure on the other. The general activity of the agency is collection, transportation and disposal of SMW and the funds are usually released for these programs from the general budget. But the fund for recycling projects being promoted recently is donated by Ethio-French Embassy to establish the center. The youth who are willing and unemployed engage in to the contract with kebeles by organizing themselves into small scale enterprises for a determined period of time with a possibility of renewal of the contract. This project is still under establishing phase and too short a time to analyze the efficiency or failure success story. Accordingly, similar trend prevails also in case of Addis Ababa EPA, while the source of fund in case of Bio- farm is from different NGOS depending on the components of the project.

4.1.10. Operational arrangement

The existing sub-contractual agreement that the city administration provided is zonal type of agreement in which a given MSE is responsible to run its activity. When ever the pre-determined area is not well handled or when other MSE intervention is found to inflict the other party, the kebele or sub-city settles accordingly.

4.1.11: Major External Constraints to the case institutions

Administrative problems: The interviewed experts of ENDA indicated in their responses to the major external constraints as follows ; "*Because we run our activities by a committee whose members are from line government bureaus, informal and formal institutions as Iddirs, farm cooperatives and pre-collector associations; bureaucratic bottlenecks associated with the election process of the country and pending Addis Ababa administration, frequent change of staffs of local authority, the administrative inefficiencies in solving the problems as soon as possible were some of the prominent administrative problems for the activities of waste management run by the committee particularly during the second phase of the project.*"

Similarly, Bio-Farm experts also indicated some problem of transportation of organic wastes during the aforementioned period to use vehicles of the municipality as required.

Environmental Problems: The experts interviewed at depth in all the four institutions and BCBS owner explained that visible solid municipal waste related environmental problems in Addis Ababa are air pollution, ground water contamination, and surface water pollutions, blockage of ditches and water channels and damage to aesthetic features of the city. Due to various activities of economic endeavor, all segment of the society are contributing to the problems. These are all the households, industrial sectors, business and commercial institutions, people coming from all corners of the country, the street people and other informal activities. These problems are further intensified by lack of appropriate method of collection, lack of proper storage and transfer station, as well as lack of proper disposal methods in place. Contrary to SBPDA'S objectives of keeping the city clean, green, beautiful and livable or habitable, the defect in structural arrangement between code enforcement at the *kebele,* sub city and SBPDA in terms of responsibility and accountability has also highly contributed to the gap in the efficient control of environmental pollution and aesthetic deterioration of the city.

Scavenging: According to the key informant of SBPDA, most of the time, the scavengers who pick items they think valuable for them from disposal site and around containers pose threats against the property and workers. They scatter the wastes that the community disposes at communal containers and dumpsite. The problems are actually deep-rooted in their activity as a way of life and can not be easily avoided.

Infrastructure: The interviewed respondents of SBPDA, ENDA, EPA and Bio-Farm Ethiopia indicated that the problems related to infrastructure are most of them heritages from the very beginning as the city is established without the disciplined hand of urban

planning. They emphasized that in most of the inner city feeder roads are not comfortable for the trucks. Others are due to steep slopes and lack of access roads in squatter settlements of the peripheral areas and households along the river banks. In some areas the roads that are available lack appropriate maintenance and the trucks face problems when driven in speed. On top of that the city has only single landfill. MSW that has to be dumped to this landfill comes from all corners of the city given all these constraints.

Problems of Transportation and collection: According to the inventory made in this research on the existing functional or nonfunctional status of available vehicles from SBPDA record unit and responses of expert interviewed from the same agency some of the trucks available from the municipality for transportation of solid waste to landfill are not at work daily. At the same time the vehicles in use are most of them served for a longer period of time. In addition; longer distance, traffic congestion, lack of maintenance on operating condition, lack of spare parts, and accidents because of negligent drivers are the main problems of transportation. Other means of transporting waste used by formal MSES such as BCBS are push carts driven by human power are used in bringing the collected waste to public communal collection containers from areas that are inaccessible. But, when the distance is too far, however, the pre-collector crews illegally dump the solid waste into river basins and any open spaces of the city. The other aspects of problems of collection are due to financial constraints, lack of community awareness, and absence of proper transfer station and absence of proper waste disposal in place.

Partnership and financial problems: According to the respondents of all five institutions under consideration in this research, the potential stakeholders in solid waste management particularly bio-recycling/composting are the local community that can play a major role in producing lion share of Addis Ababa city wastes. The others are municipal government who is responsible in resource mobilization, awareness creation, formulation of established set of execution criteria, and coordination of all concerned parties. For other alternative options in terms of financial, technological, research and

establishing socially, economically and ecologically sound municipal solid waste management, the involvement of NGOS, FBOS, informal private organizations, formal private organizations, and International funding organizations is highly required. Furthermore, absence of community awareness, lack of capacity for fund raising, cultural problems and relatively absence of cooperation in areas as research, media and schools are some of the prominent constraints in this aspect.

Research and Technology: Concerning research and appropriate technology the experts interviewed at EPA, SBPDA, ENDA Ethiopia and Bio-Farm suggested that much has to be done to improve and establish the sound waste management skills and improve the now how of handlers and generators of solid waste. Promoting appropriate, locally and socially acceptable indigenously produced, and labor intensive technologies in handling, recycling MSW is more preferable areas where research institutions can highly contribute. However, the contribution and participation of this sector is minimal.

Legal and Policy Environment: Sectoral policy directions of SBPDA in relation to solid waste management in Addis Ababa are well developed. But, they are basic principles alone and are not specifically indicating who is responsible in taking measures at the grass root whenever the immediate need arises. Furthermore, during the interview with a senior expert of SBPDA the problems of enforcement or execution of regulations was expressed this way:

"The responsibility of solid waste management and formulation of its related regulations is given to SBPDA while the responsibility of enforcement of the formulated regulations regarding MSW is given to an independent agency/party known as code enforcement or "demb maskeber." This agency and its branches are not directly accountable to the office of SBPDA at all level of tier of its organizational structure. This I feel can create a gap between the accorded objectives of regulations and undermines a commitment of code enforcement agency for its implementation. Moreover, there seems a mismatch

between community awareness about environmental problems caused by MSW mishandling and expected cooperation to prevent it as a stakeholder."

Source separation of solid waste: The main constraints of composting activities revealed by the organizations were obviously, difficulties due to failure of sorting inorganic solid wastes from organic solid wastes. In a similar manner, as described by the owner of BCBS and site coordinator expert of Bio-Farm:

"All inorganic solid wastes such as plastics, iron bars and iron chips, glasses, bottles, and unwanted dead animal bodies like dogs, cats, rats, mouse, and chicken scraps were among nuisance things heterogeneously delivered to collection containers of BCBS as well as compost preparation site of Bio-Farm project site. Moreover, the workers try to sort out items they think valuable to them out of the wastes while others are disposed off in to the municipal collection containers which are being loaded to be disposed in to landfill."

However, those MSW that are not source separated would have a potential health risks for compost workers on the site in particular and the surrounding community in general.

"In addition some people who are rearing pigs come and collect organic vegetable leftovers for feeding on their own means of transport, where BCBS only charge them sorting and loading expenses." ***-Owner of BCBS at piazza.***

Such an example is Bio-Farm in feeding organic wastes to pigs in a modern way.

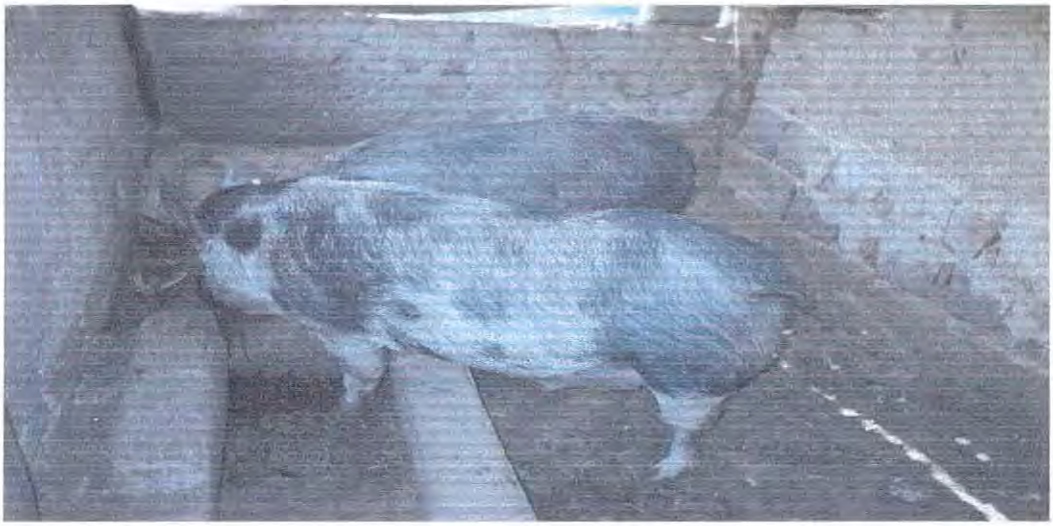

Plate9: modern method of feeding waste to animals at Bio-Farm 2008

Source: own fieldwork picture 2008

4.1.12. Major internal constraints to case institutions

As to compost demonstration site coordinator of Bio-Farm, lack of grinding or chopping machine, lack of own vehicles to transport organic solid waste from site of collection to site of preparation, and lack of budgets are some of the major problems faced their bio-recycling projects. Similarly, the main constraints expressed by the interviewed experts of EPA also include low level of resource mobilization capacity, low level of community awareness creation about sorting of solid wastes for composting purpose, financial constraints, absence of satisfactory quality standard concerning heavy metals, lack of comprehensive research, lack of institutional capacity to convince and attract the stakeholders. There is also no collaboration with *kebele* administration due to absence of offices and structure of EPA at the grass root. Moreover, very serious constraints of MSES as expressed by owner and manager of BCBS was huge shortage of capital, insufficient information on job related health risks, lack of sufficient working tools, lack of water sources necessary to avail for the workers, lack of sufficient safety wears, and

lack of enough building for warehouse are some of the major internal challenges to their activities.

Coming to the condition of SBPDA, the major institutional problems in the agency according to the responses of the experts of SBPDA include absence of community mobilization for funds and participation, absence or extremely insignificant private sector participation, absence of reasonable relationship with appropriate stakeholders particularly at the grass root and wider gap between the code executing or enforcement and SBPDA at large.

4.1.13. Prospects of bio-recycling activities.

The responses of experts interviewed in depth at SBPDA indicated that to improve the inefficiency of the agency efforts are being made to revise organizational structure and re-structure in a way that organizational relation ship will be established from the agency at the top to the *kebeles* through sub cities to ensure that direct responsibility will be realized. In addition, to minimize high turn over of the experienced and qualified manpower it is evaluating it and avoids existing obstacles in order to retain the workers on their job for a longer period of time. As to the responses of SBPDA experts pre-collection activity is also increasing in Addis Ababa. But if it is not strengthened by the city administration through supporting mechanisms, mere existence will not be sufficient. However, with the necessary support, it will have a contribution in the efforts being made to solve waste management related environmental and health problems of the city. Furthermore, said SBPDA experts:

"If sufficient land is allocated to MSES, the river basins, and open spaces of the urban areas will be a green field through forestation so that pollution of both atmosphere and aquifer will be mitigated through integrated composting/bio-recycling and seedling production."

Therefore, it requires the community and government of the city pay due attention to flourishing MSES solid waste works to overcome multifaceted urban environmental problems.

CHAPTER FIVE

CONCLUSSION AND RECOMMENDATION

5.1. Conclusion

Municipal sold wastes is a major challenge for cities in developing world and its management plays a critical role in protecting the environment and improving public health. Similarly, municipal solid waste management is one of the pressing environmental problems in Addis Ababa. For a long period of time, municipal solid waste management was the exclusive responsibility of city administration and community awareness or participation is very minimal. Contrary to efforts made in collection, transportation, disposal to landfill and provision of all necessary materials as vehicles, containers and dust bins by municipality; deterioration of aesthetic feature and pollution of urban environment is a growing challenge to the city. Added to this most of the distributed dust bins, containers and cars are non-functional due to lack of appropriate maintenance. Traffic congestion, longer distance of dump site from other corners of the city, problems of infrastructure, disposal of all types of solid waste to a single landfill without any separation at source and reuse further increased serious stress to environmental quality deterioration in Addis Ababa. Moreover, direct disposal of solid waste to open spaces, river basins, roadsides, and inaccessible slum and squatter settlements due to absence of proper disposal method are other prevalent environmental problems.

Apart from open dumping method, other formal alternative options as bio-recycling have never been in place before. Moreover, involvements of formal organizations other than the municipal government are recent phenomena. Therefore, this study assessed the activities of these formal organizations as alternatives to municipal solid waste

management in relation to the existing practice in Addis Ababa. In line with this bio-recycling or composting, recycling and incineration are duly practiced in Addis Ababa.

The finding of this research revealed that MSW management options as composting and recycling practices in Addis Ababa can contribute to solid waste management due to the following conditions. First and foremost the proportion of organic matter in the composition of sorted and composted household waste exceeds 80 percent and makes composting activity a feasible way of reducing waste at source and in a way creates employment opportunity. Secondly, the field experiments and laboratory tests made for the produced compost at EPA and Bio-Farm demonstration sites have shown encouraging and good effect on the growth of plants and constitute higher proportion of essential elements than chemical fertilizers. Thirdly, composting can reduce huge amount of waste to be land filled and minimizes the requirement for physical space to realize environmental objectives. Fourthly, when it is well designed and integrated to the agricultural sector, it boosts productivity to ensure food security and saves foreign currency expenditure for chemical fertilizer to realize economic objectives. Moreover, these organizations are making considerable efforts in transferring these technologies through different trainings being given to concerned officials, community elders, formal and informal institutions.

However, potential contamination of compost by toxic heavy metals is not yet established. National compost quality assurance and standard parameters are not well founded in Addis Ababa. Furthermore, private institutions like BCBS and its workers are facing shortage of clean water, toilet, and other facilities around the project. In order to avoid waste work related health hazards, different safety wears and overall personal hygiene plays a great role.

Moreover, other options such as recycling of inorganic non-decomposable wastes are also being undertaken in the ten sub-cities by SBPDA. Additionally, incineration is promoted

by formal governmental and non-governmental health institutions in the city. But in some cases pollution control devices are not yet properly installed.

The findings further revealed that specific implementation problems such as unclear institutional structure and responsibilities; insufficient technical and managerial expertise, inappropriate vehicle specification, failure to maintain vehicles in operating conditions, inadequate cost recovery, and difficulties in selecting sites for transfer stations and disposal facilities are among the prominent constraints.

Furthermore, the research finding strongly showed that lack of capital and resources, land shortage, bureaucratic bottlenecks, poor integration of research and appropriate technology, inadequate road infrastructure, lack of enforcement of regulations, poor integration of environmental health education in formal schools, inadequate involvement of mass media and absence of community participation are major constraints of municipal solid waste management in general and composting in particular in Addis Ababa.

5:2 Recommendations

As bio-recycling/composting is not a panacea or a magic solution by itself, it should be part and parcel of an integrated waste management strategy with appropriate processing technologies. Participation and cooperation of the stakeholders, particularly the generators, in sorting of waste at source is very important. Municipality, local government, communities and the private sector are highly expected to cooperate and work together. The role of community participation is very crucial in an integrated solid waste management particularly in the case of Addis Ababa. Depending on the findings the following are possible recommendations:

- The government policy is a general one and it should be specific and explicit in such a way that each and every stakeholder will be responsible to take part in waste management activities in financial or operational aspects. After consultation with major stakeholders; the government should introduce selective waste minimization, legalization for packaging reduction, product redesign, and coding containers.

- The government should encourage private sector composting initiatives by providing technical assistance on composting activities, financial support, allocate land, disseminate low cost technology, establish composting quality standards, demonstrate using compost in agriculture, landscaping, and park developments, promote compost use and reduce subsidies on chemical fertilizers.

- Building source separation of organic waste as preferred feed stock (input) as it minimizes contaminations by glass, metals, and household hazardous materials. Provide households with proper waste storage bins so as to enable sort waste at source.

- Organize education campaigns through media or schools, door-to-door, to inform the people to change attitude and behavior so that urban wastes can be reduced at source and promote local, regional and national educational campaigns aimed at reducing, reusing and recycling resources to the greatest extent possible. Incorporate waste management methods in formal education for environmental and social benefits of waste reduction, composting, recycling and reducing the stigma attached to waste work.

- Research institutions should study and identify quantity, physical and chemical composition by income group, best method of recovery or recycling system,

standard of recycling, market for recyclables, existing practice to decide and play facilitative role to promote source separation of waste at all level.

- The government has to facilitate the informal waste workers such as pre-collectors, itinerant buyers, the scavengers and processors through appropriate capacity building mechanisms.

- Private institutions, funding agencies, NGOS, FBOS, mass media, schools and the general public should participate in MSM activities in the city as it requires collaborative efforts of all stakeholders.

REFERENCES

Abebe Tegegn (2006). ***The involvement of micro and small enterprises in solid waste management services in Addis Ababa;*** The case of Bole and Arada sub-cities, unpublished MA thesis AAU, Addis Ababa

Addis Ababa Environmental Health Bureau (1997). ***A comprehensive overview on Addis Ababa municipality solid waste management and its environmental inspection services,*** A.A.H, B Addis Ababa

Addis Ababa NRDEB (1998). ***Solid waste management in Addis Ababa***; proceedings of a workshop held in Addis Ababa.

Amanuel Malifu (2000). ***Problems of Urban Environment***; Forum for Social Studies, Unpublished material, Addis Ababa.

Beyene Geleta (1999). ***Managing solid waste in Addis Ababa***: Integrated development for water supply and sanitation, 25th WEDC conference; Addis Ababa.

Bartone C., Bernstein J. and F. Wright (1990). ***Investment in solid waste management***: Opportunities for Environmental Improvements; the World Bank, Washington DC, USA.

Bartone C., Bernstein J., Leitmann J. and J. Eigen (1994). ***Towards Environmental Strategies for cities:*** policy considerations for urban Environmental management in Developing countries: the World Bank. Washington D.C, USA

Biocycle (2006). ***The State of garbage in America:*** Journal of Composting and Organics Recycling, USA. (http.//www. earth. columbia.edu/news/2004/story01-23-2004.html), reviewed in March, 2008.

Cointreau, L. (1994). ***Private Sector Participation in Municipal Solid waste Services in Developing Countries, Volume I***, Urban management program, World Bank, Washington, D.C. USA.

Daniel H., Lawra T. and O.Lambert (1999). ***Urban waste management; composting and its applicability in Developing countries***: Urban Development Division: The World Bank; Washington DC. USA.

Favoino, E. (1999). ***Composting Across Europe***: ***Leading experiences and developing situations:*** Ways to success, Italy.

ENDA Ethiopia (1999). ***The cycle of waste in Addis Ababa***: Research Component, unpublished material, Addis Ababa.

ENDA Ethiopia (2007). ***Environmental Development Action Ethiopia:*** Waste management project report phase II; unpublished material, Addis Ababa.

Federal Negarit Gazeta (1995). ***The constitution of Federal Democratic Republic of Ethiopia***: Berhanina Selam, Addis Ababa.

Fiseha Tessema (2005). ***Solid waste management status and efforts made:*** EPA, unpublished, Addis Ababa.

Getachew Tessema (2006). ***Industrial waste management practices in Addis Ababa***: A case study on Akaki Kality Industrial zone; unpublished MA thesis, AAU, Addis Ababa.

Getaneh Gebre and Tesfaye Beyene (2006). ***A case study on household waste sorting and composting:*** EPA, Unpublished material, Addis Ababa.

Greiling, J. Bier, M., Getachew, T. Baumgartner, J. and Bekele A. (2000): ***Integrated management of Natural Resources for sustainable Rural and Urban Development in Sub-Saharan Africa***: The Bio-Village initiative; proceedings 13th Bio-Farm Scientific Conference, Addis Ababa

Lardinois, I. and A. van der Klundert (1993). ***Organic waste***: options for small scale resource recovery. TOOL, Amsterdam and Waste Consultants, Gouda, The Netherlands.

Lardinois, I. and A. van der Klundert (1995). ***Community and private (formal and informal) sectors involvement in municipal solid waste management in developing countries.***

James, G. A. (1985). ***Integrated Resource Recovery: Municipal waste processing in Europe;*** A status Report on selected materials and Energy Recovery Projects. UNDP and the World Bank, Washington, D.C., USA.

Jerry, Y. and C. Huang (2006). ***Solid waste Disposal methods*:** Encarta Encyclopedia 2006.

Kifle Bulo (2007). ***Terminal activity report of Bio-Farm***: Unpublished material, Addis Ababa.

Nicholas, P.C. (1996). ***Biotechnology for waste and waste water treatment:*** digitally signed by Rohit Jhawer, Noyes publication, New Jersy, USA.

Norcousult (1982). ***Addis Ababa solid waste management study phase II and III,*** unpublished materials, Addis Ababa.

NUPI& MHUD (1989). Solid waste management: Integrated Urban Rural Development; The Addis Ababa Slum and Infrastructure Rehabilitation, final report, Addis Ababa.

ORAAMP (2002). ***Project proposal for Addis Ababa municipal solid waste management program:*** Office for Revision of Addis Ababa Master Plan, Addis Ababa.

Rand, T., Hankohl, J., and U. Marxen (2000). ***Municipal Solid Waste Incineration: Requirements for successful project:*** urban development unit, East Asia and the pacific, World Bank, Washington, D.C, USA.

SBPAD (2007).***Access, Knowledge, Attitude, Practice and behavior survey on water supply and sanitation in Addis Ababa;*** Plan Development and Research Center Addis Ababa.

Stevenson, S. (2006). ***Solid waste Disposal:*** Chicago Tribune; Encarta Encyclopedia 2006.

Tadese Kuma (2004). ***Dry waste management in Addis Ababa:*** a paper presented on a workshop on Accounting for urban environment, unpublished material, Addis Ababa.

Tchobanoglous, G., Theisen, H. and V. Samuel (1993).***Integrated Solid Waste Management;*** Engineering Principles and Management Issues. McGraw Hill, Inc, New York, USA.

UDP (1994). ***Solid waste management improvement program***; Addis Ababa second urban development project, report of the second intervention, unpublished material , Addis Ababa.

United States EPA (2008). ***Solid waste recycling.http.//www.epa.gov/msw/recycle.htm (accessed in March, 2008)***

World Bank (1997a). The use of Compost in Indonesia: Proposed Compost Quality Standards, Infrastructure Operations, Country Department III, East Asia and Pacific Region, Washington, D.C., USA.

Yami Birke (1999).***Solid waste management in Ethiopia***: paper presented in the integrated Development for water supply and sanitation, 25th WEDC conference, unpublished material, Addis Ababa.

Yeraswork Admassie (2007***). Introduction to Methods of Social Research***: Department of sociology and Social Anthropology; Course modules, unpublished, Addis Ababa University.

Yibeltal Beyene (2005). ***Domestic solid waste quality and composition Analysis in Arada sub-city:*** Unpublished Master thesis submitted to school of graduate studies in Environmental Science, AAU.

Zenebework Tadesse (2000). ***Environment and Development in Ethiopia,*** Forum for Social Studies, Addis Ababa.

Annex I

A check list for depth interview with team leaders SBPDA, EPA, Bio-Farm, and ENDA.

Name _____

Position _____

Organization_____

I. Administration and Resource

- When was the establishment of an organization?
- Is the organizational structure fully staffed?
- What are the major activities of the organization?

II. Solid waste management in Addis Ababa

A. Generation

- What is the volume or weight of solid waste generated in AA?
- Who are the major generators?
- What is the percentage proportion of waste generated by each?
- What is the physical composition of solid waste generated in Addis Ababa?

B. Collection

- What is the collection equipments used in Adds Ababa?
- Which are produced in the country and which are imported from abroad?
- Are these facilities available in sufficient quantity?
- Is there proper transfer station?

C. Sorting

- Is there a practice of sorting solid waste at source in Addis Ababa?
- Which socio-economic group of the society practice sorting? Why?

D. Disposal methods

1. Landfill.

- What proportion of generated waste is disposed through landfill method?
- What is the type of landfill practiced in Addis Ababa?
- Is the method ecologically, economically and technologically sound? Why?
- What are the advantages and disadvantages of open dumping?

- What would be the solution?

2. Incineration

- What proportion of solid waste is handled through incineration?
- Who are the institutions using incineration as method of waste management?
- What are the negative environmental and social consequences of this method?
- What are its advantage and disadvantages

3. Recycling (non-biodegradable)

- What proportion of solid waste is recyclable in Addis Ababa?
- Which income group is involving most in recycling activity? Why?
- What is the benefit of recycling?
- What are the disadvantages of recycling?

4. Composting (bio-degradable)

- What proportion of the solid waste generated is compostable in Addis Ababa?
- Why it was not the solid waste management option yet?
- Is there standardized guideline for composting activity?
- Is there any quality assurance for compost? What was done yet?
- Is there any responsible institution? What is the potential problem of composting activity as a solid waste management option?
- What are the potential benefits of composting?

III. Financial Aspect

- What is the source of finance for the activities undertaken by this organization?
- Is the allocated budget and fund sufficient?
- What are the main problems in financial aspect?
- What do you suggest as a solution?

IV. Stakeholders and Partners

- Who are the stakeholders and partners?

V. Technology

- Which design of composting is appropriate in Addis Ababa? Why?
- Which process of composting is appropriate in Addis Ababa? Why?
- Which scale of bio-recycling/composting is important in Addis Ababa? Why?

- What are the problems of bio-recycling activity?

VI. Institutional

- What are institutional MSWM problems in Addis Ababa?
- What solutions do you suggest?

VII. Physical environment

- Does a physical environment contribute to MSWM problems in Addis Ababa?
- What could be the reasons?

VIII. Legal and policy environment

- What legal and policy environment prevails in relation to MSWM in Addis Ababa?
- Does it encourage the involvement of stakeholders?
- What type of agreement is possible to engage into waste management activities?

IX. Constraints and prospects in alternative waste management activities.

- What are the major constraints?
- What will be the prospect of alternative waste management in Addis Ababa?

Annex II

A check list for depth interview with team composting coordinators/experts.

Name _____

Position _____

Organization_____

I. Composting as an alternative to municipal solid waste management

1. What is the reason behind your involvement in composting activities?
2. What proportion of solid waste can be decomposable?
3. Which design of composting is appropriate in Addis Ababa? Why?
4. Which process of composting is appropriate in Addis Ababa? Why?
5. What are the major parameters to be considered in composting?
6. Which institution is responsible to set or establish the standard parameters for compost?
7. What measure was taken by your organization to cope with the problems related to standard?
8. What are the potential ingredients of solid waste that can contaminate and deteriorate quality of compost?
9. Which institution is responsible for quality assurance of the compost product before distribution for marketing or application?
10. What is the health risks related to composting?
11. what are the meanses of prevention
12. Which segment of the society is at risk?
13. What are the major benefits of composting?
14. What are the disadvantages of composting?

II. Incineration as Alternative option to MSWM.

15. Does incineration contribute to solid waste management in Addis Ababa? To what extent?
16. Which institution promotes incineration in Addis Ababa?
17. Is it possible to promote waste energy recovery in Addis Ababa?
18. What are the advantages and disadvantages of incineration?

III. Recycling as an Alternative option to MSWM

19. Does recycling contribute to solid waste management in Addis Ababa?
20. What proportion of waste generated can be treated by this means?
21. Which segment of income group of society involves most in this venture?
22. What are the benefits of recycling?
23. What are the disadvantages of recycling?

IV. Prospects and constraints

24. What major constraints encountered in composting activity as alternatives to MSWM?
25. What will be the prospect of composting activity in Addis Ababa?

Annex III

A check list for depth interview with MSE owners

I. Characteristics of owner

Respondent_____

Position _____

II Socio-demographic

Age_____

Sex _____

Marital status _____

Family size _____

Level of education _____

III. Characteristics of the organization per-collection.

1. When was the organization established?
2. Which branch of the city administration is responsible to licensing your activity?
3. On what type of legal business your organization established?
4. Whose property your office is?
5. On what type of activity did you involve from the very beginning?
6. What motive encouraged you?
7. What was your previous profession/occupation?
8. Did the experience from your previous job help you for your involvement?
9. With how many workers did you begin?
10. On what basis you employ your workers?
11. What working equipments do you use to run this activity?
12. How many clients did you get at the beginning? How many they are today?
13. How much do they pay you?
14. Where do your clients store garbage until you take it away?
15. Do you receive homogeneous or heterogeneous waste from your clients?
16. Where do you store the waste?
17. Did you sort the heterogeneous solid wastes you collect from households and institutions?

18. What are the composition /items you sort from MSW from households and business institutions?
19. Do you provide your workers with some protective facilities?
20. Did they get basic training on waste handling and health risks?
21. Do you have sufficient ware house?
22. From where did you get the start up capital?

IV. Composting activity

23. Why did you involve in composting?
24. When did you begin composting?
25. How did you sort the garbage?
26. What means of transport do you use?
27. What would you do with compost?
28. what is the scale of your compost?
29. What is the water source you use for composting activity?
30. What is the benefit of compost?
31. Do you give on job training for your laborers?
32. Do you get external support? From whom?

V. Legal status

33. What legal relationship your organization has with *kebeles* and sub cities?
34. What type of sub-contractual agreement did you enter with the government?

VI. Prospects and Challenges

35. What are the major problems you face when running this job?
36. What do you do in the future?

DECLARATION

I the undersigned declare that this is my original work, which has not been presented for a degree in this, or any other University, and all sources of materials used for the thesis have been fully acknowledged.

Name: Diriba Welteji

Signature: 

This thesis has been submitted for examination with my approval as University advisor.

Aklilu Amsalu (PhD)

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