ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

CENTER FOR URBAN DEVELOPMENT AND MANAGEMENT

ORGANIC SOLID WASTE COMPOSTING AND ITS IMPLICATION ON SUSTINABLE SOLID WASTE MANAGEMENT

CASE STUDY OF BIO-FARM AND EPA ETHIOPIA

BY: YARED TESHOME

A THESIS SUBMITED TO SCHOOL OF GRADGUATE STUDIES
ADDIS ABABA UNIVERSITY IN PARTIAL FULFILEMENT OF THE
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ACRONYMS

AAHB	Addis Ababa Health Bureau
CBOs	Community Based Organization
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
H_2O	Water
ISWM	Integrated Solid Waste Management
IWBs	Itinerant Waste Buyers
K	Potassium
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
N_2	Nitrogen
NGOs	Non-Governmental Organization
P	Phosphors
UOW	Urban Organic Waste
UWEP	Urban Waste Expertise Programme

ABSTRACT

In Addis Ababa as in many cites in developing countries waste generation has been increased, both solid and liquid, as a result of the rapid rate of urbanisation. From the total solid waste, more than 50% are decomposable organic. Hence the objective of this research is mainly emphasizing on the use of composting urban organic waste and its implication on sustainable solid waste management in Addis Ababa.

In order to achieve the objective of the study, case study with in-depth interview, focus group discussion and direct observation has been administered. Further more to know there is a linkage between composting and urban agriculture, the researcher purposefully took five cooperatives and distributed 30 questionnaires (six from each).

The waste analysis of Addis Ababa showed that the percentage of organic waste in the MSW is quite high. According to the finding, the processing of these organics can deliver important environmental benefits, including the recovery and conservation of resources and a reduction in the quantity of organics going to landfills. The finding further indicate that diverting huge amount of solid from landfill reduce the environmental impact of the remaining waste by reducing methane production. Further more the analysis showed that the nutrient content of compost is much better to the growth of plant than artificial fertilizer. In addition to the above finding, the study also explains that composting urban organic waste can create employment and eventually generate income particularly fore those urban poor.

Unfortunately the finding indicated that in order to sustain the project both composting site use man made technology which create problem on the employee and the environment.

CHAPTER ONE

1 INTRODUCTION

1.1 Back ground of the problem

All over the world cities are growing because of urban migration and natural growth of population. The increase of the population is often so fast that the delivery of the basic services, such as water supply, sanitation and waste removal cannot keep up. Unemployment, growing poverty and deterioration of the environment are related problem of urban expansion.

The rapid urbanization that is taking place goes together with a rapid increase in urban poverty, urban food insecurity and urban environmental degradation. By 2020 the developing countries of Africa, Asia and Latin America will be home to some 75% of all urban dwellers, and to eight of the anticipated nine mega cities with population of more than 20 million. It is expected that by 2020, 85% of the poor in Latin America, and about 40-45% of the poor in Africa and Asia will be concentrated in towns and cities (McGee, T.G. and C.J. Griffiths, 1993.).

With an increasing population and often a more western way of living, the amounts of waste generated are consequently growing. The municipal waste collection service is usually not capable to deal with this waste problem. In most developing countries waste is removed only in some part of city, such as the central and the high-income area, in the rest of the city the waste is left along side the streets, in streams and in scattered heaps between the houses. As a result of this and the growing poverty, informal waste recovery activities have arisen. Plastic bags are washed and sold again, oil tins are used for making lamps and organic waste is converted into compost.

Huge amount of solid waste is produced in urbane area. In developing countries, it is common for municipalities to spend 20 to 50 % of their available recurrent budget on solid waste management but 30 to 60 % of the waste remain uncollected and it is only less than 50 % of the population that is served (Ibid). This indicates the coverage of solid waste collection service is so low that the waste generated is dumped at many undesignated sites such as streets, open spaces,

drainage systems, or into or beside rivers which in turn contributed to flooding, breeding of insect and at large environment problem (Bartone, C. 2000.).

Reuse of organic wastes is considered as a strategy desirable for resource management, while reuse is seen as away for urban authorities to substantially reduce the amount of waste requiring disposal and treatment. Controlled composting is the safest way to produce high quality products for all amendment, but the amount produced in compost plant in developing countries are, to date, insignificant and have had little impact on municipal solid waste management (MSWM).

It is undeniable that composting (controlled decomposition of organics) is the preferred method of processing urban organic waste for reuse. The experience with compost plants, however, has been fraught with multiple problems of feedstock; plant operation; the quality and price of the product; marketing, consumer understanding; and institutional support (Kumar S, 2009). Most of the large mechanical plants installed in Africa, Asia and Middle East in the 1970s and 1980s did not survive more than a few years; those that remain are not operating optimally.

In response to the municipal failures in managing and controlling urban waste, small undertaking and private enterprise have been promoted. In the 1990, international agencies and urban organizations began experimenting with small scale, little mechanized, and neighborhood- based composting and varmi-composting (Hoornweg 1999).

Currently there is a progress in public – private partnerships for compost plants, with a city supplying the wastes and sometimes the site for a private company (Cointreau-Levine S. 2000). Some countries have been recently brought in national and regional regulation on SWM encouraging or requiring composting for waste reduction, for instance Indian Supreme Court 1999.

1.2 Statement of the problem

Human activities create waste, and it is the way these wastes are handled, stored, collected and disposed of, which can pose risks to the environment and to public health.

In most cities and towns of the developing world, inappropriate handling and disposal of municipal solid waste (MSW) is the most visible cause of environmental degradation. In adequate municipal and industrial waste collection and disposal creates a range of environmental

problem in cities and towns of developing countries. A considerable amount of waste end-up in open damps or drainage system, treating both surface water and ground water quality and causing flooding, which provides a breeding ground of diseases. Open air burning of waste, spontaneous combustion in landfill, and incinerating plants that lack effective treatment for gas emission are causing air pollution. The situation is exacerbated in slums where households can not make use of garbage collection containers. The adverse effect of inadequate solid waste service on productivity and economic development of the city expected to be significant.

Most cites in Ethiopia share the above socio-economic and environmental problem. For instance, Addis Ababa which is the capital city of Ethiopia has a population of 2.7 million. The amount of solid waste generated per day is estimated to be 1215000 kg/day (UN-Habitat, 2008). Of this waste about 65 % is being collected, and about 10 % is being recycled. The remaining 25 % often dumped or burned in open spaces, ditches, riverbanks which ultimately cause environmental pollution and the associated health problems. However a large portion of this solid waste can be converted in to valuable material.

A large part of urban waste in cities and towns is organic and one of the ways to recovering this is through composting. Resource recover creates employment, reduce the volume of waste to be disposed of by municipal authorities, it saves foreign currency by reducing the quantity of raw materials needed in the production process and it plays a role in natural resource conservation.

Composting is defined (Engel, 1988) a controlled biological process that uses natural aerobic processes to increase the rate of biological decomposition of organic materials. It is carried out by successive microbial populations that break down organic materials into carbon dioxide, water, minerals and stabilized organic mater

The importance of compost for community based environmental protection and healthy plants and soil will be strongly emphasized. Compost is the foundation of healthy soil for natural farming and gardening. By composting, every person can reduce landfill and pollution problems. Composting is a key way to care for nature and teach earth stewardship. (Engel, 1988).

Study conducted on solid waste composition of Addis Ababa reveal that 90 % by volume and 50 % by weight is organic decomposable waste (AABOH, 2010). Hence conversion of this significant amount of resource into valuable humus material commonly known as compost not

only enhances the current solid waste management practices of the city but also the aforementioned environmental problems and reduces the cost of waste transportation and disposal to the dump site.

Particularly in the city of Addis Ababa where the waste generation rate is high, base lion data and the actual and potential roles of composting urban organic waste to the environment is scanty. This is because hardly any significant research has so far been conducted on the use of composting urban organic waste on sustainable solid waste management. Such a huge gap of information and lack of base–lion data on this important matter makes me to do this research.

Therefore this paper aims at describing association and use of composting urban organic solid waste to sustain urban solid waste management in general and that of urban agriculture in particular.

1.3 Objective of the study

1.3.1 General objective

The general objective of the study is to assess the environmental impact of organic waste composting and its significance for urban agriculture in Addis Ababa.

1.3.2 Specific objective

The specific objectives of the study include the following

- To assess composting activities in Addis Ababa
- Identifying some of the challenges of composting activities.
- To examine the contribution of composting for urban agriculture and sustainable solid waste management.
- To assess the environmental implication of composting

1.4 Research Question

1 What is the extent of composting activities in Addis Ababa?

2 What are some of the challenge of composting activates?

3 What is the contribution of composting urban organic solid waste to urban agriculture and solid waste management?

4 What are the major environmental implications of composting?

1.5 Research Methodology

The study areas for this survey are Bio–Farm Ethiopia and EPA Addis which is found in Gulele and Yeka subcity respectively. These organization are purposely selected; because of their relatively active engagement on composting urban organic solid waste. The two study areas are also help to compare the compost preparation and their effect on urban ecology.

In addition to the two study area, to know whether there is a linkage between composting and urban agriculture the researcher purposefully selected five cooperative (Mekanisa–Furisaris, Kolfe–Lideta, Kebena–Bulbula, Shankela– River, and Keranio–Medhane–Alem) that have been actively participated in urban agriculture and generated the necessary data and information by undertaking in-depth interview of the respective officials of the cooperatives. In order to ensure the information of the officials, 30 individuals (6 from each cooperatives) are selected and distributed the questionnaires for them.

1.5.1 Research Design

This study was undertaken Cross sectional survey research design in order to collect information from those purposely selected organizations and cooperatives. Data on the variable of interest has been collected more or less simultaneously at the same time through structured questionnaire, unstructured interviews methods and other relevant techniques.

1.5.2. Survey Instruments

Primary Information: - A structured questionnaire has administered to those organizations and cooperatives who engaged in compost and urban agriculture respectively. The instrument used for data collection was face to face interviews, direct observation, in-depth and focused group discussion method. Unstructured interviews also conducted with the respective departments of Addis Ababa Administrations.

Secondary Information: - Information has been collected form published and unpublished material such as magazines, journals and others relevant materials.

1.6 Scope and Limitation of the study

The scope of the study was limited to two organizations that actively engaged in composting activities in Addis Ababa however ancient and traditional in Ethiopia. At the same time organized information, researches and different compiled relevant data is limited. Farther more, do you to time and finance constraint deal with this research in detail was not possible.

1.7 Organization of the thesis

This study is organized into five main chapters. The first deals with introduction that includes background, statement of the problem, objective of the study, methodology and scope. The second chapter is concerned with related theoretical literatures while the third deals with overview of the study area. The forth and fifth chapter is about analysis and finding of data and conclusion and recommendation respectively.

1.8 Definition of terms

Aeration The process by which the oxygen-deficient air in compost is replaced by air from the atmosphere. Aeration can be enhanced by turning.

Aerobic: in the presence of air (oxygen)

Ammonia (NH3) A gaseous compound of nitrogen and hydrogen. Ammonia, which has a pungent odor, is commonly formed from organic nitrogen compounds during composting.

Anaerobic: in the absence of air (oxygen).

Biodegradable: able to be transformed to a lower state by environmentally significant biological Processes.

Commercial waste: waste from shops, offices, restaurants, hotels, and similar commercial establishments typically consisting of packing materials, office supplies and food waste.

Compost- Product produced by the mostly aerobic, microbial decomposition of plant and animal materials.

Compostable **-** Organic material that can be biologically decomposed under aerobic conditions.

composting **-** The biodegradation, usually aerobic and thermophilic, that involves an organic substrate in the solid state; evolves by passing through a thermophilic stage with a temporary release of phytotoxins; results in the production of carbon dioxide, water, minerals, and stabilized organic matter (humus)

Decomposition **-** Conversion of organic matter as a result of microbial and/or enzymatic interactions; initial stage in the degradation of an organic substrate characterized by processes of destabilization of the preexisting structure.

humus **-** A complex aggregate of amorphous substances, formed during the microbial decomposition or alteration of plant and animal residues and products synthesized by soil organisms; principal constituents are derivatives of lignin, proteins and cellulose; humus has a high capacity for cat-ion exchange, for combining with inorganic soil constituents, and for water absorption; finished compost might be designated by the general term humus.

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

leachate - Liquid which has percolated through materials and extracted dissolved and suspended materials; liquid that drains from the compost mix.

Methane (CH4): an explosive, odorless and colorless gas produced by organics undergoing anaerobic biological decomposition

Organic waste: technically, waste containing carbon, including paper, plastics wood, food waste, 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 and animal sources, and which can generally be decomposed by microorganism.

Putrescible waste - organic materials prone to degrade rapidly, giving rise to obnoxious odors.

Rapidly biodegradable organics: biodegradable organics, including putrescible organics, that are able to be decomposed under favourable conditions by microbial action, in both the presence and the absence of oxygen, to a noticeable extent within 14 days; rapidly biodegradable organics include grass clippings, food and animal organics and organic sludges

Recycling- Separating, collecting, processing, marketing, and ultimately using a material that would have been thrown away

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

Transfer station: a waste facility used to transfer waste from collection vehicles to a bulk haul vehicle in order to achieve long-distance transportation efficiency

Vermicomposting: a composting process that uses worms and microorganisms to convert organics into nutrient-rich humus

CHAPTER TWO

2 Related Literatures

2.1 Solid Waste Management

2.1.1 Concept of Solid Waste Management

Solid waste management is a common, as well as a primary, environmental concern for many cities in developing countries. Cities must allocate a large part of their budgets to handle daily solid waste management operations, which range from waste collection, transportation and final disposal to procurement and maintenance of facilities and equipment (George T, 2000).

Broadly, the material flow stream of waste from generation to ultimate disposal comprises the following:

- Generation
- Collection / transportation
- Processing / Recycling
- Disposal.

Accordingly, SWM encompasses the full range of activities for these streams, from the generation of used materials to their disposal (Ibid).

Resource recovery includes all activities of waste segregation, collection and processing which are carried out taking into consideration the economic viability of the material (Huysman, M. and I. Baud, 1993.). Re-use and recycling provide an opportunity to capture some of the values from the waste. Of these two techniques, reuse is a simpler process involving reutilization of material in its end -use form without the necessity of reprocessing (Ibid). Recycling, on the other hand, involves processing waste through remanufacture and conversion of parts in order to recover an original raw matter (Cointreau, 1984).

A review of existing literature reveals that a great number of studies on solid waste management have been undertaken even prior to 1970. Earlier studies shows that refuse management were

assumed to be the main responsibility of the public officials whose prime consideration was the quick removal of waste and its destruction (Kumar S, 2009). During the 1970s the debate shifted to issues of waste utilization. Studies during this time focused on the technical and economic issues surrounding the allocation and utilization of available resources, and examined existing state-of-the-art of resource recovery for managing urban grime (Cointreau, *et. al.,* 1984). The early studies reveal that recycling in the past was mostly industrial and based on financial considerations to reduce production cost, unlike the current emphasis on recycling as a way of reducing waste in the environment and preserve dwindling resources (Ibid).

The collection of waste and its recovery from different waste generating points is carried out by many agents, formal and informal, which represent a variety of organizational structures and relationships (George T, 2000). In most developing countries urban SWM comes under the auspices of the local municipal bodies who are the main formal stakeholders responsible for the collection, removal and disposal of garbage from public places and for the maintenance of dumping grounds (Hoorned, and Lambert Otten, 2000). Sometimes the private formal sector, such as private contractors and small and large reprocessing enterprises, as well as the non-government and community based organizations (NGOs & CBOs), assist the municipal authorities in collecting, treating and disposing waste (Ibid).

Alongside the formal sector, in developing countries resource recovery and recycling activities are also marked by the involvement of the informal sector. This comprises waste pickers, itinerant waste buyers (IWBs) and middlemen such as junk dealers and wholesalers. This informal sector mostly refers to those employers which are classified as "own account" workers, e.g. unpaid family workers and those who collect and treat mostly unregistered waste material (L.A. Obeng and F.W. Wright, 1987).

2.1.2 Characteristics of solid waste in developing countries

Cities in the developing world have undergone a rapid urbanization during the past 50 years. The number of urban dwellers is expected to double between 1987 and 2015. Nearly 90 per cent of

this increase will take place in the developing world, where growth rates exceed 3 per cent a year, three times that of the developed countries (UN-HABITAT 2008).

Urbanization in the developing world implies the expansion of existing slum areas and the creation of new ones. In the 1990s, the urban population in low-income countries increased by one third. According to a UN-HABITAT report published in 2008, nearly 1.5 billion people worldwide live in slums, or about one third of the world's city dwellers. If present trends continue, two billion people could be living in slums by the year 2030 (Ibid). Future need for waste collection in slums, therefore, is likely to put additional strain on municipalities already unable to provide the service to their current residents. Population growth intensifies the pressure on urban infrastructure in many cities already overburdened with the provision of urban services. Many developing world cities lack the resources to meet the demand for services such as water, sanitation, and solid waste management.

Many cities in Africa, Asia, and Latin America face serious problems of managing their wastes. Two of the major problems are the insufficient collection and inappropriate final disposal of wastes. Despite spending increasing resources, many cities – particularly in Africa and Asia collect less than half of the waste generated. Most wastes are disposed of in open dumps, deposited on vacant land, or burned by residents in their backyards. Insufficient collection and inadequate disposal generate significant pollution problems and risks to human health and the environment

Solid waste management in developing countries has received less attention from policymakers and academics than that paid to other urban environmental problems, such as air pollution and wastewater treatment. Depending on the country's economic activity, organics represent 20 to 80 % of the municipal solid waste (MSW) main stream and therefore constitute one of its major fractions (Kumar S, 2009)). The improper disposal of urban organic waste (UOW) composed mostly of food and green waste materials, results in well-known health and environmental issues: attraction of insects and rodents; development sites for parasites, pathogens and viruses; contamination of drainage water, and; emissions of unpleasant odours and greenhouse gases (Ibid).

Municipal solid waste (MSW) refers to the materials discarded in the urban areas for which municipalities are usually held responsible for collection, transport, and final disposal. MSW encompasses household refuse, institutional wastes, street sweepings, and commercial waste, as well as construction and demolition debris. In developing countries, MSW also contains varying amounts of industrial waste from small industries, as well as dead animals and fecal matter (Cointreau-Levine S. 2000).

The characteristics and quantity of the solid waste generated in a region is not only a function of the living standard and lifestyle of the region's inhabitants, but also of the abundance and type of the region's natural resources (Bhide, A.D. 1990). Urban wastes can be subdivided into two major components-organic and inorganic. In general, the organic components of urban solid waste can be classified into three broad categories: putrescible, fermentable, and non-fermentable. Putrescible wastes tend to decompose rapidly and unless carefully controlled, it decompose with the production of objectionable odors and visual unpleasantness. Fermentable wastes tend to decompose rapidly, but without the unpleasant accompaniments of putrefaction. Non-fermentable wastes tend to resist decomposition and, therefore, break down very slowly. A major source of putrescible waste is food preparation and consumption. As such, its nature varies with lifestyle, standard of living, and seasonality of foods. Fermentable wastes are typified by crop and market debris (Ibid).

2.1.3 Developed and Developing Countries experience in MSWM

Profound differences exist between industrialized and developing countries in terms of income, standard of living, consumption patterns, institutional capacity, and capital available for urban investment. Conventional solutions usually do not take into account these differences, resulting in less than optimum outcomes.

The primary difference between wastes generated in developing nations and those generated in industrialized countries is the higher organic content characteristic of the former.

Residents of low-income countries tend to generate less garbage than people in wealthier areas. But they are catching up fast. China, with its billion-plus population, growing economy and improving standard of living, surpassed the US as the world's largest generator of solid wastes in 2005. If current trends continue, India will also generate more total wastes than the US in the year 2025 (Boyle, D.J.K., 2005).

Table 2.1: Waste generation per capita and total waste generation

Level of income	Waste generation rate(1person/day)	Total waste generation(Million tone/year
Low– income countries	**1.3**	**569**
Middle– income countries	**1.8**	**986**
High– income countries	**3.1**	**566**

Source: Cointreau (2000)

Table2.2: Waste collection and disposal

Level of income	Waste collection in percent	Level of disposal in percent
Low– income countries	40-60	5
Middle– income countries	60	30
High– income countries	100	100

Source: Cointreau (2000)

From table 2.2, according to cointreau, even if substantial amount of urban organic waste generated per day in both developed and none developed (developing) country, the former collect and dispose 100% but not the latter.

According to Cointreau-Levine S. (2000), the following represent the major differences between developed and developing countries that are relevant to the design of MSWM solutions;

- Developed countries enjoy a relative abundance of capital and have high labour costs, while developing countries have a relative scarcity of capital and an abundance of unskilled and inexpensive labour. It makes sense for the former to devise waste management systems intensive in capital and that save in labour costs, but it often does not make sense for the latter to follow the same approach.

- Developing countries need low-cost, labour-intensive solutions that reduce poverty, particularly among the most underprivileged sections of society. Socially desirable MSWM solutions in developing countries are those that create income opportunities for unskilled workers, particularly the poor.

- The physical characteristics of cities in developing and developed countries differ markedly. Cities in the developing world have extensive areas with substandard conditions – slums – with narrow, hilly, and unpaved streets. Many immigrants cannot afford to purchase land on which to build their homes. As a result, some migrants occupy vacant land and become squatters. Most of the areas that lack refuse collection services are slum and squatter settlements. Some local authorities decline to provide refuse collection to squatters because they do not pay taxes. This refusal to provide waste collection has a deleterious effect on the urban environment.

- An important difference between developed and developing countries refers to the dissimilar amount and characteristics of waste generated. The waste generated tends to go up as income increases. Further, in addition to low-income communities generating less refuse, the composition of the waste also tends to be different. Waste generated in developing countries contains a large percentage of organic materials, usually three times higher than that of developed countries. The waste is also more dense and humid, due to the prevalent consumption of fresh fruits and vegetables, as well as unpackaged food. First-world residents consume more processed food and food packaged in cans, bottles,

jars, and plastic containers than in the developing world. As a result, waste generated in the former contains more packaging materials than in that of the latter. As a result composting in developing countries is so vital.

- Many cities in the developing world have a dynamic informal sector that has evolved around waste, which provides income opportunities for recent migrants, unemployed, children, women, elderly, and handicapped individuals.

2.1.4 Integrated solid waste management

Rapid increase in volume and types of solid and hazardous wastes a result of continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for national and local governments to ensure effective and sustainable management of waste. It is estimated that in 2012 the total amount of ***municipal solid waste*** **(MSW)** generated globally reached 2.02 billion tones, representing a 7% annual increase since 2003 (Thiesen, H.and S.Vigil. 2006). It is further estimated that between 2011 and 2015, global generation of municipal waste will rise by 37.3%, equivalent to roughly 8% increase per year.

Although considerable efforts are being made by many Governments and other entities in tackling waste-related problems, there are still major gaps to be filled in this area. The World Bank estimates that in developing countries, it is common for municipalities to spend 20-50% of their available budget on solid waste management (open dumping with open burning is the norm), even though 30-60% of all the urban solid wastes remain uncollected and less than 50% of the population is served. In low-income countries, collection alone drains up 80-90% of municipal solid waste management budget. In mid-income countries, collection costs 50-80% of total budget. In high-income countries, collection only accounts for less than 10 percent of the budget, which allows large funds to be allocated to waste treatment facilities (Diaz, L.F, 1997). Upfront community participation in these advanced countries reduces the collection cost and facilitates waste recycling and recovery. Hence, developing countries face uphill challenges to properly manage their waste with most efforts being made to reduce the final volumes and to

generate sufficient funds for waste management. If most of the waste could be diverted for material and resource recovery, then a substantial reduction in final volumes of waste could be achieved and the recovered material and resources could be utilized to generate revenue to fund waste management (Ibid).

In the developed world, the approach to waste management regarded as the most compatible with an environmentally sustainable development is called 'integrated Solid waste management'.

Integrated solid Waste Management (ISWM) is the leading concept of the Urban Waste Expertise Programme (UWEP). Integrated Solid Waste Management is a concept that has been articulated and refined in the UWEP; it is the result of working more than 15 years on waste issues in Southern countries, and coming to understand that it is not the technical issues, but the other aspects of waste management, which are most likely to influence the success or failure of interventions (Raffei, A.B.S. 1999). ISWM addresses the management of the solid waste stream as a set of resources rather then waste, thus ISWM considers the waste stream not as a homogeneous mass but as a set of individual materials that can be handled in different and appropriate ways to maximize recovery and minimize disposal.

The concept of ISWM is based on the assumption that improvements to solid waste management depend on many factors (George T, 2001). ISWM is an umbrella term which takes into account various social, economic, technical, legal and political aspects which are necessary to consider at the planning stage. An ISWM approach gives an overview of various aspects in different stages from generation to disposal of solid waste. Often it is challenging to satisfy all the aspects and create a balance between them during the implementation. However, what seems possible is to develop the tools which could analyze the situation and inform the key stakeholders.

According to Georg (2001) the concept of ISWM can be seen in three perspectives, viz.: ***lifecycle***, ***waste generation*** and ***waste management***.

2.1.4.1 Lifecycle-based Integrated Waste Management Solid

The first concept of ISWM is based on lifecycle assessment of a product from its production and consumption point of view. The reduction in consumption, and utilization of discarded products within the production system as a substitute for new resources, can lead to reduced end-of-cycle waste generation; thus, less efforts and resources would be required for the final disposal of the waste (Georg, 2001).

2.1.4.2 Generation-based Integrated Solid Waste Management

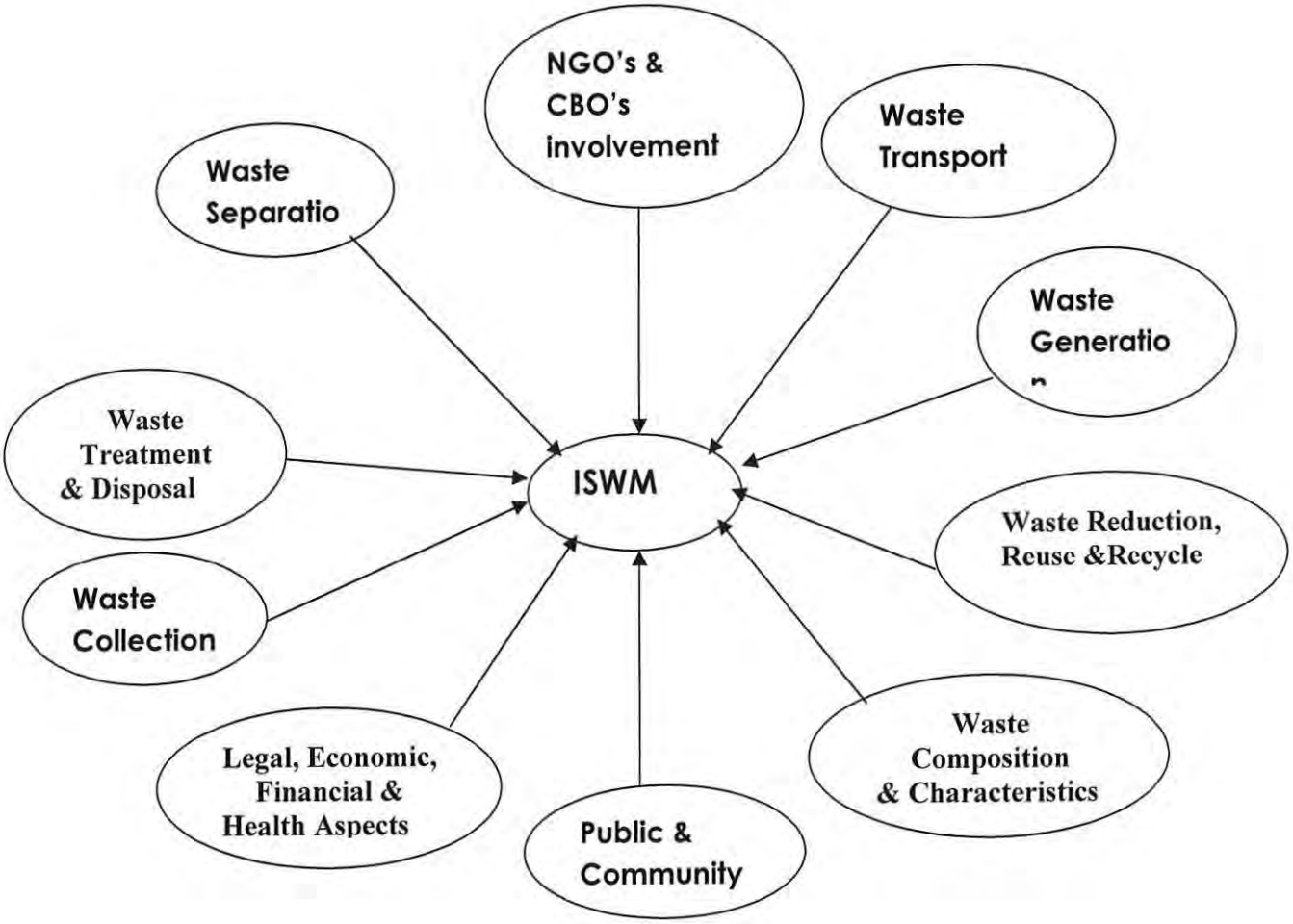
The second concept of ISWM is based on its generation from different sources including domestic, commercial, industrial and agriculture. This waste could be further classified as hazardous and non-hazardous waste. The former has to be segregated at source and treated for disposal in accordance with the strict regulations. 3R approach (reduce, reuse and recycle) is applicable both at source as well as at the different levels of solid waste management chain including collection, transportation, treatment and disposal (Georg T, 2001). .

2.1.4.3 Management-based Integrated Solid Waste Management

The third concept of ISWM is based on its management which includes regulations and laws, institutions, financial mechanisms, technology and infrastructure, and role of various stakeholders in the solid waste management chain (Georg, 2001).

According to George T, (2001), the above three perspective of Integrated solid waste management can be summarized as,

Figer2.1 Integrated solid waste management



Source: George T, (2001)

2.2 Challenges of Integrated Solid Waste Management in developing country

The rapid increase in volume and diversification of solid wastes generated mainly as a result of economic growth, urbanization, industrialization, and unsustainable production and consumption patterns has severe impacts on the global and local environment, natural resources, public health, local economy and living conditions. Thus, development of appropriate policy frameworks and institutional arrangements are essential for providing efficient waste management services to the local communities, as well as to overcome health- and environment-related challenges resulting from poor service provision and facilities (Cointreau, 1984).

According to Bartone, C. 2000, in developing countries a number of challenges and obstacles on the integrated solid waste management could be pointed out, such as the lack of organizations, systems and institutions in national and local governments, the shortage of the human resources in the local governments and the operator and the manager of the private companies and the group on waste management, financial problems of waste management services and facilities, lack of capacity of the introduction and the operation of the recycling scheme and system, the lack of the capacity and the social problems on the workers on waste management, absence of the communication with the local communities and NGOs.

The complexity and daunting nature of waste management challenges require a deeper collaboration among different stakeholders, governments, civil society, private sector, local communities, and others.

Governments/public utilities facing enormous resource challenges in providing quality public services are increasingly looking towards collaboration with the private sector to help deliver their public service mandate. However, in practice, by and large, the policy environment in developing countries had not been very conducive to private sector participation in provision of waste management services and investing in waste management infrastructure (Thiesen, H., and S. Vigil. 2006).

In practice, such collaboration or partnerships could create win-win solutions for both the public utilities and private sector if duly supported by appropriate policy frameworks. For example, such partnerships could let savings in municipal budgets, of which a large portion is often used for waste management. The private sector, on the other hand, may use this opportunity to convert waste into valuable resources and environmentally friendly products that would not only contribute towards achieving resource efficiency, but could also provide income-generating opportunities (Ibid). It is therefore important for developing countries to institute appropriate policy frameworks and governance mechanisms leading to **Integrated Solid Waste Management** to increase the efficiency and effectiveness of municipalities in delivering required services, and enable to municipalities to save valuable resources while also providing health and environment benefits, including co-benefits.

2.3 Process of solid waste management

Solid waste management is one of the most important urban services provided under a municipal responsibility nearly in all developing countries. In urban areas, especially in the rapidly urbanizing cities of the developing world, problem and issues of municipal solid waste management are of immediate important (Cointreau-Levine S. 2000)

On the base of generation-based Integrated Solid Waste Management system, urban solid waste management goes through different steps that are dependent one on the others (Thiesen, H.and S.Vigil. 2006). According to him the process of Solid Waste Management is a comprehensive **waste prevention**, **recycling**, **composting**, **incineration** and **landfill** program. An effective Solid Waste Management system considers how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment. It involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions. It aims to be socially desirable, economically viable, and environmentally sound (Ibid).

Source Reduction /Waste prevention/

Waste prevention is given the highest priority in Solid waste management. This is a preventive action that seeks to reduce the amount of waste that individuals, businesses, and other organizations generate. By not creating waste, fewer collection vehicles and fewer refuse collectors would be needed; fewer and smaller waste handling facilities would be required, and it would extend the life of the landfills (Richardes, T. 2002)

Recycling/re- use/

After the source reduction, recycling comes next in the process of waste management hierarchy. Recycling is the recovery of materials for melting them, repulsing them, and reincorporating them as raw materials. It is technically feasible to recycle a large amount of materials, such as plastics, wood, metals, glass, textiles, paper, cardboard, rubber, ceramics, and leather. Besides technical feasibility and knowhow, demand determines the types and amounts of materials that are recycled in a particular region. Areas with a diversified economy and industrial base usually demand more different types of raw materials that can be recycled (McHarry.1993),

.

Composting

Composting is the process of aerobic biological decomposition of organic materials under controlled conditions of temperature, humidity, and pH, so that the result is a soil conditioner that can be used in landscaping, agriculture, and horticultural projects.

Considering the high proportion of organic matter in the waste generated in developing country cities (typically, over 50 per cent), composting can be an option to reduce the amount of waste that is currently disposed of as landfill, thus extending the lifespan of dumps. When composting is conducted under controlled conditions, it does not generate odors and does not attract flies or other animals. Composting recycles nutrients by returning them to the soil (McHarry.1993).

Incineration

In the process of solid waste management, incineration occupies the next to last priority, after waste prevention, re-use, recycling, and composting have been undertaken. Incineration is the

burning of waste under controlled conditions, usually carried out in an enclosed structure (Huysman, M. and I. Baud, 1993).

Sanitary land filling

Final disposal of wastes at sanitary landfills is given the lowest priority in the process of solid waste management. A sanitary landfill is a facility designed specifically for the final disposal of waste in ways that minimize the risks to human health and the environment associated with solid (Huysman, M. and I. Baud, 1993).

2.4 Solid waste Management in Developing Countries

World Bank has categorized some countries as developing Countries in terms of the following criteria: low-income, human resource weakness, and economic vulnerability.

While urbanization in developing countries has contributed to wealth accumulation, it has also been accompanied by an alarming growth in the incidence of poverty. Today, one out of four people in cities lives in "absolute poverty"(UNDP, 2005). These countries have a number of priority issues pertaining to the country's development. Among those, management of municipal solid waste is one of the priorities of urban issues.

In urban solid waste management planning, many of these developing countries adopt a segmental ad hoc approach (Thiesen, H.and S.Vigil 2006). However, it is important to practice integrated solid waste management approach such as: Incorporation of more environmental and economic friendly concepts of source separation; recovery of waste; legitimization of the informal systems; partial privatization and public participation.

2.4.1 Solid Waste Characterization

As cities are becoming more urbanized, their waste composition also changes. The substantial increase in the use of paper and packaging is probably the most obvious change. Other significant changes are due to the higher proportion of plastics and consumer products and their

related packaging material in the solid waste. The negative side of greater affluence is that it brings greater volume of wastes, making it more expensive for management (Huysman, M. and I. Baud, 1993.).

2.4.1.1 Solid Waste Composition

The composition of the waste, in general, differs from country to country on the economic level of countries as well as other factors such as geographical location, energy resources, climate, living standards and cultural habits. Most of the developing countries have high percentage (50 to 80%) of organic matter. The high content of biodegradable matters results in high waste density (weight to volume ratio) and high moisture content. These physical characteristics indicate the necessity of waste treatment prior to disposal. As waste comprises a high organic content and a low calorific value; biological treatment such as composting and bio-gasification (i.e. anaerobic digestion) are thus more suitable. Incineration would not be a good option due to extreme moisture content and low calorific value (George T. 2001).

2.4.1.2 Collection and Transport

Significant amount of the solid waste generated in urban centers of developing countries are not collected/ attended and either burned openly in the streets or end up in rivers, creeks, marshy areas and empty lots thereby posing a serious threat to public health. In developing countries, municipal solid waste management costs consume 20-50% of municipal revenues, collection service levels remain low with only 50- 70 % of residents receiving service and most disposal being unsafe (Cointreau, 1984).

The collection rate varies from city to city and sometimes within different sections of one urban area. Collection rate vary from 10-90 % of the total municipal waste generated. Collection facilities are either inadequate or inefficient in almost all of the cities developing countries. In low income or squatter settlements, garbage collection is often non-existence as these settlements falls outside official service areas (UNEP, 2001c).

2.4.1.3 Processing and Disposal

According to Donevska (2005) final disposal in most of the economically developing countries is usually a matter of transporting the collected waste to the nearest available open space and discharging them. Open dumping is predominant except for the developed countries. Composting is not carried out to the capacity that can be achieved though almost half of the MSW can be reduced thus. Other forms of disposal like animal feeding, open burning and dumping in water bodies or wetlands contribute to environmental hazards. Waste burning is practiced to reduce its volume and minimize the attraction of animals and vermin. Despite the degradation of valuable land resources and the creation of long-term environmental and human health problems, uncontrolled disposal systems are still prevalent in most of the developing countries (Donevska 2005). Sanitary landfilling or engineered landfilling of MSW is often misinterpreted in the developing countries, especially when it comes to covering a dumpsite by soil. Financial and institutional constraints are one of the main reasons for inadequate waste disposal. Introduction of SWM user fees cover only the collection and transportation costs leaving practically no resources for safe disposal of the waste. Generally, when aesthetic values are in question most people are willing to pay for the removal of refuse from their immediate environment but are not concerned with its ultimate disposal. However, Significant changes have been made over the past few years, especially in the field of composting organic wastes in countries like Bangladesh, Sri Lanka and India (ibid).

2.4.1.3.1 Landfill

In most of the cities of developing countries, landfill is the most preferred method for the final disposal of solid waste. Most of these sites practice open dumping, with no regards to the requirements for a sanitary landfill. However, government and municipalities are already working to develop the sanitary landfill sites in few urban areas. Since land is fast becoming scarce within city limits, new sanitary landfill are often too distantly located compared to the open dumpsites within municipal limits, thereby making the longer collection and delivery time, which is ineffectively costly (Bhide AD. 1990).

2.4.1.3.2 Composting

Composting is the second preferred method of solid waste disposal in developing countries, mainly due to the high percentage of organic material in the waste composition. For instance there are some small-scale composting plants in Dhaka, which has shown more success such as windrow composting, however composting in bigger scale is not that popular in the whole region. The main reason why centralized composting plants are not functioning effectively in developing countries includes high operating and maintenance costs compared to open land filling and incomplete separation of materials such as plastics and glass, making the compost poor for agricultural application (Raffei, A.B.S. 1999).

2.4.1.3.3 Recycling and recovery

Recycling is generally carried out by the informal sector. In most developing countries there are no policies that promote recycling or resource conservation, and the municipalities do not have the expertise to launch the recycling activities (Huysman, M. and I. Baud, 1993). In several places, for example, In Cambodia and Tanzania more of the waste could be recycled if there was better infrastructure for collecting recyclables. However, collection of recyclable waste is done in several steps such as door to door collection, collection at secondary and primary transfer stations and even in the disposal sites. Due to the faulty collection systems and the low quality of scrap, the recycling rate is low despite of high number of waste pickers working (ibid).

2.4.1.3.4 Incineration

Due to the high capital, operation and maintenance costs involved for the installation of incineration plants, incineration is not popular as a waste disposal system in most developing countries. In addition to these, the major portion of the MSW is organic with relatively high moisture content which leads to a low calorific value (Ibid).

2.5 Composting of Organic Waste

2.5.1 Definition and type of Composting

The history of composting is both ancient and modern. As early as roman times, and possibly before, composting was recognized as a transitional force in the "life-cycle". Thus, for 2000 years, compost has been used for the maintenance of croplands and gardens. In this country, the 1940's saw the continued development and refinement of processes which composted organic wastes, such as: leaves, grass, vegetable, etc. Today, residents and municipalities from across the United States use various procedures to convert leaves and yard waste, once considered a waste, into a valuable resource (Raffei, A.B.S. (1999).).

Composting is often used synonymously with "biological decomposition". However, for purposes here, According to Hoornweg, (1999) it may be more appropriate to define composting as a method of solid waste management; whereby,

- The organic component of the waste stream is biologically decomposed under controlled conditions to a state in which the compost can be safely handled, stored, and/or applied to the land without adversely affecting the environment. or
- Composting, often described as nature's way of recycling, is the biological process of breaking up of organic waste such as food waste, manure, leaves, grass trimmings, paper, worms, and coffee grounds, etc., into an extremely useful humus-like substance by various micro-organisms including bacteria and fungi in the presence of oxygen.

Composting implies that the organic fraction of the waste stream can be managed through internal process producing a useful end product. However, because composting of organic wastes are under *controlled conditions,* composting is distinguished from the decomposition processes which occur naturally.

Controlled decomposition implies an efficient decomposition process, which is managed to avoid both environmental and nuisance problems. Controlled decomposition also allows the greatest

amount of material to be located on a dedicated composting site. A controlled decomposition of the organic wastes means production of compost that *does not adversely affect* the soil or plants to which it is applied. The end product of the composting process must be "stable". If the decomposition process is incomplete then the material, when applied to the land, will rob nutrients from the soils and plants (Ibid).

Composting activities can be categorized based on

- ✓ Nature
- ✓ Use

According to its nature composting can be,

- ➢ **Aerobic composting** - To compost with air. High nitrogen waste (like grass clippings or other green material) will grow bacteria that will create high temperatures (up to 160 degrees). Organic waste will break down quickly and is not prone to smell. The debris breakdown will slow considerably when it becomes dry or cool. If you just throw a hose on the compost the water will likely go around the dry area. To solve this problem turn your compost while you are watering. This type of composting is high maintenance, since it will need to be turned every couple days to keep air in the system and your temperatures up. It is also likely to require accurate moisture monitoring. Often with the high temperature this type of composting will create dry pockets in the center of you compost. Where you have large volumes of compost, this type of compost is perfect. Once it is done heating up it also becomes food for redworms and other soil organisms (Engel, 1988).
- ➢ **Anaerobic composting:** - This is composting without air. Anaerobic composting is low maintenance since you simply throw it in a pile and wait a couple years. If you just stack your debris in a pile it will generally compact to the point where there is no available air for beneficial organisms to live. Instead you will get a very slow working bacteria

growing that does not require air. Your compost may take years to break down (this is what happens when you throw your food waste in the garbage that goes to the landfill). The bacteria break down the organic materials into harmful compounds like ammonia and methane (Bhide,AD 1990).

- **Vermin composting** - For composting food waste this is the ideal type of compost. Along with red worms, this includes composting with bacteria, fungi, insects, and other bugs. Some of these guests break down the organic materials for the others to eat. Red worms eat the bacteria, fungi, and the food waste, and then deposit their castings. Oxygen and moisture are required to keep this compost healthy. This compost should not smell, but if it does it is likely there is too much moisture or your compost has become compacted. You need to aerate (or turn) your compost to get rid of the excess moisture. At times this compost may heat up due to the bacteria activity. When managed properly the heating process will be short and warm. This is medium maintenance compost since you need to feed your red worms and monitor the conditions. Red worms are good for producing vermin compost which is nutrient rich semi composted mulch with red worm castings. Your compost will eventually become pure castings the longer you leave it (Ibid).

According to its use composting can be,

- **Industrial systems**: - Industrial composting systems are increasingly being installed as a waste management alternative to landfills, along with other advanced waste processing systems. Mechanical sorting of mixed waste streams combined with anaerobic digestion or in-vessel composting, is called mechanical biological treatment. Treating biodegradable waste before it enters a landfill reduces global warming from escapee methane; untreated waste breaks down an aerobically in a landfill, producing landfill gas that contains methane, a potent greenhouse gas (Mougeot; L. (ed.), 2005).
- **Agriculture**: - In agriculture, windrow composting is used. It is the production of compost by piling organic matter or biodegradable waste, such as animal manure and crop residues, in long rows (*windrows*). This method is suited to producing large volumes of compost. These rows are generally turned to improve porosity and oxygen content,

mix in or remove moisture, and redistribute cooler and hotter portions of the pile. Windrow composting is a commonly used farm scale composting method (Nilsson-Djerf, J., McDougall, and F. 2000).

- **Home**: - Home composting is the simplest way to compost. At home, composting is generally done by using composting bins or in the form of pile composting. Other methods include trench composting and sheet composting. It is a small scale process and requires less outlay of capital and labor (ibid).

2.5.2 Contribution of Composting

The most considerable environmental benefit of composting is that the amount of waste going to landfill is reduced, since landfills cause serious environmental impacts. Water forms leachate when percolating through the waste and becomes contaminated by substances originating in the waste. This leachate contains oxygen depleting substances, toxic organic substances and metals, and can pollute ground and surface water. Lining and covering the landfill can in a short perspective prevent this, but in the long run some leakage is inevitable. Another environmental impact is gas emissions. When water enters the landfill, biological activity starts and landfill gas is formed, including hydrogen sulphide and methane, which is an aggressive greenhouse gas (Engel, 1988).

Composting biologically degradable waste not only reduces the amount of waste put on landfill, but can also reduce the environmental impact of the remaining waste at the landfill, since putting less organic matter in the landfill will reduce methane production. There are also suggestions that less organic material in the landfill will reduce the negative environmental impact of leachate. A fire on landfills is another factor with large environmental impact. With less organic waste going to landfill, the risk of fire can be reduced (Binder, M. and Bramryd, T. 2000).

Compost has the potential of being a fertilizer and can thus be environmentally beneficial by substituting artificial fertilizers. To what degree the compost will enhance the nutrient status of the soil depends on both the waste that the compost is made from and the treatment technology.

Even if the compost is low in nutrients it can be valuable since application of compost, or any other form of humic material, effectively enhances soil structure, improves the water holding capacity and reduces the sensitivity to erosion. Several tests also show that application of compost represses plant diseases in the field (Ibid).

From a solid waste management perspective, yard waste composting can reduce the amount of solid waste which has to be sent to a landfill. Less waste going to this traditional disposal option results in a decrease in a municipality's cost for transport and disposal.

More to the point, according to Bhide AD (1990), many areas of the country are experiencing a disposal capacity short fall. Landfills are being closed because either they have reached their life span or an associated pollution problem has been discovered. Sitting new disposal facilities is becoming increasingly difficult because no one wants landfills or burn facilities in their back yard. If such a facility is being proposed, it may take up to ten years before it could open its doors to waste. Hence as organic wastes constitute the largest fraction of the waste stream going to landfill, the composting of these materials will serve to reduce the demands on landfills and recycle resources to produce compost and other materials.

Any solid waste management option which can conserve disposal capacity and do it in an environmentally sound and economically wise manner should be implemented.

Composting thus reduces the risks of environmental degradation, but can also have other positive side effects, including economizing with limited natural resources, higher environmental awareness among the population and closing the nutrient loop between urban and rural areas. Composting is therefore an interesting option for municipalities developing their waste management by minimizing and recycling waste that today ends up on landfill.

According to Bhide AD (1990) composting is interesting to the municipal waste manager because:

- Decomposable organic waste represents the largest fraction of the domestic waste stream in most cities

- Recovery of organic materials through separation and composting decreases the amount of waste requiring final disposal, saving landfill space and prolonging the life of existing landfills and dumps.
- Composting can accommodate and help to manage seasonal fluctuations in waste volume or composition, combining such diverse waste streams as leaves, kitchen wastes; agricultural and crop residues; food processing wastes; and excreta sludge.
- Health hazards associated with untreated disposal of decomposable wastes decrease significantly under controlled conditions of composting, where the heat of the bacterial action actually sterilizes the materials; kills pathogens; and deactivates weed seeds and fungal spores.
- Managed composting of organic waste under controlled conditions can redirect or manage materials that are the greatest sources of nuisance and pollution at landfill sites.

2.5.3 Challenge of composting activities

The bulky nature and low density of the dry compost product are responsible for most of the difficulties that pertain to transport and mechanics of applying the product. Because the volume-to-weight ratio is higher, a low-density product is more expensive to transport than is one of a high density. In as much as compost generally is uncompacted low-density product, the volumetric capacity of the transport vehicle is reached long before its weight capacity. The bulkiness and low density of compost necessitate the use of bulky equipment to spread it on the field. As previously indicated, a manure spreader can be used or adapted to apply compost to the field. With regard to manual application, more trips per unit mass of material are needed (Diaz, L.F., 1997)

Whether or not organic chemical compounds can be broken down in composts depends on many factors including concentration of compound, substrate availability and adaptability of bio-flora to the environmental conditions. The difficulty of bio-degradation products must be acknowledged.

Jager (Jager et al, 1991) describes pathways of breakdown of organic and synthetic compounds in compost piles. Some organic chemicals can only be broken down under aerobic conditions, due to the particular chemistry of oxidation necessary for them: some chemical bonds are only broken in the presence of oxygen, e.g. saturated hydrocarbons. Oil is given by Jager as an example of a compound which is not easily broken down under *anaerobic* conditions.

Farther more according to Jager through significant experience in most developed and a few developing countries in composting activities there are challenges to diverting and composting the portion of the waste stream.

These include:

- Lack of composting capacity.
- Lack of communication (finding out who the players are or might be).
- Lack of hauling services.
- Restrictive regulations.
- Public health, when the product is composted human excrement or is composted industrial wastewater solids (i.e., sludge).

2.6. Urban agriculture

With the urbanization process, urban and peri-urban agriculture has evolved from a simple, traditional and also informal activity into a commercial and professional initiative. UPA has become a key element in food security strategies. It was officially recognized by the 15th COAG session in Rome during January 1999 and subsequently at the World Food Summit in 2002.

Urban and peri-urban agriculture is an industry located within (intra-urban) or on the fringe (periurban) of a town, a city or a metropolis, which grows and raises, processes and distributes a diversity of agriculture products, using largely human, land and water resources, products and services found in and around that urban area. The phenomenon of urbanization brings severe challenges to ensuring household food security in a context characterized by high rates of unemployment, increasing development of the informal sector, deteriorating infrastructure,

overcrowding and environmental degradation. In addition, cities should respond to increasing globalization; managing the process of decentralization; and providing basic services to the burgeoning urban poor, whose contribution to the economy is not usually matched by their access to basic services.

In most cases, urban residents in developing countries are increasingly exposed to the daily challenges, such as lack of safe water, inadequate sanitation and lack of environmental safeguards (air pollution, exposure to toxins and waste), and increased poverty and food insecurity. In most cities of the developing countries, urbanization has become virtually synonymous with slum growth. The slum population in these countries almost doubled in 15 years, reaching 200 million in 2005 (UNFPA, 2007) Tension has been especially high in the growing cities which depend on diminished supplies from rural areas and the global food market.

With over 50 per cent of people in the world living in urban environments, urban food security has become a huge issue, especially in developing countries where infrastructure is poor and general poverty cannot accommodate increasing food prices. As a consequence of the current global food crisis, food riots occurred in Haiti and in at least 10 African countries during May and June 2008. Food aid can only be of short term nature aimed to buffer the current problems with food supply.

For the urban sector, self reliant food production, as enabled by UPA, is one of the measures suggested to lower the impact of this development, create access to food and enhance livelihood opportunities for poor urban dwellers calling the worsening of the "world food crisis" a serious threat to the realization of the right to food for all (UNDP,1996).

Many rural migrants, seeking better livelihoods in cities, have agricultural backgrounds and often end up participating in informal activities, such as urban and peri-urban agriculture (UPA). The United Nations Development Programme estimated in 2001 that 1,200 million people are engaged in urban and peri-urban agriculture world-wide. Of these, 400 million are considered to be market producers, employing 250 million people full-time. In African countries 40 per cent of

urban dwellers are said to be engaged in some sort of agricultural activities and this percentage rises to 50 per cent in Latin American countries (Ruel et al., 1998).

In this biggest city of the country (Addis Ababa) where the population growth is most alarming, urban agriculture is highly practiced as a survival strategy, both the household and cooperative level. Particularly, along the bank of rivers in Addis Ababa, there are vegetable producing farmers who are organized into five cooperatives, namely, Mekanisa-Furisaris, Kolife-Lideta, Kebena-Bulbula, Shankla-River, and Keranio-Medhane-Alem cooperatives (AAMPPO,1999).

CHAPTER THREE

3 Background of the study area

3.1 Climate

Addis Ababa has a Subtropical highland climate. The city possesses a complex mix of highland climate zones, with temperature differences of up to 10 °C, depending on elevation and prevailing wind patterns. The high elevation (2,355m) moderates temperatures year-round, and the city's position near the equator means that temperatures are very constant from month to month.

3.2 Demography

Based on the preliminary 2007 census results, Addis Ababa has a total population of 2,738,248. Addis Ababa contains 22.9% of all urban dwellers in Ethiopia. With an estimated area of 540 square kilometers, this chartered city has an estimated density of 5070.8 inhabitants per square kilo meter. Now a day the city characterized with a number of challenges including the high rate of unemployment, housing shortage and environmental deterioration moreover scanty level of urban infrastructure is the main characteristics of the city that hinder the fast growth of the city.

3.3 Economy

The economic activities in Addis Ababa are diverse. According to official statistics from the federal government, some 119,197 people in the city are engaged in trade and commerce; 113,977 in manufacturing and industry; 80,391 homemakers of different variety; 71,186 in civil administration; 50,538 in transport and communication; 42,514 in education, health and social services; 32,685 in hotel and catering services; and 16,602 in agriculture. In addition to the residents of rural parts of Addis Ababa, the city dwellers also participate in animal husbandry and cultivation of gardens (CSA, 2007).

3.4 Waste Management Practice in Addis Ababa

3.4.1 Population and Waste

Population dynamics have significant influence on the amount of waste generated and its proper handling in the municipality. The population of Addis Ababa is rapidly increasing because of the natural increase and rural-urban migration. The population of Addis Ababa has grown from a mere 450,000 in 1960 to 1.6million in 1990 (Addis Ababa City Administration, 2004) and presently stands nearly 3 million (CSA, 2007). The national population growth rate as for the year 2009 stood at 2.7% that of Addis Ababa stood at 3.5%. This population growth has not been accompanied by increase in housing and basic sanitation facilities. The implications of these are increases in population density with low income settlements, large waste generation and increased pressure on waste management facilities. The UN-habitat (2008) observes that today's true builders and planners of cities in developing countries are the urban poor who build houses and establish legal or illegal settlements where they can make life comfortable no matter what. "Slums have been the only large-scale solution to providing housing for low-income people. It is the only type of housing that is affordable and accessible to the poor in these cities" (UN-habitat, 2008). People in the slum most often do not pay for waste services and the nature of these settlements make no room for access roads for effective waste collection.

Associated with the increasing population are rising levels of affluence, shorter product cycles, and the large number of packaging, consumption and the demand for portable products that have brought increases in the waste stream. Diaz, L.F (1997) established a relationship between the human environmental impact (I) (solid waste generation), sub-national population size, growth, and concentration (*P*), people's affluence (*A*), and the methods (*T*) it employs to obtain its livelihood and dispose of its consumed products. This relationship they expressed through a mathematical model, I = PAT. Translating this into real life situation, this means that greater waste generation and its environmental impact would accompany a large, rapidly growing, and high density population. And this is what has been the situation in Addis Ababa.

3.4.2 Waste stream information

According to Addis Ababa City Solid Waste Administration, about 15,000kg of municipal solid wastes are generated per day in the metropolis and the average waste generated per capita per day is estimated at 0.45 kg. Holding change in production and consumption patterns constant, future projections are subject to population growth, taking into account the present population almost 3million and growth rate of 3.5 per cent.

Waste from domestic sources include, food waste (most of the time residual of vegetables), garden waste, sweepings, ash, packaging materials, textiles and electric and electronic waste (here classified under metals). Waste from industrial sources include metals, wood, textiles, plastic; food waste from slaughter houses, fruit processing and grain mills. The central business districts generate waste with high food and plastic contents while waste from schools and offices have high paper and plastic contents. These wastes are classified with their proportion in the table3.1.

Table 3.1 Waste type and proportion in the Addis Ababa metropolitan area.

Waste type	Organic i.e. Food and plant	Paper	Textile	Plastic	Glass	Metal	Inert	Others
Proportion	**65%**	**6%**	**1.7%**	**3.5**	**3%**	**2.5%**	**17.1%**	**1.2%**

Source: Ababa health Addis office (2010)

The high proportion of food and plant waste is due to the fact that Ethiopia's economy largely depends on agricultural products for export and domestic consumption.

3.4.3 The solid waste management system in Addis Ababa

Addis Ababa is the economic, social and political hub of the nation as well as the diplomatic seat of the Africa union and other prestigious UN organizations and liaison offices as well as dozen embassies and chancelleries. The city is almost 123 years old. Addis Ababa is a metropolis having modern and indigenous urban formants. The city has diverse man made and natural attractions, suitable climate and relatively safe neighborhoods. In addition, the city has a number of services serving institutions and so forth that eventually attract people from all over the country to come and settle in search of better facilities and job opportunities.

For decades, the city has been expanding in all its direction and now almost saturated in terms of land use densification. In compliance with this situation and other factors, the city has faced social, economical and environmental challenges attributed to its fast growth and other issues. Among the challenges, the issue of solid waste and its management has been the foremost that needs the real concern of the city administration and the wider populace.

Solid waste management has given due emphasis by the city management of Addis Ababa especially following the structural reform act of the year 2004. The city government has been striving to curb the challenge faced in solid waste management through providing lows, strategies and other measurement. It is evident that much progress and success have been attained in the past five years than what was before. Yet, it is not debatable that much work needs to be done a head.

Among the solid waste problem, lack of an effective and efficient sanitary landfill site is the major one. As it is known, the existing open landfill site with the name "koshie" has served the city for the past 47 years and is now over standard. In addition the landfill site has been causing great environmental, social and economic problem amongst the local as well as the entire city dwellers. Koshie landfill site was intended to serve the city only for 25 years. However, it is now

over 45 years old and its size as well as solid waste management system dose not suits the city's ever growing demand and International status.

In the Addis Ababa metropolitan area, solid waste collection and disposal is the responsibility of the municipality of Addis Ababa. The department therefore sees to the collection, transport, treatment and disposal of municipal solid waste. The municipality is thus responsible for the management of the solid waste disposal sites at the Repi landfill site and the new sanitary landfill site under construction at Gefersa in Oromiya.

Currently, the administration of the city has decentralized the solid waste management system to the lowest administrative units. Most of the collection activities from the households to the containers are carried out by small community-based organization and private firms. However, the municipality is still the major actor of solid waste management in the city.

3.4.3.1 Solid Waste Generation

According to the report of Addis Ababa health bureau, the main sources of waste in the city are households, hotels, industries, street sweep, commercial centers, and hospitals. Household waste accounts about 76% of the total generation.

3.4.3.2 Solid Waste Collection

For the purpose of waste collection, the city has been demarcated into waste collection districts (one districts contain 1000 household) where a company is contracted to collect waste in one district or two. More than 300 waste collection co operatives have been contracted.

The collection system is carried out using 24 side loaders 14 compactor trucks and 47 container lifter trucks (Addis Ababa City Administration 2010).

> Taking the total population of the city as 3.3 million and the average family size of a household as 5, one truck serves about 10,313 families or about 51,562 people. This implies that the geographical coverage and frequency of disposal is by far below expectation (YIRGALEM, 2001: 75)

The main types of vehicles currently in use by co operatives is skip trucks. The wastes are taken by road directly to the disposal sites. There are no waste transfer stations.

3.4.3.3 Solid waste disposal

The Repi landfill site is located in the south-western expansion areas of Addis Ababa in Lafto-Nifas-Silk Kifile ketema. In 1960s, the site was considered to fall outside the city's master plan since it was inhabited by only a few farmers. The municipal administration of Addis Ababa started to use the site in 1964.

The disposal system is characterized by inappropriate location for disposal site coupled with uncontrolled, non-ecological land filling. At present, the dumping grounds are not engineered to serve as sanitary landfill site. It therefore constitute high potential for the spread of infections through run offs during rains and contamination of underground water.

Photo3.1: Repi landfill site (Qoshe).

Source: during field survey

Source: Yirgalem Mahiteme (2005)

In addition, since the formal systems of solid waste disposal cannot cope with the ever-increasing volume of solid waste being generated in Addis Ababa, the public itself employs various means of waste disposal. Waste is thus disposed off indiscriminately especially in watercourses and drainage channels and also through burning. According to 2007 Housing and Population Census about 625,746 people were asked how to dispose domestic waste and the result is tabulated as follows

Table 3.4: different means of public waste disposal in Addis Ababa

Means of waste disposal	**Population**	**Percentage**
Waste collected by agents	122,034	19.5 %
Burned by household	76,359	12.2 %
Public dump	321,824	51.4 %
Dumped elsewhere	72,016	11.6 %
Buried by household	28,948	4.6 %
Other	4,565	0.7 %
Total	625,746	100%

Source: CSA (2007)

These statistics though did not cover the whole population of Addis Ababa, are a fair representation of what goes on as far as solid waste disposal is concerned.

3.5 Profile of the organization

3.5.1 Bio–Farm Ethiopia

The Bio–Farm Ethiopia demonstration site is an integrated, natural 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 part 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 coutry wide. Silmilarily,

3.5.2 Addis Ababa EPA

In the history of Ethiopia, constitutionally established EPA is a recent phenomenon. 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– cites. However, the agency has no administrative structure at kebele level. It has established composting project site at Bole sub– city kebele 10/11 since 2006 (Getaneh and Tesfaye, 2006)

CHAPTER FOUR

4. Analysis and Finding

4.1 Benefits of composting Urban Organic waste in Addis Ababa

The processing of organics solid waste can deliver important environmental benefits, including the recovery and conservation of resources and a reduction in the quantity of organics going to landfills, reduction of impact of waste in or around the landfill site, generation of income to the urban poor and so on

4.1.1 As means to divert substantial amount of waste from landfill.

The Bio-Farm and EPA has collected and segregated about 100,754kgs between Septembers 2010- January 2011. Of these amount 86.7% was turned in to compost while the remaining portion which is about 13.3% was transported and dumped into community waste collection bin. In fact the amount of organic solid wastes that are converted in compost (86.7%) is more or less exaggerated as compared to the proportion of decomposable organic solid waste (which is more than 50%) by weight in Addis Ababa. The reason behind this is those wastes that are collected and segregated came from vegetable and fruit market which is found at the heart of Addis Ababa (mercato).

Table– 4.1 type of collected and sorted waste (September 2010– January2011)

Waste type	Month					Total (Kg)	% of waste
	Sept.	**Oct.**	**Nov.**	**Dec.**	**Jan.**		
Decomposable organic waste (kg)	17471	17780	17163	18090	16850	**87353**	**86.7**
Plastics(kg)	1411	1515	1301	1625	1196	**7048**	**7**
Bones and bones scraps(kg)	606	661	546	709	501	**3023**	**3**
Glass(kg)	301	335	271	368	236	**1511**	**1.5**
Clothing(kg)	314	337	297	338	296	**1582**	**1.57**

Source: Bio–Farm and EPA documentation

The study result on the project site revealed that the decomposable organic waste covers 86.7% of the total amount processed organic waste which eventually converted into compost. Hence almost more than 50% of the aggregate solid waste composition of Addis Ababa is decomposable organic waste, converting these into compost means diverting substantial amount of waste from landfill which in turn increase life span too.

4.1.2 Contribution to sustainable solid waste management

Effective solid waste management systems are needed to ensure better human health and safety. They must be safe for workers and safeguard public health by preventing the spread of disease. In addition to these prerequisites, an effective system of solid waste management must be both environmentally and economically feasible.

- Environmentally feasible: It reduce the environmental impacts of waste management at the minimum cost and
- Economically feasible: It must operate at a cost affordable to community.

Clearly it is difficult to minimize the two variables, cost and environmental impact, simultaneously. There will always be a trade off. The balance that needs to be struck is to reduce the overall environmental impacts of the waste management system as far as possible, within an acceptable level of cost.

An effective and feasible SWM system considers how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment.

An economically and environmentally sustainable solid waste management system is effective if it follows an integrated approach i.e. it should deals with all types of solid waste materials and all sources of solid waste.

According to the head of Addis Ababa City Solid Waste Administrator (Ato Nega Fentahune) effective and feasible waste management system includes one or more of the following options:

(a) Waste collection and transportation.

(b) Resource recovery through sorting and recycling i.e. recovery of materials (such as paper, glass, metals) etc. through separation.

(c) Resource recovery through waste processing i.e. recovery of materials (such as compost) or recovery of energy through biological, thermal or other processes.

(d) Waste transformation (without recovery of resources) i.e. reduction of volume, toxicity or other physical/chemical properties of waste to make it suitable for final disposal.

(e) Waste transformation i.e. environmentally safe and sustainable disposal in landfills.

He farther added that solid waste management involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions. It aims to be socially desirable, economically viable, and environmentally sound.

Figer4.2: process of solid waste management

Source: EPA documentation (|2009)

- **Note:** Those diagrams that gird toward EPAS indicate that in the process of solid waste management the organization focused on those steps that are friendly to the environment.

Figure 4.2 show that starting from source reduction to landfill, each and every process have their own contribution and relation to the urban solid waste management.

Composting of urban organic waste is the process of production of compost. During the indepth interviews of EPA and Bio–Farm has pointed out that after the implementation of Maximum Available Control Technology, waste-to–wealth, plants produce compost "with less environmental impact than almost any other type of urban solid waste management.

Similarly the field observation on the study site revealed that, the composting process converted more than 80% of those waste that came from fruit and vegetable market in to compost. Since from the total solid waste of Addis Ababa, more than 50% is decomposable organic waste composting urban organic waste have had a great contribution in the process of solid waste management.

4.1.3 Reduce the environmental impact of waste

By transformation of one natural ambient into location for disposing municipal waste, the space obtains new functional characteristics. The contact surface between the body of the landfill and the morphologically formed nature structures represents a zone with high risk for environmental pollution (Binder, M. and Bramryd, T.2000). Solid waste deposits in landfills decompose by a combination of chemical, physical and biological processes. The decomposition produces solid, liquid, and gaseous byproducts. All of them are of concern in the overall management of the landfill.

According to the head of Addis Ababa City Solid Waste Administrator (Ato Nega Fentahune) a large number of adverse problems may occur from landfill operations. These problem can vary: fatal accidents (e.g., scavengers buried under waste piles); infrastructure damage (e.g., damage to access roads by heavy vehicles); pollution of the local environment (such as contamination of groundwater and/or aquifers by methane generated by decaying organic wastes (methane is a greenhouse gas many times more potent than carbon dioxide, and can itself be a danger to inhabitants of an area); harboring of disease vectors leakage and residual soil contamination

during landfill usage, as well as after landfill closure); offgassing of such as rats and flies, particularly from improperly operated landfills and simple nuisance problems.

Moreover, leachate from random dumps may contaminate the groundwater which is one of the sources of drinking water. There has never been any planned leachate-collection system and treatment at any stage in the entire operation of the Repi landfill site, and therefore the amount of leachate production for the site is not known. However, the physical composition of waste generated from different sources, indicate the presence of some pollutants that can potentially degrade the environment. It comes as no surprise, then, that the residents in areas that practice waste open dumping have constantly complained about the sensible negative effects of this practice.

Generally speaking, none of the forms of waste disposal are conducted according to acceptable standards. Moreover, the dumpsites visited during this study were not fenced and easily accessible. It was very common to see stray animals, waste scavengers, and children within the boundaries of waste disposal areas. This is a serious problem since the municipalities and hospitals (medical waste) dispose of their waste in the same dumps mixed with MSW without the proper segregation and treatment, which puts the people and animals that come to contact with this waste under the risk of being infected with various diseases

According to Medina 2008, many areas of developing country are experiencing a disposal capacity short fall. Landfills are being closed because either they have reached their life span or an associated pollution problem has been discovered. Sitting new disposal facilities is becoming increasingly difficult because no one wants landfills or burn facilities in their back yard. The various factors that need to be considered in selecting a landfill site have made it very difficult to find appropriate sites for solid waste disposal.

According to the informant of Addis Ababa City Solid Waste Administrator, sitting new disposal facility in Addis Ababa is unimaginable. He farther added that the only alternative finding landfill site is around the city which is both difficult to get the site and also incurred huge amount of transport cost to transfer the bulk amount of waste from the source to that of disposal site.

Even if we found land that is friendly to environment, social resistance is one and the major problem since health is a basic human right and all people deserve to live in a clean environment.

Ato Eyobe Getanhe, who is an urban environmentalist in Addis Ababa administration, said

> "Leachate is the most toxic byproduct of a solid waste decomposition. The chemicals within the leachate vary over time depending on the physical, chemical and biological activities occurring within the landfill. Resource recovery through waste processing i.e. recovery of materials (such as compost) or recovery of energy through biological, thermal or other processes reduce the amount of byproducts decomposition which interne reduce the environmental impact of waste at the landfill".

Similarly, from field observation and focused group discussion on the study area I understand that the process of composting activity reduce the amount of solid waste that gone to the landfill which directly reduce the environmental impact of waste on and around landfill site.

4.1.4 Quality of soil improvement.

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 plot 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 as:

> "A continuous observation, measurement and recording for 60 consecutive days indicated that a vigorous plant growth was observed on the seedling produced on organic soil (compost) mixed with local soil".

Bio–Farm Ethiopia has tested the nutrient content of compost conducted by International Livestock Research Institute (ILRI) laboratory by comparing the chemical composition of essential element for plant growth in local soil, a produced compost, chemical (artificial fertilizer) and the following results have been obtained. Table 4.2 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 (EPA, 2009).

Table4.2: nutrient analysis of the compost at Bio–Farm 2010/11

Analysis parameters	Average demand for plant growth	Available nutrient based on laboratory test			
		Local soil	Organic soil (compost)	Inorganic fertilizer	
		–	–	DAP	UREA
PH:H_20	5.5–7.5	–	10.16%	–	–
Total N_2	>0.15%	0,22%	0.60%	–	46%
Organic matter	>2%	3.95%	11.16%	–	–
Available p.	25		257.60%	10–20	–
Exchangeable k.	5%	–	10.8%	–	–

Source: Bio–Farm documentation unit (2010)

Photo4.3: packed organic fertilizer in Bio–Farm compost site (during survey)

From table 4.2 one can generalize that the nutrient content of compost much better than inorganic fertilizer. Hence, the MSW compost prepared during the present study area was found to be a good quality for soil amendment.

Therefore the application of compost would be an investment in the long-term for the fertility of soils and plants growth. Finally, it is concluded that a module of this type for the recovery of valuable and economical organic fertilizer, the compost, can be adapted country wide to recycle the organic residues as waste management option.

4.1.5 Fertilizer for urban agriculture

As it is confirmed by interviewed experts of Bio–Farm Ethiopia and Addis Ababa EPA compost as a natural fertilizer is socially, economically and ecologically friendly as opposed to chemical fertilizer. Furthermore, green areas, urban forest area, parks, road squares, river basins and botanical gardens are potential developmental areas with high demand of compost in Addis Ababa. In addition, 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.

Photo4.4: Urban agriculture (vegetables) practice in Bio–Farm (during survey)

In general the interviewed compost site coordinator explained that over the last six years alone, EPA and Bio–Farm Ethiopia produced more than 100,000 seedlings and planted and distributed for different stake holders by using compost on seedbeds (nursery) at their own demonstration site.

Photo4.5: Bio–Farm nursery site (during survey)

During the survey for this research, the researcher conducted in-depth interview with those head Mekanisa–Furisaris,Kolfe–Lideta,Kebena–Bulbula,Shankela–River,andKeranio–Medhane–Alm cooperatives whether they used organic fertilizer (compost) or not on their urban agriculture. From the discussion, four cooperative (80%) are not using but only 20% is using organic fertilizer.

To ensure the above information I systematically selected 30 individual from those five cooperatives (six from each) and distributed questionnaire to know whether they are used compost or not.

Table4.3: Percentage of respondents who have been using different fertilizers.

Types of fertilizers	Number of respondents	Percent (%)
Organic (compost)	6	20
Inorganic(Artificial)	8	26.7
Non of them	16	53.3
Total	30	100

As shown in table 4.3, 20% of the respondents said they are using organic fertilizer and 26.7% said they are used inorganic fertilizer whereas 53.3% responded that they neither organic (compost) nor inorganic (Artificial) fertilizers are used in their urban agriculture.

In order to know why they are not using organic fertilizer the researcher purposefully put question why they are not applying organic fertilizer in your urban agriculture. From the questionnaire the following table is summarized.

Table4.4: respondents that are not using organic fertilizer.

Reason why not using organic fertilizer	No of respondent	Percent (%)
No alternative other than inorganic fertilizer	13	54.2
Lack of knowledge about organic fertilizer	11	45.8
Total	24	100

Those informants that gave answer of not using organic fertilizer are 24, of these 54.2% said there is no alternative other than inorganic fertilizer while 45.8% informants said lack of knowledge about organic fertilize.

4.1.6: Income generation and employment benefits

Data collected in the survey suggest that composting procedure used during the pilot study was aerobic windrow type. The advantages of windrow process over other composting process lies into its simplicity, low level technology and involvement of unskilled labor that is usually employed in running the process.

The most important benefit of composting urban organic waste for the households is creation of jobs and generation of income.

As it is confirmed by interviewed experts of Bio–Farm Ethiopia and Addis Ababa EPA, to get quality compost, collecting, sorting, transporting and making compost is a vital event. This and the aerobic windrow process of composting in the project site confirm that the composting process need man power particularly unskilled labor.

Table4.5: Educational level of people that engaged in the process of composting urban organic waste in the two projects site.

No	Types of activity	Number of people	Educational level
1	Collecting	34	4–9
2	Sorting	20	2–7
3	Transporting	6	5–10
4	Composting	14	0–10
	Total	74	

Source: from field survey

From table 4.5 and during field observation, I realized that a total number of 74 people are engaged in composting process of urban organic waste in the Bio–Farm Ethiopia and Addis Ababa EPA pilot compost site. To know whether composting activity is the only means of income or not the researcher asked questions, by said that is their any source of income other than composting activity, and from responses 64% of the employed composting urban organic waste is the only source of income. Therefore one can infer that composting of urban organic waste (particularly if we scale up the process in different site of Addis Ababa city) not only reduce the amount of waste that goes to landfill site but also it serve as income source and employment opportunity particularly fore those poor and unskilled people.

Photo4.6: Employee in composting activities (from field survey)

4.2 Challenges of Composting Urban Organic Waste in Addis Ababa

As to compost demonstration site of Bio–Farm, lacks grinding or chopping machine, lack of own vehicles to transport organic solid waste from site of collection to site of preparation, and lack of budget are some of the major problem 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, lack of consistent market of compost and lack of institutional capacity to convince and attract stakeholders are the most from those different Challenges of Composting Urban Organic Waste.

The responses of an expert interviewed in-depth at EPA of Addis Ababa also indicated that in addition to the above challenge, economic and motivational challenges are one and the most important. According to the export waste management decisions are based on short-term cost alone. Current economics with inexpensive landfill tip fees make it difficult for composting to compete if looking only at today's costs. When one considers the "true cost" of waste management, however, it involves not only the short-term financial costs and avoided tip fees, but also the long-term financial, social and environmental impacts.

Generally significant experience in composting in Bio–Farm and in EPA over the past six year indicate that, they found challenges to diverting and composting the portion of the waste stream Comprised of decomposable urban solid waste. These include:

- Lack of composting capacity.
- Lack of communication (finding out who the stakeholders are or might be)
- Lack of hauling services.
- Lack of creation of awareness to the society about the use of compost
- Lack of consistent market for compost
- Lack of Restrictive regulations and

4.3 Sustainability of composting of urban organic waste in Addis Ababa

4.3.1 Economic Sustainability

4.3.1.1 Initial Funding

Both (Bio– Farm and EPA) of the projects had started with help from external funding. The most common source from governmental is infrastructure particularly that of land, road and water which can contribute with up to 70 percent of the investment costs. In one case the support was not only economic, but also consisted of long term aid of a consultant based in another country. The project considered this to be very valuable. Other sources are international aid and national private funds.

4.3.1.2 Investment costs

In our case studies the costs for setting up and equipping the composting site ranged between 50,000 and 70,000 depending on the scale and ambitions of the project. To this the costs for external drop off sites was added. This is because in most cases the municipality supplied the project with land and water, thus reducing the costs. The location of the site is important from an economical point of view, due to the cost of transport. On one hand it is important that the site is located within a distance accepted by the households. Otherwise insufficient amounts of waste may come to the site and the risk of illegal dumping is enhanced.

The workers at one of the visited projects did not have the economic means to go by bus to work. They walked a long distance which affected the time and energy spent at the work, and thus the efficiency and the economic sustainability of the project. If the goal of the project is to convert substantial amount of organic waste to "wealth" and to support the entrance of previously disadvantaged people into the economy, even the practical possibility to participate must be improved.

Regardless of the scale, the cost for equipment and machinery requires considerable investments in relation to the available economical resources. The larger the project, the more expensive the equipment is required. On the other hand, even very small scale projects need some machines. In

the two small projects, costs on machinery were saved by substituting machines with manual labour, using home made equipment. Some tasks done manually were sifting and sometimes turning. Other task, as for instance the chopping of the waste, is too difficult to do manually and machinery is necessary. The chopping machine was one of the most expensive machines needed in the projects.

According to the in-depth interview of the EPA and Bio–Farm head project One of a large chipper machine cost $ 20,000 a medium chipper cost about $5,000. To prevent this large amount of expense the projects tried to sort out hard wood from the waste which also increase the number of labour force in project site.

4.3.1.3 Operational costs

The calculations in the two project site suggest that the treatment costs per cubic meter of (unchopped) green waste was in the interval of 20-30 birr. Since it took about 8 m3 of unchopped waste to produce one cubic meter of compost, the production cost per cubic meter of compost was 160-240. In the case where the municipality used a private contractor to treat and collect the green waste, they paid about 10 birr per cubic meter of chopped green waste. That came down to 8 birr per cubic meter of unchopped green waste, or 80 birr per cubic meter of compost.

4.1.4.3. Marketing and Sales

The general experience in the projects was that the compost was not easy to sell. There was a small demand for compost and growing media from homeowners, gardeners and landscapers. The projects differed in how much effort and finance they put into marketing, one project doing no marketing at all. One of the projects, particularly that of Bio–Farm put big efforts in marketing and creation of goodwill. It is probably so that with growing volumes to sell and with more competition, marketing will pay a more crucial role.

According to the head of Bio–Farm compost site manager most of the customer in his organization is/are embassies, those peoples who cultivate vegetables in there garden and flora

industries that are found around Addis Ababa. For him most cooperatives that actively participated in urban agriculture are not the user of compost.

4.3.1.5 Self-Sustainability of the Projects

Composting is not only a way of treating waste, but also production of a useful product that generates income when sold. When the municipality does the composting themselves, they therefore have the possibility of covering all, or parts of the costs by selling the compost. Our calculations, based on the volumes and prices of compost and the operational costs, suggest that when sold in bag, the compost gave incomes that covered the production costs, but not when sold in bulk since it then rendered a lower price. Since most of the compost was sold in bulk, it was sold at a loss. It is however important to emphasise that most of the projects were still in the starting phase and because of this also might have had higher costs per produced cubic meter of compost than will be the case in a few years time.

4.3.1.6 Skill Enhancing and Training

Almost both projects respond that they are giving, or intend to give, the workers "training". Specifically the Bio–farm of Ethiopia, in addition to its own employee it has given training to more than 1,500 farmers from pri–urban of Addis Ababa and from three different regional steps of Ethiopia. Basically the training focused on how compost is done and what are the basic stapes that we consider to produce standardized compost that are safe to the workers and to the environment (soil).

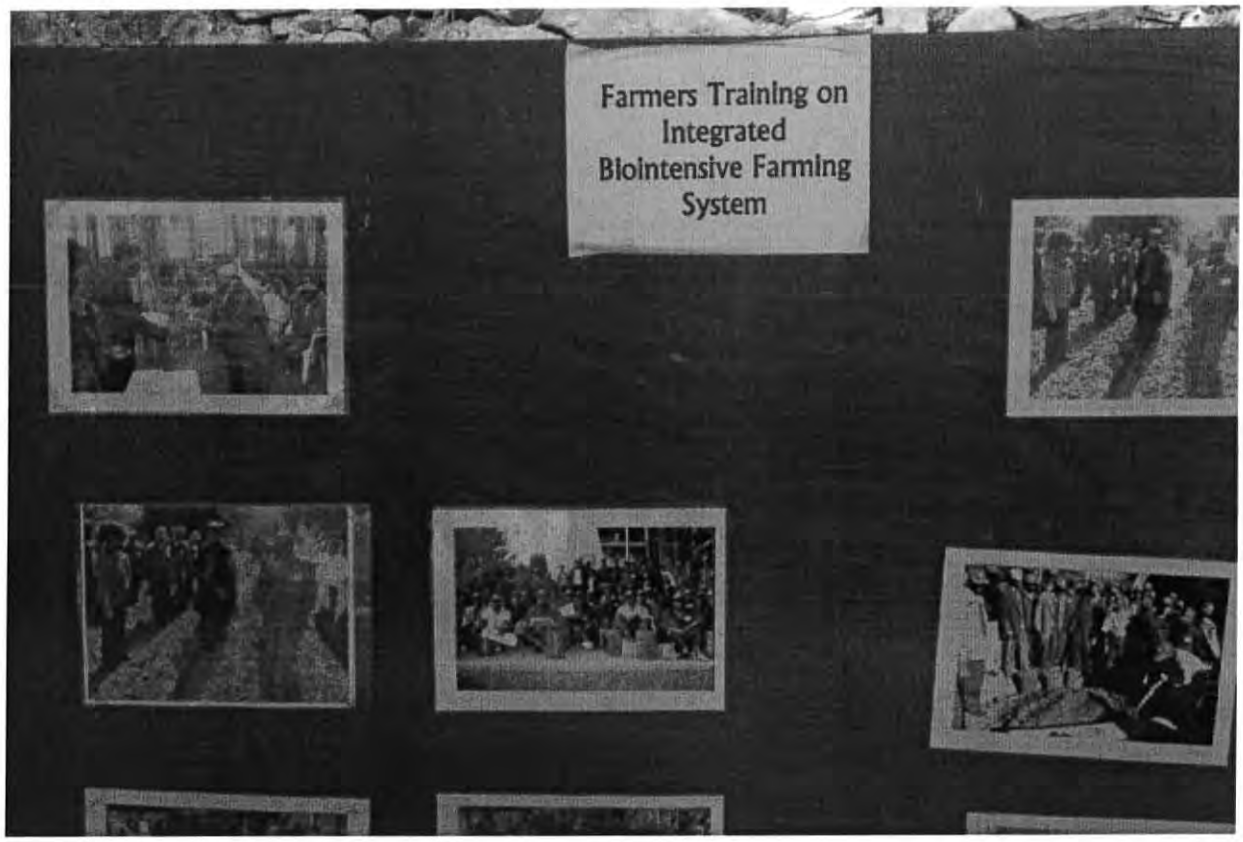


Photo4.7: Farmers training at Bio–Farm compost site

4.3.1.7 Job Creation and Working Conditions

The two projects employ 74 persons, with 14 persons involved in the actual composting and the others engaged in collection, sorting, transporting and chopping of waste. This figure was highly dependent on seasonal variations in activity. In order to reach sufficient volumes, large scale projects required special personnel working at internal or external drop off sites making sure that as much waste as possible is sorted out for composting.

The policy for job creation and poverty reduction was well spread and accepted and both projects were motivated to contribute to the fulfillment of this policy. The fact that labour was extremely cheap, whereas especially foreign technology is expensive, and since most of the process of composting need unskilled persons could be a contributory cause to this. In many cases it was a

lack of economical resources rather than the job creation policy that dictated the level of mechanisation. One of the projects (Bio–Farm of Ethiopia) had the resources to go for a more technology intensive practice with larger machines.

During in-depth interview the head of Addis Ababa City Solid Waste Administrator emphasized that focusing too much on labour intensive practices might also worsen the work conditions for the staff. Some parts of composting, for example turning and sifting, are very heavy work if done manually. Working manually with the compost can be detrimental to the workers as bioaerosols and dust can cause health problems. This risk is enhanced in the cases where the staff and their families live on the site and thereby are constantly exposed to the dust.

In one project, the members of the co-op preferred to employ more people even if they had to accept lower wages. In the case of an independent and democratic co-op this is of course optional, and it might even be beneficial for the community to spread the income among more people. The policy of job creation is thus well spread, but we see the risk that the goal of creating as many job as possible might lead to compromises in work place safety and levels of payment.

4.3.2 Environmental Sustainability

The environmental legislation of Ethiopia is ambitious, demanding that an Environmental Impact Assessment (EIA) is done before giving a permit for a new waste treatment site. In the case of composting garden waste, an exemption is normally given, reducing the demands of the full EIA. Still the EIA process was seen as very difficult and time consuming by both projects.

It was evident that the regulation was not enforced everywhere, and it seems to be applied differently in different places. One project met demands on run off water to be collected and recirculated, while others had taken no measures to lessen the environmental impact.

According to Ato Eyobe Getanhe, who is an urban environmentalist in Addis Ababa city administration, a general view in the projects was that the environmental impact of green waste composting is negligible in comparison with other ways of treating waste, such as landfilling. As long as the projects are small scale and treat only garden waste this is true, especially during the

dry season. However, many of the projects plan to upscale and change to more problematic wastes, such as sewage sludge and abattoir waste and therefore the question should not be neglected. Since the main environmental impact of composting is contamination of ground and surface water a minimum demand is therefore that the leachate should be collected and recirculated to a compost heap which has not yet been sanitised.

4.5 Summary of the chapter.

From different book and from this study, Municipal Solid Waste Management is not a one step action rather it is the processes which start from collecting to that of dumping with landfill. From those processes composting is one and the basic step which play a great role in MSWM.

According to the analyzed data the basic function of composting urban organic waste is to divert substantial amount of waste from landfill. From table 4.1, 87,850kg of decomposable organic waste was converted into compost. Moreover the findings show that In addition to diverting waste, composting UOW plays a significant role in reducing environmental impact of waste at the landfill by reducing the amount of leachate from random dumps. It was also founded that the nutrient content of compost is much better than artificial fertilizers which play a vital role in the improvement of the quality of soil and used as fertilizers for urban agriculture. Composting by it self is a process which needs large number of people that carry out the activities. As a results of this, the analysis clearly indicate that the project site (composting site) create employment opportunity and hence income generation predominantly for the poor.

Farther more the analysis indicates that in order to sustain and save money, since the cost for equipping the composting site is so expensive, the two project site substitute machines with manual labour which is very detrimental to the workers.

In addition the finding clearly shows that inspit of potential production of compost in Addis Ababa, both the government and the two projects lack creating public awareness and growing media about the use and availability of compost. As a result of these, according to the finding there were shortages of demand particularly from those cooperatives that are engaged in urban agriculture which is a future work for those stakeholders.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Because of population increase and changes in lifestyle in urban area, the quantity and quality of MSW has changed. Hence production of MSW and its UOW fraction is expected to increase very rapidly. If landfilling is maintained as the main and only treatment option, such growth will further add to already existing waste management issues and resource shortages.

Current state of solid waste management in Addis Ababa city has been improved slightly in the last decade, traffic congestion, longer distance of dump site from other corners of the city, disposal of all types of solid waste to a single landfill without any separation at source, lack of resources, infrastructure, suitable planning, leadership, and public awareness are the main challenges in MSW management.

The waste analysis of Addis Ababa showed that the percentage of organic waste in the MSW is quite high, mainly due to the use of unprocessed foods in the daily diet of inhabitants. The processing of these organics can deliver important environmental benefits, including the recovery and conservation of resources and a reduction in the quantity of organics going to landfills. These benefits come from turning organics into useful and safe products, without causing harm to the environment. However, if commercial composting facilities are not well managed they can have serious environmental impacts.

The finding of the research revealed that all process/steps of urban waste management should be applied in effective and efficient way to make it sustainable. From those process of waste management system composting urban organic waste is one and the most important particularly for those cities where much of their waste is decomposable organic waste.

The finding farther showed that composting urban organic waste can bring a number of benefits. From those benefits first, (since more than 50% the solid waste of Addis Ababa is organic) it

diverts substantial amounts of decomposable organic waste from landfill and hence minimizes the requirement for physical space which is very scarce in Addis Ababa and increase the service year of the landfill. Secondly, as a result of diverting huge amount of solid waste from landfill it reduce the environmental impact of the remaining waste, since putting less organic matter in the landfill will reduce methane production, Thirdly, as compared to artificial fertilizer different literature and this finding clearly show that the nutrient content of compost is much better to the growth of plant than artificial fertilizer which is very economical to both the environment and economy. Fourthly, according to the finding of the research the process of composting urban organic waste needs collecting, sorting, transporting and the actual making of compost. This and the aerobic windrow process of composting in the project site confirm that the composting process need man power particularly unskilled labor which create employment and ultimately generate income particularly to the urban poor.

According to the result of the finding composting urban organic waste have potentials benefit however, if the process is/are not well managed it creates both environmental and health problem. Furthermore the finding of this study identified that in order to sustain the project both composting site use man made technology which may create problem on the employee and hence equipping the composting site at least with minimum standard is vital.

Furthermore the finding clearly indicated that lack of composting capacity, lack of communication between stockholders, lack of infrastructure, lack of restrictive regulation and strictly lack of consistent market is/are the basic problem and challenge of composting activity in Addis Ababa.

5.2 Recommendation

There is no single solution to MSWM. Different country may use different means of waste management depending on the level of economy and composition of waste. The composition of decomposable organic waste is much greater than other wastes generally in developing countries particularly to that of Ethiopia.

According to this study from those processes of waste management composting urban organic waste is one and the basic. The finding of the two project site confirmed that it converted

substantial amount of waste from landfill. The following are some ideas that could be pursued to strengthen composting organic solid waste as a means to divert waste from landfill.

- There should be effective source separation of the waste, both to get a good process, a high quality product and to reach sufficient volumes. Factors affecting this is public awareness and motivation among the staff working at the drop offs. If the persons responsible for the separation of the received waste are responsible for the whole composting process, a better result is reached. When this is not the case education and motivation for the staff at the drop of the site is important.

- A paved surface is recommended since it improves factors such as working condition, control of leachate but we are aware that this is very costly and that it is therefore is not seen as an option for those composting projects. However, minimum standards should be applied to safe the employee and environment.

- The environmental impact of green waste composting is viewed as negligible by the operators. Together with insufficient enforcement of the environmental legislation, this results in a situation with few incentives to prevent environmental impacts. This neglect was so far not posing any major problems, but if the projects change to more problematic wastes and increase their throughput, the situation might change. With ambitious environmental policies and legislation the government shows intent to improve the environmental situation and it is thus advisable to take these factors into account from the start. More measurements should be done to make sure that the end product does not contain harmful substances. The risk for this is especially high in the case when mixed household waste is treated, and therefore only source separated wastes should be treated.

- At this stage none of the visited projects generate income from sales that cover the costs. This is partly because both of the projects have not been running for very long. Both project see great potential in the business and are calculating that the projects soon will break even. However, municipality driven projects (which is now at infant stage) should be calculating with the savings in costs for alternative treatment of the waste and either

making overall savings already, or valuing the benefits in other areas such as environmental status, social policy fulfillment and job creation as high enough to make up for the costs of the project. When municipalities are calculating the economical viability of compost, the save costs from alternative treatment of the waste should be taken into consideration in order to get a just picture of composting as an alternative to landfill. When it comes to improvements in the environmental status and other nonmarket values, estimation of the benefits in these areas must be made in order to promote sustainable development.

- The advantage of running small scale compost facilities is that they do not need as large investments in machineries and formal education in composting. With motivation and a minimum of training, the people working with the project develop a hands-on-knowledge that is enough to treat the waste and produce compost. It is however important to stress that the costs and effort that small scale projects demand should not be neglected. All work is not suitable to do manually and therefore some machinery is needed. If the staff is unskilled, efforts in business training and other basic skills is also necessary

- The last but not the least is, both of the projects are producing a product that has a market as a result a better national certification system for compost should be developed in order to specify the quality difference on the market and thereby give the producers incentives to further develop the product.

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Annex I

A check list for interview with team leaders of the project organization

Date.....

Name of the Organization.....

City.....

Subcity.....

Kebele.....

PART ONE: about the Organization

1 Type of Organization

a. Governmental b. Non Governmental

C. Private d. Other specify.....

1. Could you give a short description of your organization?
2. Are there any activity /project/ out of the basic mission of your organization?
3 In question no 2 if your answer is yes, is composting part of the project?
4. When did the project start?
5. What are the objectives of the project?
6. What is the role of your organization in the project?
7. How many households/persons are involved in the project?
8. Is the project cooperating with other projects?
9. In question no 8 if your answer is yes, list down the name of the project.

PART TWO: about the compost

1 Were is the source of waste in composting activity?

2 Is there any transportation cost to collect waste to composting activity?

3 In question 2 if your answer is yes what is the cost of transportation? 4 What are the major costs of starting up and running a compost facility?

5 How is income generated?

6 What technology is used to decompose the waste?

7 Is there any challenge that you faced in composting activates?

8 In question 7 if your answer is yes what is/are the challenge/s?

9 Is there any quality control mechanism in your composting activity?

10 In question 9 if your answer is yes what is/are the mechanism/s?

11 In question 9 if your answer is 'No' why are not using?

12 Is it likely that the compost has substantial environmental impacts?
13 If your answer for question 12 is yes what are those environmental impacts?

14 Is there any urban agriculture in your organization?

15 In question 14 if your answer is yes, Is compost being used in urban agriculture in the project area?

16 How much compost is used?

17 Is there any customers who buy compost from your organization?

18 In question 17 if your answer is yes, who are the current and potential customer segments for your compost?

19 what are their requirements regarding quality and price?

20 What is the price of compost in relation to other (artificial) fertilizers?

21 In question 15 if your answer is not why not using?

22 Is the project economically sustainable?

23 In question 19 if your answer is yes, how it becomes sustainable?

24 In question 19 if your answer is not, way not?

25 What is the implication of composting on solid waste management?

26 Is it feasible to bring composting activities under solid waste management system?

27 Is it economically feasible to use domestic waste to Addis for composting?

28 How the demand situation of your compost?

Annex II

For Addis Ababa City Solid Waste Administration

Position.....

Organization.....

1 Administration and Resource

1.1 When was the establishment of an organization?

1.2 Is the organizational structure fully staffed?

1.3 What are the major activities of the organization?

2 Solid waste management in Addis Ababa

2.1 Generation

2.1.1 What is the current volume or weight of solid waste generation in AA?

2.1.2 Who are the major generators?

2.2 Collection

2.2.1What is the collection equipments used in Addis Ababa?

2.2.2 Which are produced in the country and which are imported from abroad?

2.2.3 Are these facilities available in sufficient quantity?

2.2.4 Are there proper transfer stations?

2.3 Sorting

2.3.1 Is there a practice of sorting solid waste at source in Addis Ababa?

2.4 transportation and landfill

2.4.1 What is the cost of transportation from the source to dumping area?

2.4.2 Is there economic, environmental, social and technological challenges in building sanitary landfill in Addis Ababa? If it is yes what are that challenge?

2.4.1 What amount of hector is needed to build standardized landfill?

2.4.2 What amount of money is needed to build today's landfill in Addis Ababa?

2.4 Composting

2.4.1 What proportion of the solid waste generated is compostable in Addis Ababa?

2.4.2 Is there integrated solid waste management in AA?

2.4.3 If your answer is yes, is composting part of it?

2.4.4 If your answer is not, what is the reason behind it?

2.4.5 Is there standardized guideline for composting activity?

2.4.6 Is there any institution/ governmental/ who undertake composting activity?

2.4.7 What is the potential problem /challenge/ of composting activity in ISWM?

2.5.8 What are the potential benefits of composting?

3 Composting as an alternative to municipal solid waste management

3.1 What is the reason behind your involvement in composting activity?

3.2 Where is/are the source of waste to your/s composting activates?

3.3 What proportion of solid waste can be decomposable?

3.4 What are the major benefits of composting to your organization?

3.5 Are there any organization or institute or cooperative or individual who buy your compost product?

3.6 If your answer is yes what are organizations or institutes or cooperatives or individuals?

3.7 If your answer is not what is the reason?

3.8 Is there any challenge in composting activity?

3.9 If your answer is yes what are those challenges?

Annex III

For those organization/households/individual that actively participate in urban agriculture

Date.....

Name of the Organization (households).....

City.....

Sub city.....

Kebele.....

1 Type of Organization

a. Governmental b. Non Governmental

C. Private d. Other specify.....

2. When did the project start?

a. Before one year b. Before Two Year

c. before three year d. other specify.....

3 Is fertilizer being used in urban agriculture in the project area?

a. Yes b. No

4. If your answer for question 3 is "yes" What type of fertilizer use?

a. Artificial (Inorganic) b. Natural (Organic)

c. not used d. other specify.....

5 In question 4 if your answer is inorganic, the reason why you use inorganic is because

a. It is so cheap b. no alternative other than inorganic

c. lack of knowledge about natural fertilizer d. other specify.....

6. What is the price of inorganic fertilizer in relation to other fertilizers?

a. So expensive b. almost the same c. so cheap

7 In question 4 if your answer is organic, the reason why you use organic is because

a. It is so cheap b. no alternative other than organic

. c. it has no negative impact on soil

d. other specify.....

8 What is the price of compost in relation to other (artificial) fertilizers?

a. So expensive b. almost the same c. so cheap

9 How much land you have to your urban agriculture (in hectare)?

.....

10 In question 4 if your answer is organic, How much compost is used per hectare? .....

11 Are there any problems when using compost?

a. yes b. no

12 In question 11 if your answer is 'yes', what is/are the problem/s?....

13 Do you have a plan to involve in composting activity or are you already engaged?