

**ECONOMIC ANALYSIS OF SOLID WASTE MANAGEMENT OPTIONS IN
MOROGORO MUNICIPALITY, TANZANIA**

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF SCIENCE
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ABSTRACT

Economic analysis of solid waste (SW) management options in Morogoro municipality was conducted to assess efficiency of solid waste management options in Morogoro Municipality. The study set out three specific objectives: to analyze the types and sources of MSW produced in Morogoro municipality, to assess possible SW management options in Morogoro municipality and to conduct Cost benefit analysis of solid waste management options in Morogoro Municipality. Using structured questionnaires, data were collected from households as waste producers, key informants interviews and focus group discussion were used to gather information from waste collectors and processors. Analysis was done by descriptive statistic, Microsoft excel and Cost benefit analysis. The study revealed that a major type of SW generated is organic/food waste constituting about 60.2%, their main sources being residential and commercial. Available management options in the municipality are recycling, composting, dumping and locally dug pits. The study applied CBA to determine an option which is economically efficient, and the results suggested that both recycling and composting are profitable since they had positive NPV's but recycling outlined to be most economically efficient since it had a higher positive NPV compared to composting. Sensitivity analysis revealed that, for risk management, it is profitable to undertake both management options at lower discount rates than higher discount rates. Based on the findings, the study recommended that waste sorting at source and management options should be extended to the household level. Likewise, government should encourage investments in composting and recycling, since they are viable and efficient SWM options.

DECLARATION

I, EUNICE LEMBRICE MOLLEL, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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(MSc.ENAREC)

The above declaration confirmed by:

Prof. John F KessyDate

(Supervisor)

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DEDICATION

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LIST OF ABBREVIATIONS AND ACRONMYS

BoT	Bank of Tanzania
BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CBO's	Community Based Organizations
CCIAM	Climate Change Impacts, Adaptation and Mitigation
IRR	Internal Rate of Return
MMC	Morogoro Municipal Council
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NPV	Net Present Value
SA	Sensitivity Analysis
SPSS	Statistical Package of Social Science
SW	Solid Waste
SWM	Solid Waste Management

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Municipal solid waste (MSW) is defined as non-air and sewage emissions created within and disposed of by a municipality, including household garbage, commercial refuse, construction and demolition debris, dead animals, and abandoned vehicles (Igbinomwanhia, 2011). Other literature defines MSW as any waste generated by household, commercial and/or institutional activities and is not hazardous. Depending upon the source, MSW is categorized into three types: (i) residential or household waste which arises from domestic areas from individual houses; (ii) commercial wastes and/or institutional wastes which arise from individual larger sources of MSW like hotels, markets, office buildings, restaurants and schools; (iii) municipal services wastes which arise from other sources like streets, parks which usually contains food wastes, paper, cardboard, plastics, textiles, glass, metals, wood, street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other recreational areas (Khandelwal, 2007).

Solid-waste management is a significant environmental challenge in Africa, especially in large cities. Alternative uses, such as composting, waste to energy, reuse and recycling which are capable of converting waste into assets and also assist in generating employment and income, are desirable if the continent is to catch up with the international trends and standards of managing Municipal solid waste (Simelane, 2011). Amenity attributes of many urban centers in Tanzania are being affected due to inefficient collection, management, disposal and reuse of MSW. Rectifying this requires a change in attitude on how MSW is viewed, treated and used. MSW needs to be viewed as a resource

that should be incorporated into human development agenda and urban development (Hosseini, 2011). This has the potential for generating income through adoption of appropriate technologies, such as recycling, composting and waste-to-energy for a variety of purposes.

Solid waste management has been laden with the most environmental sanitation problems in urban areas in Tanzania during the past two decades. According to National Environmental Council of Tanzania cities and towns are generating an ever-increasing volume of waste, the effectiveness of their solid waste collection, transportation and disposal systems are declining. Urban local authority problems are often considered as problems that need long-term solutions which Tanzanian cities and towns cannot explicitly afford (NEMC, 2012). The reason for not managing this domain is due to the weak financial structure and institutional incapacity of urban local authorities to handle these problems. As a result, wastes are poorly managed and improperly disposed posing serious risks of the potential impacts on public health and the environment.

In Morogoro Municipality about 200 metric tones of solid waste is generated daily, but the Municipal authorities can only collect and dispose less than 35% of the generated waste. About 35% of the uncollected waste is disposed in refuse pits while 30% is dumped in streets, streams and rivers (SUMO, 2003). If not properly managed, solid waste creates favorable breeding ground for vermin and insects and causes a serious risk of communicable diseases. In addition, solid waste in waterways causes pollution of the water as well as blocking the flow of water causing flooding during heavy rains (Mombasa, 2012).

One of the many un-answered questions relates to identifying the most economically efficient solid waste management options in urban areas. This study therefore conducted economic analysis of solid waste management options in Morogoromunicipality.

1.2 Problem statement

A report written by Beede and Bloom (1995) summarized that Municipal solid waste management involves three basic components of collection and transportation, processing, and disposal. Collection and transportation is the function which gathers and removes solid waste from its source of generation. Processing modifies the physical characteristics of the waste in order to attenuate for its more offensive characteristics, reduce its threat to public health, enhance its disposability, and where possible, to extract any economic value from the waste. Processing usually involves functions such as recycling, composting, waste to energy, burning and compacting. The final stage of disposal serves to isolate and contain any remaining material after processing is complete Kumar (2010).

Recycling systems have four major components for their effective functioning (Heinz *et al.*, 2004). They include consistent and reliable source of the recycle materials, methods for processing the recovered materials, markets for the reprocessed materials and consumer's willingness to participate. It is only when all these components function in an economically viable manner that successful recycling system can exist, reports written by (Khandelwal, 2007) and (Igbinomwanhia, 2011) about types and sources of MSW are there but not in Morogoro municipality so this study has managed to assess sources and types of MSW in Morogoro municipality.

Investment in MSW management involves establishment cost, operation cost and maintenance cost. It requires good equipment and machinery to produce advanced and modern recycling products, piece of land for composting, waste separation cost and basic equipment for moisture control (Senzigeet *al.*, 1999). Dumping require labour cost, transport cost, fuel and maintenance of trucks. While composting can serve as source of organic fertilizer, which is cheap and environmentally sustainable and can feed into initiatives like “Kilimo Kwanza” in Tanzania. Recycling is a source of cheaper raw materials which can be used to create new products through which new jobs are created and resources are conserved(Marshall, 2013). MSW management benefits should trade-off business as usual. There were no record on studies on cost and benefits on solid waste management options in Morogoro municipality to ascertain economically viable options. This study was conducted to fill this knowledge gap.

Methods of MSW management include recycling, composting, waste to energy and final disposal (dumping). In most urban centers plastic SW are recycled to produce new products (Kaseva, 2002) and biodegradable waste are converted to compost manure and energy generation for example the CCIAM project (Momboet *al.*, 2012).In Morogoro Municipality the wastes are collected, sorted then organic waste is used to produce compost, recyclables are crushed by small scale enterprises and transported to Dar es salaam while the remaining waste/ residual waste which regarded as useless waste is transported to Kihonda dumpsite for final disposal. So this study was conducted to assess which option is economically viable.

1.3 Justification of the study

The study generated empirical information on types of municipal solid waste generated in Morogoro Municipality, solid waste management options and the economic analysis of

alternative MSW management options in Morogoro municipality. Such information are useful as a tool in decision making, showing which option is cost effective as well as showing cost centers which can be unnecessary and which can be reduced. The study was in line with Millennium Development Goal (MDG's) especially goal number seven: 'Ensure environmental Sustainability'. Also fits with the Tanzania National Strategy for Growth and Reduction of poverty (NSGRP) or 'MKUKUTA' where one of its strategies is improvement of quality of life and social wellbeing of people. Under this cluster, the operational target is to reach 95% of people with access to basic sanitation (URT, 2005).

1.4 Objectives

1.4.1 General objective

The general objective of the study was to assess economic efficiency of solid waste management options in Morogoro municipality

1.4.2 Specific objectives

- (i) To analyze the types and sources of MSW produced in Morogoro Municipality.
- (ii) To assess possible SW management options in Morogoro municipality
- (iii) To conduct Cost benefit analysis of solid waste management options in Morogoro Municipality

1.5 Research Questions

- (i) What are the types and sources of MSW produced in Morogoro municipality?
- (ii) Which SW management options are used in Morogoro municipality?
- (iii) Which MSW management option is most economically efficient in Morogoro municipality?

1.6 Conceptual Frame Work

A conceptual frame work is a narrative outline or diagrammatic presentation of variables to be studied and hypothetical relationships between and among the variables (Kajembe 1994).

The essential theoretical foundations of cost-benefit analysis (CBA) are benefits and costs. The benefit is defined as increases in human wellbeing (utility) while cost is defined as reductions in human well-being. CBA was conducted by accounting for the benefits and costs of both alternatives and comparing them to determine which have the greatest net benefit. In this case, the decision maker has a better basis for final alternative selection (Wilson, 2001).

This study conducted cost benefit analysis of MSW management options, whereby sources and types of MSW were identified, cost and benefits of each management option were studied; capital, operation and maintenance, collection and disposal costs comprise the total costs associated with MSW management options. These costs are the major costs that must be taken into consideration before embarking on such projects. Also benefits obtained (outputs) should consider social benefits like avoidance of liabilities from MSW management options, economic benefits and social benefits (Hella, 2007). Using NPV criteria the best option scenarios were identified which is economic efficiency and which lead to environmental sustainability (Wilson, 2001).

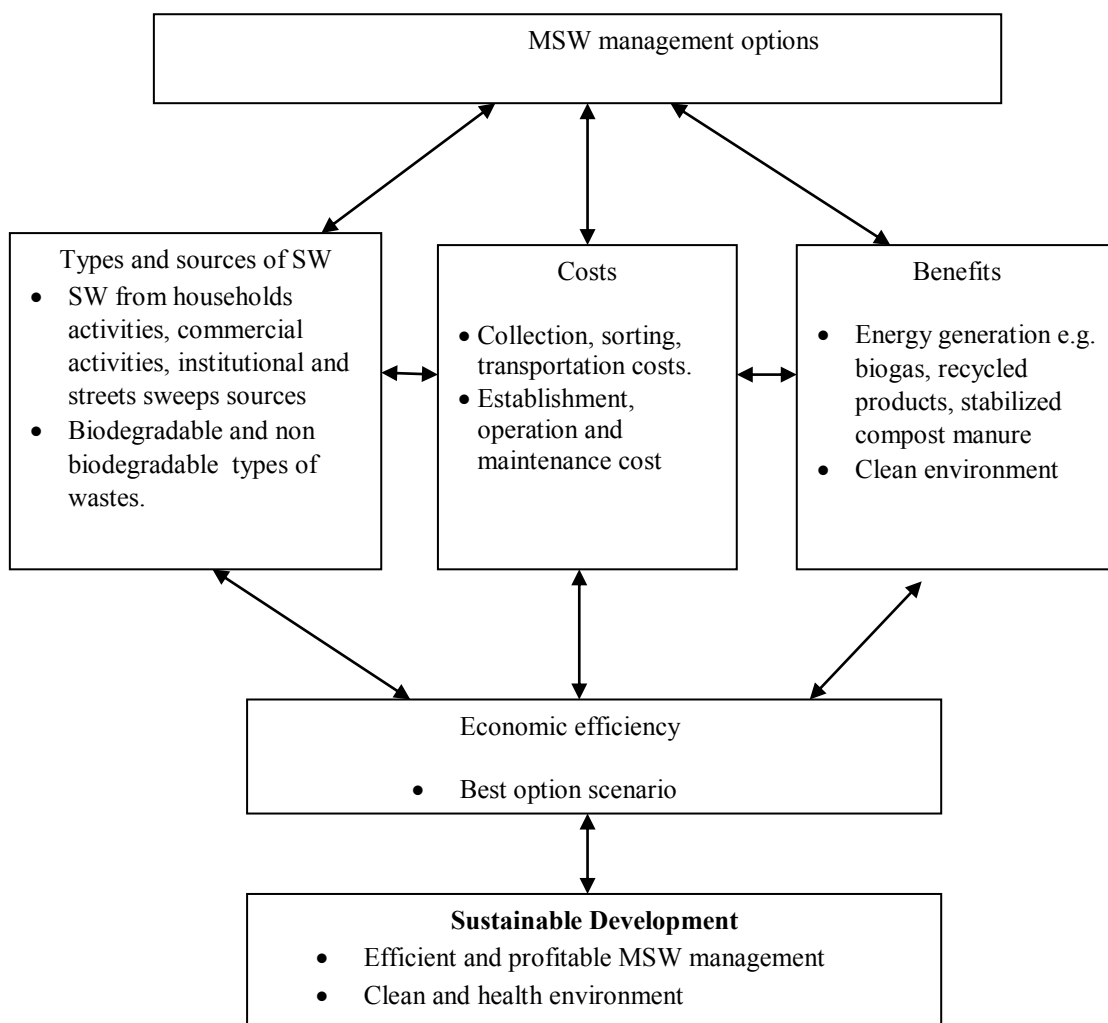


Figure 1: Conceptual framework of the study of economic analysis on SWM options in Morogoro Municipality

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Conceptualization

Solid waste is an overall term used to include litter and refuse or garbage. Municipal solid waste includes the waste generated from residential areas, commercial, industrial, agricultural, institutional, construction, demolition process and municipal services (Hoornweg and Thomas, 1999). In developing countries municipal solid waste include refuse from households, institutions like hospitals and hotels, market places, street sweepings and wastes from industrial and commercial establishments (Tam and Tam, 2008).

Solid wastes are generated from various sources and of different categories as follows: household waste, commercial waste, building materials waste, car wreck, worn out component and industrial wastes. Solid waste management problems have brought environmental degradation to an extent that most efforts are made by City Authorities to ensure that garbage's, roadsides littered with refuse are well managed (Muller, 1998).

A large proportion of solid wastes generated in most urban areas of Tanzania originate from residential areas and agricultural products. Solid waste arises from human activities such as consumption and production activities. Agricultural wastes accumulate in market places, households, livestock markets and slaughterhouses. Agro-waste generated at market places includes remains of fruits, vegetables, fish, livestock products, packaging materials and others resulting from value adding processes. At the household level, agro-waste includes food remains and animal manure in addition to the above. Livestock markets and slaughterhouses generate dung and other gastrointestinal wastes. Although

there is no detailed information, previous studies demonstrated that agricultural wastes accounts for about 70 - 80% of the urban waste generated in developing countries (Akinmoladun and Adejumo, 2011). The rest is inorganic waste which includes plastic bags (5%), scrap metals (4%), waste papers (3%), plastic containers (2%), hospital waste (2%), bottles (2%) and other industrial wastes (2%).

For example, in Dar es Salaam City markets alone, 1200-1400 tons of solid waste is generated daily out of which 95% is of organic origin (Mbuligwe *et al.*, 2003). This implies that if appropriate collection, separation and processing arrangements are in place, the rotting garbage heaps that are common in market places could be turned into a valuable resource for agricultural production as well as providing income to hundreds of urban and peri-urban dwellers, especially youth and women.

According to Mato (2002) the composition of solid waste in Dar es salaam were as follows; vegetable waste/organic waste (62.5%), papers (6.2%), glass (0.3%), metal (1.2%), textiles (1.2%), plastic and rubber (1.8%), bones (0.3%) and inert matter (27.3%). According to Mato (2002) only 35 percent of generated wastes were collected and properly disposed off in Dar es Salaam. Uncollected wastes disposed haphazardly on the streets roadsides and in open spaces.

The composition of waste depends on a wide range of factors such as food habits, cultural traditions life styles, climate and income (Vidanaarachhiet *et al.*, 2005). Waste generation rates per person depend upon the socioeconomic conditions of the particular urban society, its cultural background, climatic condition and seasonal variations. Seasonal variation may increase fresh vegetables and fruits availability, thereby giving rise to varying rates of waste generation.

Economist compare the generation and composition of waste in terms of income level(life style), household size, household income and age profile of the household level. The household size, household income and population are important factors affecting the quantity and composition of SW (Richardson, 1978). In urban areas of most developed countries, more than 50% of the MSW generated comes from households, 20-40% from commercial operations, and the remainder comes from industries (Ashworth, 1996).

According to Malisa (2007) most parts of urban areas are not easily accessed by refuse trucks, because they are unplanned and these parts carry about 60 - 70 % of the urban population in Tanzania. This means that, the remaining solid waste has to be managed by other means like disposal pits, incineration and disposal in open spaces

This is probably due to the increasing urban population resulting into increased generation of solid waste. This is consistent with the study findings by Onibokun (1999) who observed that, due to rapid urbanization, the population increase inserts the pressure to local authorities on the management of solid wastes.

2.2 Solid Waste Management Options

Solid waste management involves control of generation, storage, collection, transportation, processing and disposal in a manner that is in accordance with the best principles of public health, economic, engineering and other environmental concerns (Afrozat *et.*, 2010). Inappropriate waste handling, storage, collection and disposal practices pose environmental and public health risks in urban and peri-urban areas.

2.2.1 Solid waste Composting

Organic wastes can be composted and the compost obtained can be used as an organic fertilizer on agricultural fields. Organic compost is rich in plant macro nutrients like Nitrogen, Phosphorous and Potassium, and other essential micro nutrients. Composting is successful because it is a low cost and low infrastructure set-up and also produces compost, which is a marketable byproduct.

In addition to making a positive contribution to agriculture, the sale of organic wastes reduces the amount of waste to be collected and disposed of by municipal authorities Kumar (2008). According to MNRE in India they explained that “Composting is a biological process in which micro-organisms, mainly fungi and bacteria, convert degradable organic waste into humus like substance. This finished product, which looks like soil, is high in carbon and nitrogen and is an excellent medium for growing plants (MNRE, 2003).

Composting could minimize the need for costly waste disposal methods such as land filling and incineration. Composting reduces the quantity of waste going to landfill, biological decomposition of most of the solid waste generated in urban centers is probably the most attractive and sustainable alternative to waste re-cycling. According to CORE (2008), composting can reduce the amount of materials discarded to landfills by up to 50%.

Utilization of composted organic waste materials as fertilizers will not only result in increased production through its potential for contribution of essential nutrients but will also help in minimizing sanitary, environmental and soil conservation problems. Compost could provide an easily available and affordable source of fertilizer and soil conditioner

for low-income earners in urban and peri-urban areas. Processing of solid waste could serve as one of the best fertilizer alternatives if well processed and managed, since inorganic fertilizers are in most cases unaffordable to resource poor farmers (Kimbi and Semoka, 2004).

Successful composting requires among other things, suitable materials and construction of appropriate bio-digestion facilities. Previous studies observed that about 70 - 80% of urban solid waste generated is agricultural wastes which are biodegradable (Akinmoladun and Adejumo, 2011). It is also important to develop a system of waste separation and hauling to the composting facility.

Composting could be a very viable recovery alternative over solid waste management (Mbuligwe and Kasenga, 2002). Most of local authorities have become economically constrained in providing efficient management of solid waste. Therefore, the possibility of converting municipal solid wastes to organic earth like material by means of composting can provide a significant contribution to the solution (Linzner *et al.*, 2007). As indicated earlier that about 80% of solid waste generated in Tanzania is biodegradable which can be turned into compost if appropriate strategies are in place. This approach reduces pollution and provides a valuable substitute for chemical fertilizers. Successful composting for urban agriculture and source of income to urban dwellers can sustainably be done under specific groups.

2.2.2 Waste to Energy conversion

Waste-to-Energy combustion (WTE) is defined as a process of controlled combustion, using an enclosed device to thermally breakdown combustible solid waste to an ash residue that contains little or no combustible material and that produces, electricity, bio

gas or other energy as a result (Themelis, 2008). Energy requirements of a community can be satisfied to some extent by energy recovery from wastes as a better alternative to land filling. Energy recovery is a method of recovering the chemical energy in Municipal Solid Waste. Chemical energy stored in wastes is a fraction of input energy expended in making those materials. Due to the difference in resources (materials/energy) that can be recovered, energy recovery falls below material recovery on the hierarchy of waste management Kumar (2010).

2.2.3 Recycling Solid waste

Plastic waste recycling also has a great potential for resource conservation and GHG emission reduction, such as producing fuel from plastic waste (Spokas, 2007). Recycling has also been viewed as a veritable tool in minimizing the amount of house hold solid waste that enters the dumpsites. It also provides the needed raw materials for industries. These management aspects of recycling, reuse, disposal and others, require that members of the respective community be aware of proper management techniques and the potential impacts of improper management. Residents of Morogoro municipal too should be aware of this management technique if the public and environmental problems associated with plastic wastes are to be avoided.

Often in developing cities, there are found “buyers” of waste materials such as cardboard and glass (UNEP, 1996; USEPA, 2002). These buyers could help to divert many materials out of the waste stream. Since recycling materials is a financially viable undertaking, small enterprises have and will continue to spring up whenever there is an opportunity. In fact the theft of source separated recyclable materials has been documented in many pilot schemes in both developed and developing nations (UNEP, 1996). Municipalities should not only recognize the trade in recyclables, they should

embrace it, by allowing small interposes to address the problem, valuable funds are saved, jobs are created and landfill space is saved. Perhaps through micro-loans or small –scale assistance, local governments could support and legitimize these entrepreneurs.

2.2.4 Landfill option /Dumping solid waste

Most of the MSW in developing countries is dumped on land in a more or less uncontrolled manner. These dumps make very uneconomical use of the available space, allow free access to waste pickers, animals and flies and often produce unpleasant and hazardous smoke from slow burning fires (Bartoneet *al.*, 1991).

The dumping of solid waste in landfills is probably the oldest and definitely the most common form of ultimate garbage disposal. Many “landfills” are nothing more than open, sometimes controlled, dumps. The difference between landfills and dumps is the level of engineering, planning and administration involved. Open dumps are characterized by the lack of engineering measures, no leachate management, no consideration of landfill gas management, and few, if any operational measures such as registration of users, control of the number of “tipping fronts” or compaction of waste. In an examination of landfills throughout the developing world in 1997-1998, Johannessen (1999) found varying amounts of planning and engineering in MSW dumping. Among the various regions visited, African nations (with the exception of South Africa) had the fewest engineered landfills, with most nations practicing open dumping for waste disposal.

2.3 Cost Benefit Analysis

2.3.1 The concept

Cost benefit analysis (CBA) systematically analyses of the economic justification of a potential investment decision. It involves identifying, measuring and placing monetary

value on costs and benefits of a particular project proposal and then comparing these costs and benefits of a particular project proposals and then comparing these costs and benefits as an aid for decision making (Gittiger, 2001). Cost –benefit analysis is a discounting measure of the project worthiness which originated in the USA in 1936 and has become a worldwide tool to evaluate choices between alternative projects in decision making (Pearce *et al.*, 1993).

CBA is also concerned with identification, quantification and valuation of information about benefits and costs in order to determine the worth of an enterprise. Once costs and Benefits have been identified, if they are to be compared, they must be Valued. Since the only Practical way to Compares differing goods and services directly is to give each a monetary value, proper prices for the costs and benefits had to be found in the analysis.

2.3.2 The process approach

Bojoet *al.* (1988) as cited by Kessy (1993) provided a summary of systematic procedure in CBA as follows:

1. The establishment of a decision criterion: the criteria by which the project will be judged, is clearly defined at the onset of analysis. This may involve considering distributional consequences of the project such as the impact on different social economic groups.
2. Identification of the costs and benefits involved in the project
3. The quantification of costs and benefits: all the costs and benefits identified in step two above are quantified as far as possible.
4. Valuation of costs and benefits this involves estimating the private and social values of the effects brought about by the project.
5. Setting appropriate time horizon it is used to determine time horizon of the project

6. Discounting it involves using a real private or social rate of discount to estimate the value today of a stream of future costs and benefits.
7. Uncertainty and sensitivity analysis the variables with greatest uncertainty about the future are identified and sensitivity analysis is done to show how changes in these may affect the project outcome.
8. Conclusion/recommendations based on criteria used in the analysis, a conclusive statement about economic efficiency of a project is given. This is used as a basis to recommend to the decision/policy makers whether to accept or reject the project.

2.3.3 Payback period

Refers to the period of time required to recoup the funds expended in an investment, or to reach break -even point(Willians, 2012).Payback period is usually expressed in years. Starting from investment year by calculating Net cash flow for each year: Net cash flow year 1= Cash Inflow year 1- Cash Out flow year 1. Then Cumulative Cash flow= (Net Cash flow Year 1 +Net Cash Flow year 2 + Net Cash Flow year 3, etc.) Accumulate by year until cumulative Cash Flow is a positive number: that is the payback year (Farris *et al.*, 2010)

Payback period has a number of limitations such as follows; does not take into consideration the time value of money and therefore may not present the true picture when it comes to evaluating cash flows of a project also does not consider risk, financing or other important considerations, such as opportunity cost While an alternative measure of return such as NPV is normally preferred(Willians, 2012).Payback period does not specify any required comparison to other investments or even to not making an investment (Paul *et al.*, 2010) Payback period ignores the cash flows beyond the payback period. Most major capital expenditures have a long life span and continue to provide

cash flows even after the payback period. Since payback period focuses on short term profitability, a Valuable project may be overlooked if the payback period is the only consideration (Farris *et al.*, 2010).

2.4 Decision Criteria

As far as (CBA) is concerned three criteria are commonly used in project analysis all of which utilize the discounted costs and benefits (=present value) of the project over time. These criteria involve Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR). However, important items for consideration in this analysis involve; discount rate, identification of costs and benefits and valuation of benefits and costs.

2.4.1 Net present value (NPV)

Net present value is defined as the net value of a future stream of costs and revenues discounted back to the present at a predetermined interest rate (Armitage, 1998). NPV is a tool that can indicate a net value when evaluating management alternatives (Shayo and O'Kitingi'ati, 1999). It is usually expressed in cash per acre or amount of money from a given investment on a given piece of land. The NPV can be calculated using the following equation

$$NPV = \sum_{t=0}^T Bt(1+i)^{-t} - \sum_{t=0}^T Ct(1+i)^{-t}$$

Where: NPV = the Net Present Value

Bt = the project benefits in year t

Ct = the project costs in year t

r = discount rate

t = the number of years in the planning horizon

The criterion for project acceptance is: accept if $NPV > 0$.

2.4.2 Selection criterion

The investment is said to be economically efficient if the NPV is positive greater than Zero.

Or the project with higher positive number or greater than zero is the one which is selected; the financial return on the project is economically acceptable.

One advantage of NPV over other discounted measures is that it makes no difference at all as to what point in the computation process, the netting-out of benefits and costs takes place regardless of whether it is done in the middle or end of the project life. However, since NPV is an absolute and not a relative measure it imposes a serious drawback because no ranking of acceptable alternative project or management level is possible using this criterion. A small highly attractive project may have smaller NPV than a large marginally acceptable project. Another limitation is that this measure cannot be applied unless there is a relatively satisfactory estimate of the opportunity costs of capital. It is to use the NPV method correctly; it is much more difficult to use the IRR method correctly (Bierman, 1986).

The weaknesses of NPV are that, it is very sensitive to the discount rate: a small change in Discount rate causes a large change in the NPV. As the estimate of the suitable discount rate is doubtful, this makes NPV numbers much undecided. Also NPV often relies on uncertain forecasts of the future cash flows. The magnitude of this problem obviously depends on how uncertain the forecasts are. One solution to both problems is to calculate a range of NPV numbers using different discount rates and forecasts, so that one can generate, for example, best, worst and median NPV numbers, or even a probability distribution for the NPV (Lin *et al.*, 2000).

2.4.2 Benefit cost ratio

The Benefit cost ratio (BCR) is the present value of benefits divided by the present value of cost. It is the method of evaluating the proposed investment in terms of all relevant investors cost and benefits associated with it, including social cost and benefits. Benefits cost analysis is the technique for comparing the stream of net benefits produced over time by competing investment opportunities (Hella, 2007). Benefits and costs are accounted at the time they are earned or spent and the cash flow is extended over a period of several years. Usually the number of years is assumed to be the useful life of the useful economic life of the proposed project. Since the project life extends over several years, the cash flow must be discounted to compensate for the time value of money. The decision rule in the benefit- cost analysis is to accept all projects with benefit-cost ratios greater than one when discounted at the selected opportunity costs of capital. It can be calculated by the following formula

$$BCR = \frac{\sum_{t=0}^T B_t(1+i)^{-t}}{\sum_{t=0}^T C_t(1+i)^{-t}}$$

The BCR express the benefit generated per unit of cost and it was interpreted as follows:

- (i) BCR>1: present value of benefits exceeds the present value of costs.
- (ii) BCR=1: present value of benefits equals present value of costs.
- (iii) BCR<1: present values of costs exceeds the present value of benefits

Selection Criterion

Projects with a BCR of 1 or greater are economically acceptable when the costs and benefits streams were discounted at the opportunity cost of capital. The absolute value of the BCR varies depending on the discount rate chosen; the higher the discount rate, the smaller the BCR.

2.4.3 The internal rate of return

Internal Rate of return (IRR) is expressed as an interest rate, much as the rate earned on a certificate of deposit or a saving account (Armitage, 1998).

It is a discount rate, at which discounted costs equal discounted revenue, or the rate at which the projected NPV of future cash flow is zero. It does not require the use of a discount rate for its calculation because the IRR is the discount rate that makes the net present worth of the incremental cash flow equal to zero (Gittinger, 2001; Backer, 2002). It is calculated by the following formula.

$$\left| \sum_{t=0}^T Bt(1+i)^{-t} - \sum_{t=0}^T Ct(1+i)^{-t} = 0 \right.$$

OR

$$\left| \sum_{t=0}^T Bt(1+IRR)^{-t} - \sum_{t=0}^T Ct(1+IRR)^{-t} = 0 \right.$$

Decision criterion

If the IRR is greater than the cost of capital, accept the project.

If the IRR is less than the cost of capital, reject the project.

For the ease calculation, this study adopted the NPV method. IRR and BCR do not show the size of the net effects (Obonyo *et al.*, 1996). Reliance on both the IRR and BCR can easily lead to a result in which the total economic effects from an investment that has been selected are smaller than if the NPV indicator is selected (Armitage, 1998). With NPV the reinvestment can be controlled.

2.5 Sensitivity Analysis

Sensitivity analysis (SA) is an analytical framework for dealing with uncertainty. The objective is to reduce the likelihood of undertaking bad projects while not failing to accept good projects in order to ensure that the discount rate (and/or horizon value) used by the researcher is appropriate and is not solely responsible for the outcome of a project appraisal, the researcher may wish to perform a sensitivity analysis (Franzelet *al.*, 2001) This can be used to improve the robustness of a CBA, and is particularly useful where there is uncertainty over the discount rate.

Sensitivity Analysis is also another important tool in decision making and in developing recommendations for decision makers, better communication, increased understanding or quantification of systems and model development. In this study the focus of SA was on the first three uses uncertainty about their future values. Since the parameter values and assumptions of any economic analysis/model are subject to change or error, SA was done to investigate these potential changes and errors and their impact, i.e. the difference they make to the conclusions drawn from the economic analysis when there is uncertainty about future values. SA gives information that is important in developing flexible recommendations which depend on circumstances. It is also important in identifying sensitive or important variables. Secondly, SA gives information for increased understanding or quantification of the system by estimating the relationship between input and output variables, and lastly, how much worse off the decision makers would be if they ignored the changed circumstances and stayed with original or some other strategy (panel, 1997). However, Franzelet *al.* (2001) reported that the method has one measure shortcoming since it fails to account for the probabilities of future outcomes of concerned analysis.

Sensitivity analysis was used by FAO(1992), Gittinger (2001) and Senkondo *et al.* (2000) to assess the effect of changes in key parameters such as input-output coefficients, discount rates or prices of inputs and outputs(Franze *et al.*, 2001) and to come up with other values of NPV which were used to decide on investment proposed.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location and social-economic profile

Morogoro municipal lies between Latitude 6⁰ 50' 15" South, Longitude of 37⁰ 39' 40" East and is situated between 500 and 600 m above the sea level. Morogoro municipal is located 200 km west of Dar es Salaam (World Bank, 2004). Administratively it is divided into six divisions and 19 wards, which are Kingo, Kilakala, Kingolwira, Mazimbu, Bigwa, Kichangani, Mwembesongo, Mjimpya, Mjimkuu, Mzinga, Mbuyuni, Sabasaba, UwanjawaTaifa, Kiwanja cha ndege, Kihonda, Mlimani, Sultani Area, Boma and Mafiga (MMC,2015).

According to population and Housing census of 2002 the population of the municipality was 115 224 (URT,2002)while the current population indicates that the population has grown up to 315 866 (URT,2012) which shows an increase of 16% compared to 2002 census, this rapid increase in population and overall economic growth accompanied by increased levels of urbanization and consumption from 2002 up-to-date census have also resulted in increased generation and diversification of the waste sources (Mlonzi, 2011).

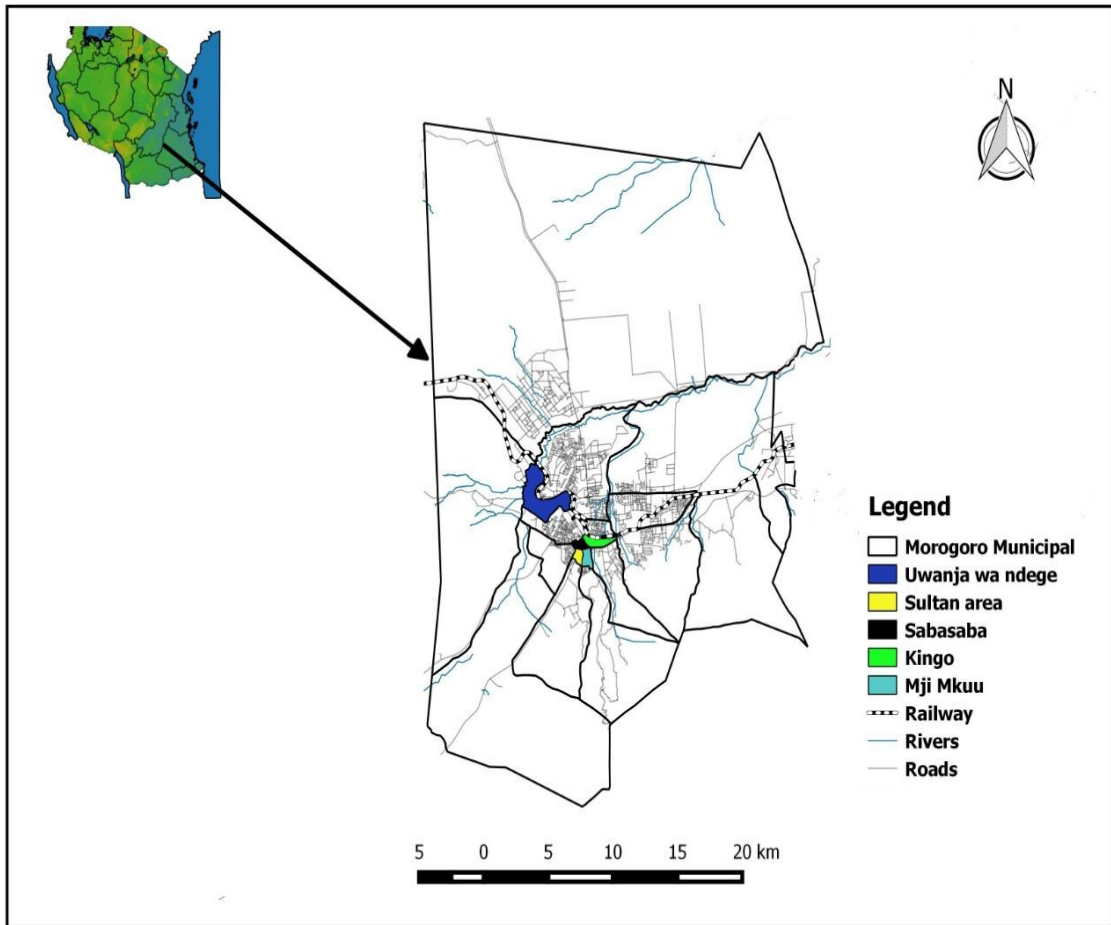


Figure 2: Map of Morogoro Municipality. (Source): Uiterkamp *et al.*, 2011

3.1.2 Weather

Morogoro receives considerable varying amounts of rainfall from year to year. The area experiences warm and cool dry seasons receiving precipitation of about 900 mm per annum. The temperature ranges between 27.7⁰C and 34⁰C. However, minimum temperature can reach as low as 13.9 ⁰C during the cool season. The rainy season starts in March and ends in May while the cool and dry season starts in June and ends in August (TMA, 2012). The weather condition is favorable for water-borne diseases like typhoid, Malaria and outbreak of cholera if solid waste is poorly managed in the Municipality.

3.1.3 Physical features

The major physical features include the famous Uluguru Mountains, which lies in the Southeastern part, Mindu and NguruyaNdege mountains, which are in the western part of the municipality. There are three main rivers with several tributaries, which form a number of alluvial flood plains. These are the Morogoro, Kilakala and Bigwa rivers. These rivers are among important sources of water for various uses in the municipality although another source includes the Mindu dam which serves both industrial as well as domestic supplies (URT, 2012). Poor solid waste management can result to the pollution of water sources in the Municipality and later on diseases.

3.1.4 Economy

According to the Morogoro Municipal Council Survey (2015) the main economic activities of the municipal include processing industries like Tobacco companies, food, clothing and mini supermarkets outlets, transportation, government and private white collar employment and urban farming. These in combination with other activities at academic institutions, financial institutions and household level produce considerable amount of wastes into the municipal environment (World Bank, 2004).

Morogoro Municipality residents have mixed economic activities including civil workers, famers, business enterprises such as solid waste management, commercial retailing as well as wholesaling and industries of various categories (World Bank, 2004). The major industries are Morogoro Canvans Mills, Tanzania Packaging Manufacturers (1998) Ltd, 21st century Textiles Ltd, Abood Soap Industries, Morogoro Seed Oils Mills, Tanzania Tobacco Processing Company, Alliance One Company and Morogoro Plastics. Farming includes Sisal, Paddy, Maize, vegetables, fruits, yams, diary, poultry and pork (URT,

2002). These in combination with other activities at household level produce considerable amount of wastes into the municipal environment

3.2 Sampling Procedure

This study employed a triangulation approach because there was more than one source of primary information which involves waste producers, collectors and dealers or processors. Purposive sampling technique was used to select waste producers, collectors and dealers or processors as the directly group dealing with solid waste management options.

The sample groups for this study were (i) waste producers including households waste producers and commercial waste producers (food vendors, hotels and food markets), (ii) waste collectors who are municipal council, Community based organizations (CBO's) plastic bottle and metal collectors, and (iii) waste dealers or processors dealing with CCIAM project, and SWISS CONTACT under their project called 'Taka ni Mali' and others who are dealing with alternative municipal solid waste management options. Purposive sampling technique was employed to select five wards out of 19 wards in the municipality. The selected wards were Sabasaba, MjiMkuu, Kiwanja cha Ndege, Sultan area and Kingo. These wards were selected based on location of relatively big markets and other associated waste generation operations. It is from these wards where Kikundi and Sabasaba markets are located and relatively number of hotels, restaurants, food vendors and other activities are performed with relatively higher rates of solid waste generations. Again CBO's which have succeeded to produce compost and crushing plastic bottles and waste-energy project under CCIAM project are found in these wards.

3.2.1 Determination of sample size

The sampling frame of this study involved waste producers/households, collectors and processors. Since there was more than one source of primary information the researcher determined the sample size differently. Ten percent (10%) of households (considered as waste producers) were determined by using a formula (Eq 1) recommended by Kothari (2004) while purposive sampling technique was used to determine 40% waste collectors and waste processors.

3.2.2 Sampling of households waste producers

The sampling frame for determining household's sample size of the study consisted of the total number of households of the five selected wards which amounted to 24702 households (URT, 2012). Due to this study's limited resource and time budget, it was not possible to interview the entire population of the households in the sampling frame. Thus, the sample size was determined using the following equation (Kothari, 2004).

$$n = \frac{NZ^2 \frac{\alpha}{2} pq}{(N-1)e^2 + pqZ^2 \frac{\alpha}{2}} \dots \dots \dots \text{(Equation 1)}$$

Where;

n is the sample size

N is the total population in all wards = 24702

P is the proportion no of households enjoying the benefits of alternative MSW management options= 0.12

$Z_{\alpha/2}$ = 90% = 1.645 in the normal table

e is the acceptable error (the Precision) = 0.05

q = 1-p (probability of failure) = 0.8

Therefore;

$$n = \frac{24702(1.645)^2 0.2 * 0.8}{24701 * 0.05^2 + 0.2 * 0.8(1.645^2)}$$

$$n = 173$$

The proportion of households selected from each study ward is shown in Table1.

Table 1: Distribution of study sample across wards

Ward	Total no HH	No of Households sampled
Kingo	2944	21
Sultan Area	2604	18
Sabasaba	2339	16
MjiMkuu	4612	32
Kiwanja cha Ndege	12203	86
Total	24702	173

Source: Morogoro Municipality survey, (2015)

3.2.3 Sampling of waste collectors

Purposive sampling technique was used to obtain a sample size of two Community Based Organizations (CBOs) out of five available in the study area until the researcher achieved 40% of the population which were producing compost and selling both compost and plastic bottles since they were the ones which were able to provide both information.

3.2.4 Sampling of waste processors

Purposive sampling technique was used to select two small scale factories dealing with plastic bottles recycling out of 5 in the Municipality until the researcher achieved 40% of waste processors. Because these small scale factories were the ones dealing with crushing plastic bottles in the Municipality so the researcher selected the group because they had useful information required to accomplish the study.

3.3 Data Collection

Primary data collection involved the use of key informants interviews, questionnaires surveys, focus group discussion and personal observation.

3.3.1 Questionnaire Surveys

For waste producers both quantitative and qualitative data were obtained through administering structured questionnaires with both closed and open ended questions that were distributed to the 173 respondents. The questionnaires were designed to capture information for the first two objectives on types and their sources and available options SW management options as shown in Appendix 1, bags were issued to families (6bags/family) for the collection of different types of solid waste such as food waste, paper, plastic, glass, metal and other. All families were instructed to collect these different types of solid waste in separate bags. Collected solid wastes were observed to see the types of SW generated (October to November, 2015).

3.3.2 Focus Group Discussions

Information from waste collectors were obtained using a focus group discussion technique which was guided by a checklist, which was conducted with 2 sampled community based organizations (CBO's) out of 5 CBO's in the study area, as shown in Appendix 2. The information collected included the sources of SW, types of SW collected and sorting/separation cost and transportation cost and benefits obtained

3.3.3 Key Informants Interviews

Information's from waste processors were obtained through conducting an interview which was guided with a check list as shown in appendix three. The interview involved One Municipal health officer, two owners from two different small scale factories dealing with crushing plastic bottles, and one member from CCIAM project. They provided additional information on equipment cost, operation, maintenance cost, labor cost (collection, separation and sorting cost), transport cost, processing cost and benefits obtained ensuring that time and amount data was captured, they also provided information on price of processing products produced by each type of alternative municipal solid waste management option.

3.3.4 Participant Observation

Qualitative data were obtained through participant observation which was guided by a schedule of indicators such as: the types of solid waste generated, methods of solid waste collections, solid waste management options and direct benefit and cost of observed management options.

3.3.5 Secondary Data Collection

Secondary data were obtained from different sources such as Sokoine National Agricultural library, other information were obtained from electronic sources on the internet and published and unpublished materials from various reports on solid waste management records and references (documentary Sources) from Morogoro municipality regarding cost and benefits of solid waste management options.

3.4 Data Analysis

Data which were obtained from questionnaire survey and interviews were compiled coded, and then analyzed using Statistical Package for Social Science (SPSS version 16) software. Descriptive statistical analysis was carried out to obtain mean, frequencies and percentages inputs, outputs and cost of inputs were summarized into mean and range in microsoft excels. Data from FGDs and interviews were used in Cost benefit analysis by Net Present Value (NPV) criteria to establish a practical SWM option which is economically efficiency.

3.4.1 Identification of cost and benefits of alternative MSW

The CBA methodology involved identifying total benefits and costs. The costs were classified into fixed cost and variable cost, depending on whether they are incurred only once during the establishment of a project (hence establishment costs) or whether they recur even after the project is established (hence operating costs) (Msikiza, 2003). In this study the costs of land preparation for composting, site for biogas production, machines and equipments were classified as fixed cost (FC), since they were incurred only once during project establishment. While the costs of various types of inputs, including labour, fuel, sorted wastes, trucks and maintenance and repair of trucks and machines were classified as variable costs (VC) since they are recur even after project establishment.

The net benefit, which indicated the improvement, was valued according to the prevailing market prices to get current money per product recovered. It was measured by subtracting total costs from total benefits (Senkondo, 1992). In comparing four options which are composting, recycling, waste to energy and final disposal or dumping, the net benefits were compared to determine which was better. The net benefits were compared between waste to energy, recycling, composting and final disposal, which evaluate for economic

feasibility. The total benefits represented the advantages of waste to energy, recycling, composting and final disposal, which included the direct and indirect benefits. The total benefits and costs were expressed in Equation. (2) and (3) as follows:

$$TB = BEconomic + BSocial + BEnvironment \quad (2) \dots\dots\dots (Equation 2)$$

$$TC = CEconomic + CSocial + CEnvironment \quad (3) \dots\dots\dots (Equation 3)$$

Where the

TB denotes the total project benefits,

BEconomic represents economic benefits,

BSocial denotes social benefits

BEnvironmental denotes environmental benefits

TC represents the total cost of using resource using recycling, waste to energy, dumping and composting

C Economicseconomic costs,

C Social denotes social costs and

C Environmental representsenvironmental costs.

Net benefit can be expressed by: Eq. (4)

$$NB = TB - TC(4) \dots\dots\dots (Equation 4)$$

The net benefits were expressed as net present value, calculated as the current value of future cost and income streams. The NPV test discounts future project CBA as follows:

$$NPV = \sum_{t=0}^T Bt(1+i)^{-t} - \sum_{t=0}^T Ct(1+i)^{-t}$$

According to this criterion a SWM option was considered economically efficient, if the NPV was greater than zero. Discounted nominal prices were used to determine the net present value by assuming inflation rate of 5% per annum will continue, the time horizon for this study was 3 years under assumption that at year 3 the benefits or outputs and cost

of the management options can easily be track like biogas, compost manure and recycled products. All the calculations which were made on each management option, the prices were in Tanzanian shillings, Similarly Hella (2007) suggest using Tanzanian shillings for calculations in public investments projects.

3.4.2 Choosing the discount rate

Usually it is difficult to estimate an exact discount rate, however, both Powers (1981) and Baum and Tolbert (1985) suggest using real discount rate of 10% to 12% for public investment projects. Gittinger (2001) suggested a common choice to be 12% and World Bank proposed 10% to 12% as an opportunity cost of capital for Tanzania. Therefore, the discounting rate used in this study was 12%.

3.4.3 Pricing of costs and benefits of recovered products from SWM option

The main assumption in undertaking the CBA is that prices reflects value or can be estimated in that manner. Economic theory states that commodities have to be priced at their marginal value product (MVP) that is where the MVP of the commodity equals its price (Senkondo, 1992). Alternatively, commodities are to be valued where the price of every goods and services is exactly equal to the value that the last unit utilized contributes to production. Another method is the use of opportunity cost in valuing goods and services.

In this study economic analysis was carried out using prices that reflect real resource use or consumption satisfaction. Therefore market prices were determined at the point of the first sale of recovered products. Theoretically pricing should be at the point where MVP, opportunity cost and price are equal. At this point no more transfer of resources could result in greater output or satisfaction. However, this occurs where real perfect marketing

are operating. That is, where there are many buyers and sellers with knowledge about market and there is no government intervention in the markets. In the real world, markets are not perfect and never in equilibrium Gittinger (2001), cited by Nduguru (2009). However, market price is the best approximation of the true value of goods and services that is fairly widely bought and sold. In this study economic analysis was carried out using prices that reflect real resource use or consumption satisfaction. Therefore market prices were determined at the point of the first sale of recovered products.

3.4.4 Pricing of non-traded goods

For non-traded goods such as labour, clean and healthy environment and land, its economic analysis required that they were valued at their marginal value product if they are intermediate goods or services, or according to the willingness to pay criterion if they are final goods or services (Backer, 2002).

3.4.5 Uncertainty and sensitivity analysis

Sensitivity analysis was carried out to examine the investment NPV outcomes towards favorable and unfavorable directions. Since the parameter values and assumptions of any economic analysis/model are subject to change or error, sensitivity analysis was done to investigate these potential changes and errors and their impact, i.e. the difference they make to the conclusions drawn from economic analysis when there is uncertainty about their future values or what would happen to the NPV if discount rate was increased or decreased to various levels (Msikiza, 2003).

In the case of this study, the most important parameter which is the discount rate was considered before recommending an alternative, given that this most directly impact how the Municipality views the options. SA was analyzed through varying a discount rate at 5%, 11%, 13% and 30%.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of the Respondents

4.1.1 Age

Majority of heads of households (62.4%) who are waste producers surveyed in this study ranged between 31-50 years (Table 2). This suggest that, most of the household heads were in the active age who are doing various economic activities and home based activities which influence the quantity and composition of SW generation, This is supported by (Richardson, 1978) who explained that age is an important factor which affect quantity and composition of waste.

Table 2: Distribution of respondent by their social characteristics (N=173)

Variable measured	Frequency (N=173)	Percent (%)
Age		
<30	34	19.7
31-50	108	62.4
>51	31	17.9
Sex		
Male	66	36.6
Female	107	63.6
Family size		
<4	74	42.8
5-9	96	54.3
>10	3	2.9
Education level		
Primary	95	54.9
Secondary	41	23.7
Collage	37	2.4

4.1.2 Sex

In this study both male and female participate in solid waste generation activities and at the same time management activities, although the participation of female is higher than that of male. On average the participation of female were 63.6% as indicated in Table 2. According to the key informants this could be due to the fact that most of the home based activities are mainly done by women and women spend most of their times at home also most of the food vendors in town are owned by women.

This implies that the female are very much concerned with SW management, because of various activities especially home based activities, petty business such as vegetables in the market areas, bus stands and along the roads and food vendor which contribute much on the increase in quantities of SW in the Municipal. This is supported by observation made by Wickramasinghe (1997) who studied women and minority groups in environmental management and reported that women are recognized as managers of the environment, though they are relatively invisible partners from the grassroots to the policy level, they are happy doing their work.

4.1.3 Family size

The findings suggest that family size had an influence to the quantities of SW generated, majority of respondents had 5-9 which was (54.3%) Table 2. This means that families with few members produce less waste compared to the families with many members. This implies that increase in household members leads to increase in resource consumption resulting increase in waste generation at their houses. Achankeng (2003) observed that population size/increase has an impact on Solid Waste generation. This observation is also supported by (Ghorbani *et al.*, 2007) who explained that; family size is an important

determinant in household waste production. Also Beed and Bloom(1995) indicated that an increase of one percent in family size is equivalent of 1.04% increase in MSW.

4.1.4 Education level of the respondents

Results in Table2revealed that, majority of respondents interviewed had primary education (54.9%). Education level increases the ability to understand environmental issues. Experience from NEMC (1995) shows that the understanding of environmental concepts is very limited among those with primary and secondary education as opposed to those with collage education where environmental education is taught as a specialized. Respondents who reach the university level were able to provide their perception in SWM options. At the same time level of education was not a determinant factor on the awareness of management of solid waste since the respondents who reach primary education, also gave information relevant to the study. Therefore, this implies that each individual regardless of their education level had different perception and awareness on management of solid waste.

Table 3: Distribution of households by their economic characteristics

Variable measured	Frequency (N=173)	Percent (%)
Occupation		
Farmer	44	25.4
Employed	30	17.3
Business	80	46.2
Food vendor	19	11
Income level		
Low income	56	32.4
Middle income	81	46.8
High income	36	20.8

4.1.5 Occupation level of respondents

The study observed that the main occupation of the head of household in the study area earn their living through business of different types (46.2%) (Table3). Occupation of respondents has an implication on the generation of solid waste, since business like shops generates papers, plastic bottles, hotels, restaurants and food vendors generate mostly organic wastes and recyclables. These pollute the environment, when improperly managed.

4.1.6 Income level of respondents

Results in Table 3 indicate that majority of respondents 46.8% has a middle income living standard. Solid waste generation depends on the level of income of the family. This implies that income of the family is a determinant to the quantity and composition of waste generated. This is because, wealthier individuals consume more than lower-income ones, which result in a higher waste generation rate for the former. Medina (2002) also reported that a positive correlation tend to exist between a community's income and the amount of solid waste generated.

4.2 Types of Solid Waste Produced in Morogoro Municipality

Results from Table 4 revealed that a major type of solid waste generated in the Municipality is organic waste 60.2%, it was observed that the food waste is usually the predominant component in the waste stream due to the habit of fresh food consumption and composition of all other types of waste are low in all households studied. The highest proportion of food wastes is because of the heavy dependence on home prepared meals, which consist of vegetables, meal left-over and scraps associated with preparation of food.

Table 4: Types of Solid Waste generated in the Study area

Variable measured	Frequency	Percent (%)
Organic/food waste	104	60.2
Recyclables	35	20.2
Residual/other wastes	18	10.3
Hazardous	16	9.3
Total	173	100

A study conducted by (Mbuligwe *et al.*, 2003) observed similar results that only Dar es salaam itself can generated 95% of organic waste also the results are consistent with previous studies which indicate that about 70 - 80% of the urban waste produced in Tanzania is of organic origin (Akinmoladun and Adejumo, 2011). Also, Mato (2002) who conducted research in Dar es Salaam observed that large portion of domestic solid wastes (62.5%) in the city come from the kitchen and most of it is of organic nature. The UN-HABITAT report (2006) had similar findings when noted: “a large proportion of waste within lake Victoria region is organic in nature, which can be recycled for use in agriculture if there is a good waste management regime. Similarly, study conducted by Visvanathan (2006) found that food wastes dominate over the major portion of the waste generated in most developing countries in Asia like China, India, Sri Lanka, and Thailand. Furthermore the results are comparable to the information obtained from Swiss contact project manager that, the composition of SW in Morogoro municipality is composed of 60% organic, 20% recyclables, 10% hazardous and 10% residual.

Further findings from the key informants has revealed that the types of SW generated in the municipality are domestic waste/residual(households), (food related wastes and plastic(recyclables) wastes, commercial waste (from hotels, restaurants or food vendors and market places), animal remnants, industrial waste, trees residual waste (gardens, fruits, decoration trees production) and construction debris such as houses and roads(Personal communication November, 2015).

4.2.1 Sources of solid waste generated in the Municipality

The results from Table 5 revealed that, a large proportion of solid waste generated in the municipality originate from residential and commercial activities. Which makes a total of 52% of the total SW generated, of which 28.9% is from residential sources such as single-family, multi -family dwellings, low, medium and high density apartments and 23.1% is from commercial sources such as stores, restaurants, hotels, motels, markets, auto repairs shops, service stations and office building.

Table 5: Sources of solid waste in Morogoro municipality

Sources of Solid Waste	Frequency (N=173)	Percent (%)
Residential	50	28.9
Commercial	40	23.1
Institution	34	19.7
Industrial	25	14.3
Construction and demolition	16	9.5
Agriculture	8	4.7

These results are similar to results obtained by(Igbinomwanhia, 2011) who elaborated that the sources of municipal solid waste are residential, commercial, institutional and construction and demolition. This result is consistent with Muller (1998) who reported that SW is generated from various sources and categories like households, industrial and commercial sources. Furthermore this is in agreement with the results obtained by (Hoornweg and Thomas, 1999) and (Tam and Tam, 2008) on the sources of SW generated in the Municipality.

4.3Solid Waste Management Options at Household Level

Results from Table 6 indicate that 84.4% of the respondents depend on the Municipality to manage their solid waste, they just pay 2000 TZS to 6000 TZS per month to the household waste collectors and they come to collect their wastes.

Table 6: Solid waste management option at household level

SWM Option	Frequency (N=173)	Percent (%)
Vehicle collection/dumping	146	84.4
Locally dug pit	27	15.6

This implies that, management options at household level are very limited, meaning that, if there were diverse options, people could take waste as an opportunity to generate income in the household since they could sell plastic bottles, they could compost organic waste at home and sell or producing biogas that they could use for cooking and reduce the quantity of waste that could be disposed off.

Vehicle collection/dumping which is mainly done by the municipality using CBOs (community based organizations) who pass door to door using trucks to collect households wastes. These wastes are brought to their collection point then sorted, the residual wastes are then sent to the dump site. Addo-Yobo and Ali (2003) reported that, door to door method using trucks and communal containers are commonly practiced in Ghana, though a communal container is less efficiency than door to door service.

Locally dug pits is another management option observed in the municipality where by a number of respondents reported that they apply this method, although they know that this method is not safe they are still using since some said they do not have fee to pay to the municipal to collect their wastes, inaccessibility of their home places by Municipal trucks and some said that the frequency of collection of wastes is too low so they do use this option sometimes, which is not safe because it can cause health problems since it is not a safe method. The results are comparable to the results observed by (Malisa, 2007) who reported that, most parts of urban areas in Tanzania are inaccessible by refuse trucks

because they are unplanned which make uncollected waste to be managed in different methods like disposal pits, incineration and disposal in open spaces. The results are similar to (Lah, 2002) who reported that unsupervised process of dumping solid waste locally becomes a source of diseases, leachate from the decomposition which percolates into the soil and the water sources resulting in polluting water, soils, and air. In addition, the improper management of MSW causes harmful effects to the public health and environment.

Information from the Key informants who included Municipal health officer, CCIAM project member and Swiss contact project officer revealed that there are several options that are taking place in the Municipal level including composting organic waste into compost manure using food wastes which is mainly done by CBO's also they sell plastic bottles to owners of small scale factories dealing with crushing plastic bottles. This result is in-line with CORE (2008), (Linzner *et al.*, 2007), (EAWAG, 2006) and (Mbuligwe and Kasenga, 2002) who reported that composting can reduce the amount of materials discarded to landfills by up to 50% since about 80% of solid waste generated in Tanzania is biodegradable which can be turned into compost if appropriate strategies are in place. Also it is a source of income to urban dwellers can sustainably be done under specific groups or Community Based Organizations and provides a valuable substitute for chemical fertilizers. UNEP (1996) and USEPA (2002) reported that there are always buyers of recyclables in developing countries, who can help to divert many materials in the waste stream. Also the Municipality in collaboration with Sokoine University of Agriculture has an ongoing plan of developing a waste to energy plant to produce biogas at Mawenzi market.

Further information provided by the owners of small scale factories dealing example SN plastics and FARID NAHADY Company limited Plastic Bottles dealers dealing with plastic bottles recycling revealed that in Morogoro Municipality there is an option of crushing plastic bottles and transporting to Dar es Salaam for sell then they are shipped all the way to China for re-use. The observation is supported by (UNEP, 1996) who reported that small scale enterprises should continue spring up whenever there is an opportunity to recycle plastic materials since it is a financially viable undertaking.

4.3.1 Knowledge about other management options

A large proportion of respondents about 56% reported to have the knowledge about other solid waste management options apart from dumping and locally dug pits. Regardless of their awareness about other management options still they explained that were not undertaking such options at household level due to the following reasons; other management options like recycling and composting requires fund to establish, they couldn't undertake such options since they do not have capital to buy materials required to implement the management options, time limitation, lack of space/land to undertake the management option and lack of enough knowledge on how to implement the option. Knowledge on other SWM options has an implication on this study, since having knowledge on other options and implementing such options is very useful at household level since they could generate income out of waste through adopting such SWM options.

4.3.2 Level of satisfaction on the management option

About 38.7% of the respondents were less satisfied with vehicle collection/dumping option. The most important reasons for dissatisfaction in SW management options is long interval of collection (low frequency of SW collection), the collection frequency is reported to be once or twice a week, the collection frequency is thought to be enough if

wastes were picked regularly but in Morogoro municipality wastes are not picked regularly instead wastes get rotten and become breeding areas for disease pathogens and vectors. This is supported by (Majani, 2000); who reported that wastes should be removed regularly to avoid environmental pollution and degradation.

The household survey revealed that the cost charged for the service ranged 2000-6000 TZS per month to households and 10000-15000 TZS per month to hotels and restaurants. Respondents complained that this cost is relatively high, compared to the service they are getting, which decreases their willingness to pay and the rate of satisfaction. The results are also comparable to (URT, 2002) who reported that respondents complained that the cost of 800 to 2400 per month was high.

Another reason being inaccessibility of some streets as a result of poor routes design and poorly designed collection points, the results obtained are comparable to (Agha, 2006) who reported that, the main causes of dissatisfaction being long distances to main roads, poor design of the routes and scattered location of collection points..

4.4. CostsBenefit Analysis of SWM Options

Cost benefit analysis was used to analyze the cost and benefits of solid waste management options in Morogoro Municipality, the target was to conduct CBA of four options which were recycling, composting, waste to energy and dumping to see if which one is economically efficient. But according to the availability of data only recycling and composting had the cost and benefits. Waste to energy is an ongoing option which is still taking place between Morogoro Municipal and Sokoine University at Mawenzi market to produce biogas it is a prototype test so it has only the costs which involves establishing a bio-digester, processing cost(collection, sorting,production,gas cooker+experts) and

building a kitchen which has a total cost of 15984500 TZS, and Morogoro Municipality under dumping solid waste option has operations costs including environmental cleaning and administration, hiring a wheel loader and fuel with a total costs of 294350000 TZS, so the benefits were not successfully obtained. So the results of cost benefit analysis of Recycling and composting are shown in Table 7.

Table 7: Identified Costs and Benefits

Costs and benefits	Solid waste management options	
	Recycling	Composting
	Monetary value(TZS)	Monetary value(TZS)
COSTS		
Quantity purchased/plastic bottles (kg)	26927.9	
Buying price (Tsh/kg)	240	
Total cost of buying plastic bottles	6462702.703	
Water bills		391764.8
Labor cost/10 workers	470107	112556
Machine workers/3 workers	566521	
Electricity bills	5694.44	
Packaging materials(for parking recovered materials)	12832.43	
Maintenance of machines	171250	
Transportation cost to Dar es salaam	1399563	15000
Hiring a wheel barrow		
Total cost	9115839	519320.8
BENEFITS		
Quantity sold(kg)	23980	
Quantity of compost sold(kg)		7581.667
Selling price (Tsh/kg)	580	200
Total selling recovered materials& compost	14515844	1516333.4
Total benefits	14540404	1516333.4
Net Benefits/return	5424565	997012.6
Net present value (NPV)	13 102 767.01	2 399951.759

NPV are for three yearstime horizon using a discount rate of 12% and their calculations for each option are found in Appendix 4.

The results of CBA in respect to two SWM options, which were recycling and composting are shown in Table 7. The results from this analysis showed that after discounting all the benefits and costs at 12%, all the SWM options earned positive Net

Present Values(NPV), which means that in all scenarios the production costs can be recovered and the firm will remain with the profit.

From these results on decision criterion selected, the cost benefit analysis indicates that all SWM options are worth undertaking. However, the criterion was to select the higher value for the calculated discounting measures which is higher in recycling option at a chosen discount rate for the period of 3 years. This is because recycling is mainly done by small scale factories, using machines for crushing plastic bottles, this makes them crush large quantity of plastic bottles example FaridNahady Company limited and SN plastics which increases the production rate of recovered materials hence it results to high profit, compared to composting which is done by Community Based Organizations (CBO's) locally, who don't have a composting plant, so they do not use any technology to produce compost, they just uses local methods to decompose a small amount of organic waste aerobically every after three months, so this results to the low demand of the compost produced due to poor quality of the produced compost hence market unavailability which results into low profit. Which later on makes a huge amount of organic waste remain unattended and brought to the dump site.

The results of this study is supported byUNEP(2011) which elaborated that although composting plants/facilities are quite cheap to set up, there is a failure of establishment of facilities in many municipalities in developing countries, this is due to high operating costs of centralized facilities and low demand of produced compost, the result of high operation cost is poor management and poor waste separation from the source hence low quality of compost.

While (Ennayetullah *et al.*, 2006) observed that recycling plastic materials are very competitive and meet a high demand on industrial market, thus significant increase in production of recycled pellets, estimates of potential foreign currency income are at USD 29.42 millions/year. This is also observed by (USEPA,2002) who reported that, recycling materials is a financially viable undertaking since valuable funds are saved, jobs are created and landfill space is saved , small enterprises have and will continue to spring up whenever there is an opportunity.

4.4.1 Sensitivity analysis

The CBA does not consider risks and uncertainties. NPV is very sensitive to the discount rate a small change in the discount rate causes a large change in NPV (Lin *et al.*, 2000). For these reasons, systematically the NPV results were subjected to various tests. Observations were made of what would happen to the earning capacity of the two processors dealing with SWM options, if the discount rate was increased or decreased to various levels. The results in Table 8 showed that, the NPV varied as the discount rate (r) was varied.

Table 8:Sensitivity of the management option’s NPV to Choice of discount rate.

Discount rate	Solid waste management option	
	Recycling NPV Values	Composting NPV values
r=5%	14 823417.87	2 715112.598
r=11%	13 331 713.21	2 441886.399
r=13%	12 849 694.17	2 353 597.99
r=30%	9 885 621.821	1 810 687.426

NPV are for three years time horizon and their calculations for each option and discount rate are found in appendix 5.

The results revealed that, the implementation of both options (recycling and composting) in Morogoro Municipality is economically efficient even when the discount rate is as

higher as 30%. However, the magnitude of the NPV decreases by 20% when the discount rate increases from 5% to 30%. With a low discount rate therefore 5%, it is easier to convince the municipality and private investors to invest, or donors to continue funding such a project because the present value of the future benefits is reasonably high compared to the situation when high discount rates are used.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

(i) Types and sources of solid waste generated in the municipality

The study indicates that solid waste generated in Morogoro Municipality has high content of organic waste and recyclables (paper, plastics, glass, metals and waste) which account for 60.2% organic waste and 20.2% recyclables, which makes a total 80.4% of the waste generated. Ideally, if all could be recycled the authorities would remain with only 19.6% to dispose.

Investment in recycling and composting would create employment and engage a good number of the unemployed youth, greatly reduce the quantity of solid waste to be disposed in dumpsites and associated cost. Moreover recycling will recover raw materials which would otherwise be wasted. Also the study indicated the main sources of SW generated in the Municipality as residential and commercial sources.

(ii) Solid waste management options available in the municipality

The study concluded that at the household level there were very limited options regarding SWM since there were only two main options which included locally dug pits and dumping/vehicle collection. While at the municipal level there were CBO's practicing composting and small scale enterprises dealing with recycling and Municipality itself is dealing with vehicle collection/dumping. Although they had knowledge about other management options they were not practicing since they mentioned that they do not have capital to buy material

required to implement the management options for example machinery for recycling ,establishing a composting plant and time limitation and landor space.

(iii) Economic analysis of SWM options

An investment Project is said to be economically efficiency if the magnitude of the NPV is positive. Since the calculated NPV's of both SWM options were positive, it can be concluded that SWM options (recycling and composting) in Morogoro Municipality are economically efficient. But recycling happened to be the one with highest NPV which implies that recycling is the most economically efficient option in Morogoro Municipality.

5.3Recommendations

Basing on the findings of this study the following recommendations are made.

- (i) Source separation, composting of the organic waste and recycling of the recyclables should be encouraged and formalized as these would greatly reduce the amount of solid waste to be disposed (to only 19.6%) into the dump site, hence reducing the cost. This calls for the authorities to enact policies, rules and regulations to that effect. With enabling policies, residents can either as private individuals or through community-based organizations set up investments for making items like briquettes, paper products like toilet tissues, gift bags, conference folders and even factories for recovering e-waste materials and smelting and molding plastics products. Such initiatives will not only be the source of income earning activities, but also reduce waste that must be disposed by municipal authorities and in the process reduce cost on the government. Furthermore, breeding places for mosquitoes and other disease vectors will be reduced and hence save lives which would otherwise be lost due to malaria and cholera.

- (ii) The findings of the study indicate that organic waste is generated at a highest quantity in the Morogoro Municipality. Construction of the composting plants at Municipal level should be provided so as to reduce the solid waste and generate the profit from the product of the solid waste. Through constructing composting plant, it will help to reduce the amount of organic solid waste which appeared to be the leading amount of solid waste.
- (iii) Since the results indicated that, it is only CBO's and small scale factories, CCIAM project and municipal who are mainly dealing with solid waste management options, at household levels there were no any option observed instead they just pay fee so that the municipal could collect wastes they do not bother do deal with the wastes themselves.

Since the study has revealed that SWM options are extremely worth environmentally and socially, and food waste is identified as the predominant waste in entire study area. Home composting can be carried out using various methods and materials: compost bins, worm bins, composting toilets, grub composting, using fly larvae, using special microorganisms etc. Moreover, the study calls upon the support from government and various donors to support the initiatives.

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APPENDICES

Appendix 1: Household structured questionnaire (waste producers)

Background information

Instructions

Fill the blanks that are left open by putting a tick and choose an answer which you think is correct

- 1) Age..... (a) 20-30 (b) 40-50 (c) 60+
- 2) Education level (a) none or primary level (b) secondary level (c) college r university
[]
- 3) Sex (a) Male b) female []
- 4) Level of income of the family..... (a) Lowlevel income (b)Middlelevel income (c)
high level income family
- 5) Family size number of boys..... Number of girls.....
- 6) What types of solid wastes do you produce mostly?
 - a) Food wastes
 - b) Plastic wastes
 - c) Residual/other wastes
 - d) Hazardous
- 7) What are the sources of solid waste you mostly produce?
 - 8) Which solid waste management option do you use?
- 9) Are you satisfied with the management option you undertake?
 - a) Very satisfied
 - b) Satisfied
 - c) Less satisfied
- 10) Are you aware of other management options? Yes or no, why are you not using?

11) Is there any cost you incur in SW management? If yes mention

12) Benefits you get per management option.

Appendix 2: FGD questionnaire (waste collectors/ CBO's)

- 1) Name of committee
- 2) Number of participants
- 3) When did they start to operate
- 4) What types of solid wastes do you collect? How do you collect?
- 5) Where do you obtain SW?
- 6) Who are the producers? Mention by ascending order
- 7) How many households do you cover per day?
- 8) What time do you use for collection of SW per day?
- 9) How many days per week do you collect solid waste?.....
- 10) Which cost do you incur during SW collection? (Collection, transportation, sorting, labour & others specify each and its cost in TSH)
- 11) Which benefits do you get from SW collection? (Price of selling food products and other wastes and other benefits specify and its cost in TSH)

Appendix 3: Key informants questionnaire (waste processors)

**Checklist for key informants surveys (municipal dealers/ municipal health officer/
small scale factories dealing with plastic waste recycling, CCIAM body members
and CBO's)**

- 1) Types of MSW generated
- 2) Sources of MSW
- 3) What types of solid wastes do you process?.....
- 4) Quantity of materials purchased? (Estimate amount per tone).....
- 5) How much do you buy per kg?
- 6) Where do you obtain SW?
- 7) Which types of SWM options are practically applicable in the municipality?
- 8) Identify cost and benefits per each option (including establishment cost, operation cost and maintenance cost (labour cost) and benefits includes price of recovered products and other benefits).

THANK YOU FOR YOUR COOPERATION

Appendix 4: Calculations of NPV of SWM options in Morogoro municipality

Time Horizon (n)= 3years

Net Benefits =TB –TC

Interest rate (i) Or Discount Factor=12%

Discount Factor = $(1+I)^n$

V_0 =Discounted Net Benefit

Discounted Net Cash flow = $V_0/(1+I)^n$

$$NPV = \sum_{t=0}^T Bt(1+i)^{-t} - \sum_{t=0}^T Ct(1+i)^{-t}$$

RECYCLING

Year	Costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	9097118	14540404	5443286	12%	1.12	4860076.7
2	9097118	14540404	5443286	12%	1.25	4354628.8
3	9097118	14540404	5443286	12%	1.4	3888061.4
						NPV= 13102767.01

COMPOSTING

Year	Costs	benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	519320.8	1516333	997012.6	12%	1.12	890189.8
2	519320.8	1516333	997012.6	12%	1.25	797610.1
3	519320.8	1516333	997012.6	12%	1.4	712151.9
						NPV=2399951.8

Appendix 5: Sensitivity analysis

Sensitivity analysis was carried out at 5%, 11%,13% and 30% interest rate/discount rate

RECYCLING

Year	costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	9097118	14540404	5443286	13%	1.13	4817067.3
2	9097118	14540404	5443286	13%	1.28	4252567.2
3	9097118	14540404	5443286	13%	1.44	3780059.7
						NPV=12849694.2

RECYCLING

Year	Costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	9097118	14540404	5443286	11%	1.11	4903861.3
2	9097118	14540404	5443286	11%	1.23	4425435.8
3	9097118	14540404	5443286	11%	1.36	4002416.2
						NPV= 13331713.2

RECYCLING

Year	Costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	9097118	14540404	5443286	5%	1.05	5184081.9
2	9097118	14540404	5443286	5%	1.1025	4937220.9
3	9097118	14540404	5443286	5%	1.157625	4702115.1
						NPV=14823417.9

RECYCLING

Year	costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	9097118	14540404	5443286	30%	1.3	4187143.1
2	9097118	14540404	5443286	30%	1.69	3220879.3
3	9097118	14540404	5443286	30%	2.197	2477599.5
						NPV=9885621.8

COMPOSTING

Year	Costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	519320.8	1516333	997012.6	11%	1.11	898209.5
2	519320.8	1516333	997012.6	11%	1.23	810579.3
3	519320.8	1516333	997012.6	11%	1.36	733097.5
						NPV=2441886.4

COMPOSTING

Year	Costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	519320.8	1516333	997012.6	13%	1.13	882312.0
2	519320.8	1516333	997012.6	13%	1.28	778916.1
3	519320.8	1516333	997012.6	13%	1.44	692369.9
						NPV=2353597.9

COMPOSTING

Year	Costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	519320.8	1516333	997012.6	30%	1.3	766932.8
2	519320.8	1516333	997012.6	30%	1.69	589948.3
3	519320.8	1516333	997012.6	30%	2.197	453806.4
						NPV=1810687.4

COMPOSTING

Year	Costs	Benefits	Net benefits	Discount rate	Discount factor	Discount net cash flow
1	519320.8	1516333	997012.6	5%	1.05	949535.8
2	519320.8	1516333	997012.6	5%	1.1025	904319.8
3	519320.8	1516333	997012.6	5%	1.157625	861256.9
						NPV=2715112.6