Land Pollution and Population density: The case of Kwekwe City residential areas, Zimbabwe

by

JAISON CHATSIWA

Submitted in accordance with the requirements for

MASTER OF ARTS

IN

ENVIRONMENTAL MANAGEMENT

at the

University of South Africa

Supervisor: Mr Maiyana, A. B. (University of Venda, South Africa)

Co-supervisor: Mr Mujere, N. (University of Zimbabwe)

February 22, 2015

STUDENT NUMBER: 45541477

DECLARATION

I declare that, **"Land Pollution and Population Density: the case of Kwekwe City residential areas, Zimbabwe"** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

SIGN

ACKNOWLEDGMENTS

I wish to express my profound gratitude to my supervisor Mr Bethania Maiyana Avhatendi and co- supervisor Mr Never Mujere for their time, valuable inputs, tireless patience, excellent supervision and encouragement throughout my research.

To Dr. Jenny Elliott and Dr. Cryton Zazu I say thank you for your inspiration and guidance. Dr Gibson Muzhombwe, I also want to thank you for reading through my document and also your valuable input. I acknowledge my indebtedness to the following people for the roles they played during data collection and in some cases technical expertise and advice: Energy Mangwiro, Hove; Nyajena, Chiyangwa, Muzata, Bandama and Manyakara, Shonhe who provided the information that I needed.

I am very grateful to the Municipality of Kwekwe, in particular the following departments: Department of Environmental Health; Department of Housing and Community Services; Department of Works and Public Construction; Department of Town Planning and Urban Development and Environmental Management Agency.

University of South Africa staff, from the academic and non-academic fraternities, I say thank you for your invaluable support. Special thanks to postgraduate coordinator, Van Wyk Matha who was so quick to respond to my queries.

Dedication

To the memory of my late father whose dictum still lives on, also to my mother, wife Juliet and children Sharon, Shalom, Shalon and Shannon who were by my side when things were difficult and never complained when I was working in isolation.

ABSTRACT

In most developing countries, the problem of inefficient municipal solid waste management (MSWM) is endemic. The problem is manifested by heaps of uncollected solid waste found on open areas and by the street sides. This dissertation examines the relationship between land pollution and population density resulting from solid waste generation in the City of Kwekwe in Zimbabwe. Questionnaires and interviews were conducted to 375 randomly selected households in low, medium and high density residential suburbs. The household survey was triangulated with field observations, key informant interviews and secondary data sources. The average household size in high, medium and low density residential areas was 11, 8 and 5 people respectively. The study revealed that the amount and composition of solid waste generated varied according to household size, income and education levels of residents. The higher the population density, the more the solid waste produced. However, waste generated was not carried to the dumpsites for disposal. Also the higher the income, the higher the amount of solid waste produced, although residents with high income were able to ferry their wastes to the dumpsites hence less land pollution. The solid waste generation rate in high density areas was 0.04 kg/capita day, in medium density areas was 0.35 kg/capita/day and in low density areas were 0.84 kg/capita/day. It was also observed that among high income earners, the educated people produced more waste than low income earners. However, the low income earners and the less educated people could not take care of their environment to limit roadside and open space littering. However, lack of public awareness coupled with inefficient and ad hoc waste management system continue make provision of effective solid waste management services illusive. Based on the research findings, it is suggested sound environmental stewardship amongst residents will limit land pollution in the city of Kwekwe.

Keywords: Solid waste, Waste management, Municipal solid waste, Population density, Affluence, Pollution, Kuznets curve.

Table of Contents

APPENDICES

FIGURES

LIST OF ACRONYMS AND ABBRIVIATION

BIMCO	Buchwa Iron Mining Company
BSAC	British South African Company
CBD	Central Business District
CBO	Community Based Organization
CRT	Cathode Ray Tube
CSO	Central Statistics Office
EKC	Environmental Kuznet Curve
EMA	Environmental Management Agency
GHG	Green House Gases
GNP	Gross Net Product
GDP	Gross Domestic Product
HSW	Household Solid Waste
ISCO	Integrated Steel Company
ISWM	Integrated Solid Waste Management
KCC	Kwekwe City Council
LCA	Life Cycle Assessment
LEDCS	Less Economically Developed Countries
MBT	Mechanical Biological Treatment
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NGO	Non-Governmental Organization
NIMBY	Not In My Back Yard
PAT	Population Affluence Technology
PAYT	Pay-as-you-Throw
PB	Pay-by- the- Bag
PDA	Personal Digital Assistants
PPP	Polluter Pays Principles
RDC	Rural Development Council
SWM	Solid Waste Management
TPY	Tons per year
UPP	User Pays Principles
WIS	Waste Information Systems
WTE	Waste to Energy

ZIMASCO	Zimbabwe Iron and Smelting Company
ZISCO	Zimbabwe Iron and Steel Company

TABLES

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Solid waste management (SWM) is an integral part of the urban environment metabolism and planning of the urban infrastructure to ensure safe and healthy human environment while considering the promotion of sustainable economic growth. Land pollution and solid waste generation have become major issues in cities of less economically developed countries as put forward by Abdelnaser and Gavrilescu (2008). The possible causes of urban land pollution are development, urbanization and increase in income per capita income. This tripartite relationship gives rise to the whole menace of land pollution due to solid waste mismanagement. Solid waste from domestic, social and industrial activities is increasing in quantity as a result of growing population, rising standards of living and development of technology (Suess, 1985; UNEP, 1991; Dickerson, 1999). Solid waste management is a complex technical, social and economic problem which calls for multidisciplinary approaches (Manfredi and Christensen, 2009). Any method to deal with solid waste should be environmentally effective, technologically feasible, economically affordable and socially acceptable.

1.2 Background

Rapid population growth and expanding urbanization have caused a drastic increase of the municipal solid waste generation and the variety of the waste composition. Many cities in developing countries face serious environmental degradation and health risks due to the weakly developed municipal solid waste (MSW) management system (Nguyen *et al.,* 2011).. MSW consists of all types of solid waste generated by households and commercial establishments. It is usually collected by local government bodies (Bhada-Tata and Hoornweg 2011). The majority of substances composing MSW include paper, kitchen waste, plastics, metals, textiles, rubber and glass.

Thomas-Hope (1998) also states that solid waste generation has been a major consequence of development and modernizations, yet some of the greatest challenges to its management are felt mostly in less economically developed countries (LEDC). This shows that there is an inextricable link between urban population growth, development

and environmental problems. However, the relationship is not straightforward, especially as increased waste generation does not itself suggest that, many environmental problems lessen as cities get larger. The interaction of factors such as income per capita or affluence, population density and economic development will be explored to understand the causes and composition of solid waste produced in Kwekwe from different income residential areas.

1.3 Global overview of solid waste management

The volume of global solid waste generation increases with increasing global population. Improvement in standard of living across the globe is expected to contribute its quota not only to the global waste volume but also its complexity. Globalization of the world economy is expected to have the same effect on solid waste as improvements in standards of living across the globe. According to Cointreau *et al.* (2000), high-income countries produce about three times more municipal waste per capita than the developing countries. One argument linked to this is how countries like Zimbabwe can easily become dumping sites for waste materials in form of outdated computers donated at times for free by richer countries and second cars which are now lying idle in residential areas and open spaces contributing to land pollution. The same applies to generation of hazardous waste. Table 6 provides an overview of municipal waste generation per capita from global perspective and it shows that the higher the income the more the solid waste generated.

1.4 Goals and principles of municipal solid waste management

According to Schubeler *et al.*, (1996) there are four goals of municipal solid waste management (MSWM). The first goal is to protect the health of the urban population, particularly that of low-income groups who suffer most from poor waste management. Secondly, MSWM aims to promote safe environmental conditions by controlling water, air, soil and cross media pollution, and ensuring the sustainability of ecosystems in the urban region. Thirdly, MSWM supports urban economic development by providing demanded waste management services and ensuring the efficient use and conservation of valuable materials and resources. Fourthly, MSWM aims to generate employment and incomes in the sector itself. The goals if well implemented will help cities to become better and safer places to live.

1.5 Statement of the problem

Poor solid waste management is one of the environmental problems facing urban areas in the third world cities (Hope and Lekorwe, 1999; Manyanhaire *et al.,* 2009). Most studies on solid waste management have been done in large cities such as Harare, Bulawayo and Chitungwiza in Zimbabwe (Tevera, 1995; Moyo, 1997; Masocha and Tevera 2003; Mapira 2007; Mapira and Mungwini, 2007; Makwara, 2011; Mapira, 2011). However, not much is known on waste management in small in cities. Thus, there is a knowledge gap in which this study aims to fill, taking the city of Kwekwe as a case study.

1.6 Research questions

- Is solid waste generated from each household related to the number of people per household?
- What is the relationship between population density, and the amount of solid waste produced?
- Is there evidence of a link between income and household waste pollution?
- How effective is Kwekwe's solid waste management system?

1.7 Aim and objectives

1.7.1 Aim

To investigate the relationship between land pollution and population density in residential areas of Kwekwe city.

1.7.2 Research Objectives

i. To characterize amount and types of solid waste generated from high, medium and low density residential areas;
ii. To assess the socio-economic factors contributing towards solid waste generation;
iii. To evaluate the effectiveness of the municipal solid waste delivery system; and
iv. To make recommendations for improving the management of solid waste.

1.8 Hypothesis

There is a strong positive relationship between the quantity of solid waste generated and, population density and income levels.

1.9 Justification

This research is important in the sense that, it will help the Kwekwe Municipality particularly the solid waste department to sustainably manage the solid waste and reduce land pollution. The research findings will also help the Ministry of Local Government to improve the management of solid waste in Zimbabwean cities and other African cities. Kwekwe residents will also benefit because the research will bring out the potential health hazards that may develop as a result of poor solid waste management system. This research will help to identify and characterize solid waste from Kwekwe residential areas. Maybe due to paucity of data and no publications on solid waste information, this will give the basis of solid waste studies in small cities such as Kwekwe. Results will also stimulate further researches and contribute towards the reduction of solid waste generation leading to land pollution. The research will quantitatively and qualitatively assess the solid waste generation and composition. Kwekwe Municipality will be evaluated through the use of questionnaires on its delivery system and compliance with the Environmental Management Act (EMA; 20:27). The research outcomes will help to establish whether it is the Municipality's failure to cope with the menace or a paradox between economic development and land pollution.

In addition, this study is necessary to develop practical alternatives to strengthen Kwekwe's current solid waste management system and to increase awareness about sustainable approaches to solid waste management. The study is also expected to give more useful information for solid waste practitioners and decision makers when they are conducting long term planning of solid waste management. Its application will produce environmental and economic benefits to Kwekwe residents. The preceding discussions show that the solid waste management in Kwekwe has a crucial problem requiring urgent attention from academics as well as practitioners because of its ramification on the environment, health, aesthetics and the toll it takes on the state and cities' resources. This rationale justifies this research.

1.10 Limitations of this study

It was not possible to achieve 100% participation by the residents because some of the households selected from the list did not participate due to a number of reasons such suspecisions of political party affiliation, victimisation, children and old people who were not able to answer the questions and some were just unwilling to answer the

questionnaires for unknown reasons and therefore more alternative respondents were selected to maintain a 375 sample. Some of the municipal officials were not able to answer the questionnaire due work commitments and also to keep the municipality secrets. In some households, all members were employed and there was no one at home during day time however, evening visits were done to make sure that data has been collected. A few residents who agreed to participate in the beginning did not continue the process of sorting of waste throughout the study period. In such instances the waste had to be sorted and weighed at the time of measurement. Another challenge was that there were no baseline records of solid waste in the Municipality except for the last recorded in 1999, so it was difficult to make quantitative and qualitative comparisons.

This research only focuses on solid waste generation which leads to land pollution from households. Other areas of the city such as the industry and central business district (CBD) and the industrial areas were not included in the study because time and financial resources to carry out the research were limited. However, all these limitations did not compromise the research findings.

1.11 Structure of the dissertation

This research is divided into six chapters. Chapter one gives an introductory explanation of the research. Statement of the problem is also outlined. Hypothesis and justification of the research is explained in this chapter. The conceptual framework, aim and objectives are stated under this chapter.

Chapter Two reviews literature on the contemporary solid waste management practices and methodologies in developing countries' cities. It also looks at various factors affecting the amount of solid waste generated leading to land pollution in urban areas.

Chapter Three focuses on the study area; its location, geography and the socio-economic and demographic characteristics. The implementation and compliance of the Environmental Management Act Chapter 20:27 are assessed under this chapter.

Chapter Four highlights the research methods that have been applied to acquire information. These are data collection and analyses. Both primary and secondary data

sources including interviews, questionnaires and participant observations were used in the research methods. Qualitative and quantitative methods were used in this research method to collect and analyze data.

Chapter Five is about results and their discussion. Data collected from questionnaires, field observations and pictorial inserts will be discussed under this chapter. It establishes gross household waste production and the scope and nature of solid waste in Kwekwe residential areas.

Chapter Six gives the conclusion and recommendations of the research. It assesses the current solid waste management, factors affecting the generation of solid waste resulting in land pollution. Recommendations to improve solid waste management in Kwekwe are also given in this chapter.

The annexes and reference follow after Chapter Six.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

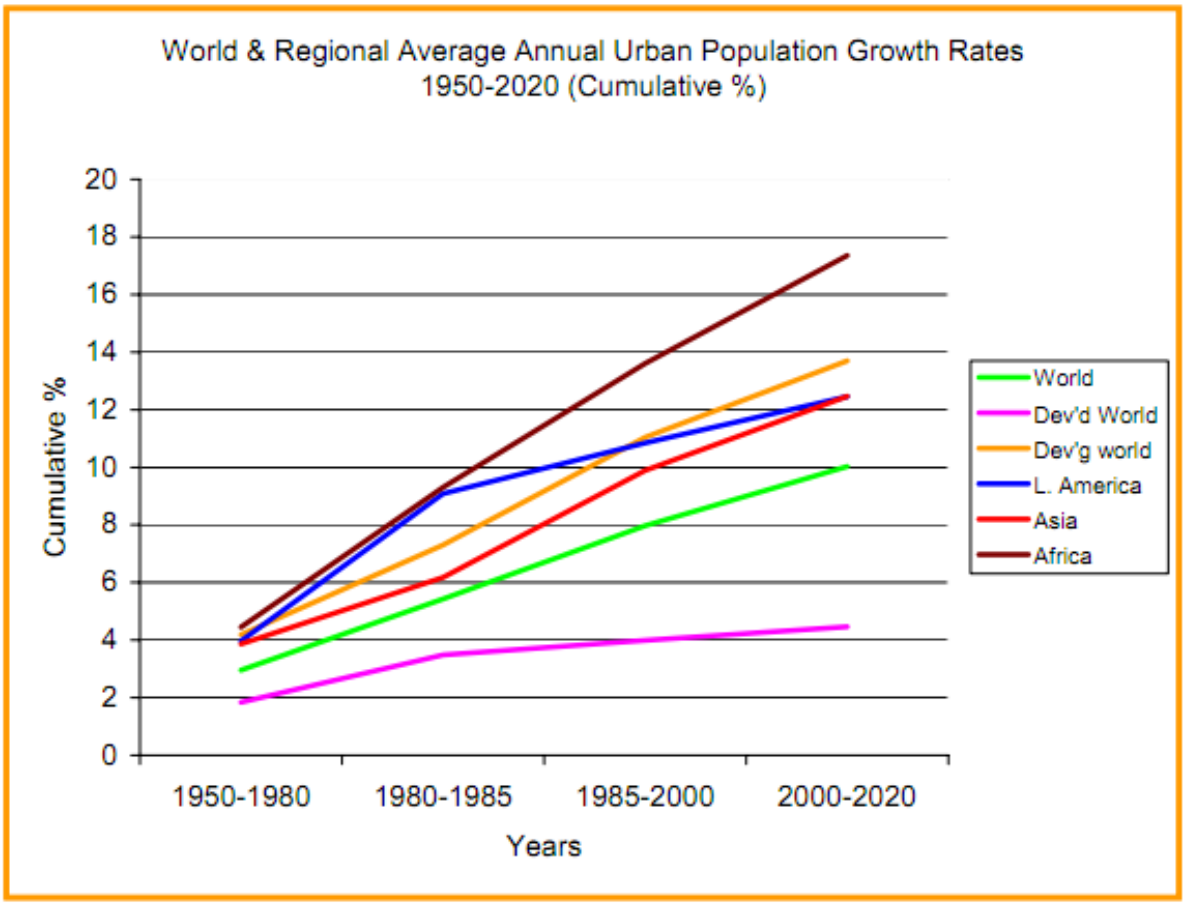
Rapid population growth and expanding urbanization have caused a drastic increase of the municipal solid waste generation and the variety of the waste composition (Nguyen *et al*. 2011). MSW consists of all types of solid waste generated by households and commercial establishments, and collected usually by local government bodies (Bhada-Tata and Hoornweg, 2011). The majority of substances composing MSW in developing countries include paper, kitchen waste, plastics, metals, textiles, rubber, and glass. Many cities in developing countries face serious environmental degradation and health risks due to the weakly developed MSW management system (Nguyen *et al.* 2011).

Increasing scale of economic activities, industrialization, urbanization, rising standard of living and population growth, has led to an increase in the quantity of waste generated. The inability of municipalities to handle the increasing amount of solid waste generated has caused endemic environmental problems in urban areas. Hassan (2000), states that the amount and composition of solid waste generated is affected by factors like the socio-economic development of the area, degree of industrialization and climate. This can be supported because the greater the economic prosperity and the higher the percentage of urbanization the greater the amount of solid waste produced. This assertion agrees with the World Bank (1992) which noted that waste generation tends to increase with an increase in population and economic growth which together add up to the problem of solid waste management posed not only to the environment but also to public health. Tisdell (1991:13) states that "wastes and pollution are end-products of economic production and consumption." All of the countries that have a Gross National Product (GNP) per capita less than US $400 produce under 0.25 tons/person/year. As GNP increases toward the middle income range, the per capita waste generation rates also increase, ranging from 0.18 to 0.40 tons per year (African Development Bank, 2002).

2.2 Rates of regional and world urbanization

Ojeda-Benitez and Beraund- Lozano (2003) state that solid waste generation is an inevitable consequence of production and consumption activities in any economy

(Eugenia *et al.*, 2002). UNEP (2005) also reports that fast expansion of urban, agricultural and industrial activities spurred by rapid population growth has produced a huge amount of solid waste that pollutes the environment and destroys natural resources. Figure 1:1 shows the cumulative percentages of world and regional annual urban population growth rates.



Dev'd World=Developed World
Dev'g World=Developing World

Figure 1.1: World and regional annual urban population growth rates from 1950 to 2020

Source: Hardoy *et al.*, (2001)

Onibokun, (1999) put forward that the rapid growth of uncontrolled urbanization in developing countries of Africa has brought environmental degradation. There is evidence that some pollutants follow an inverse U-shaped pattern relative to income, and this relationship is called the Kuznet Curve. The environmental Kuznets curve (EKC) is a hypothesized relationship between various indicators of environmental degradation and income per capita (Abrate and Ferraris, 2010). Another hypothesis to be tested in support of the Kuznet Curve is that the greater the income the higher the emission of pollutants

until some level; increasing of income has a positive effect on the Gross domestic product (GDP) of a country, that is, there is a technological and policy effect on the market strategy as put forward by Abrate and Ferraris (2010).

This increase in population would pose serious challenges for any formal management system. As a result, many African cities are now faced with serious environmental degradation and health risks caused by uncollected and poorly disposed refuse in streets, open areas, and urban drainage systems that have become clogged by indiscriminately dumped refuse, and the pollution of water resources near uncontrolled dumping sites. According to Songsore *et al.,* (1998) households have been estimated to account for about half of the solid waste generated by weight in developing world cities. This overwhelming rate of waste generation has resulted in open dumping as the most widely used means of disposal of solid waste in the developing world (Bartone *et al.,* 1991; IETC, 2000). Cointreau (1982), and, Stren and White (1989), estimate that in the cities of developing countries some 30 to 50 per cent of solid wastes often remain uncollected, rot, wash away, burn out in the open, and be scavenged at dumps, where the wastes are piled up uncovered. These dumpsites have become refuges for disease spreading parasites. The use of incineration is limited in many African and Latin American cities due to the high cost of operation, high moisture content of the waste and the high proportion of organic matter (IETC, 2000).

2.2 Scope and framework of municipal solid waste management

Within the overall framework of municipal solid waste management (MSWM*)*, according to Schubeler, *et al.*, (1996) states that the scope of MSWM encompasses the following functions and concerns the three principle dimensions, corresponding to the following questions:

i. What is the scope of waste management activities?
ii. Who are the actors and development partners in the field?
iii. How should strategic objectives and issues be addressed?

The scope of waste management activities ("what") and the concerned actors and partners in development cooperation ("who") are then described as shown in Figure 1.2. The conceptual framework outlines the context in which solid waste management systems operate at the political, socio-cultural, economic and environmental levels.

Figure 1.2 demonstrates how the scope, stakeholders (actors) and strategic aspects need to be integrated within city specific contexts. A special innovation is involvement of the local population to the extent where is recommended that they conceive, initiate, decide and execute their own projects with the council's collaboration rather the other way round. This is described as the bottom up approach as opposed to top down approach**.**

Goodey (1973 cited in Omuta 1987) justifies this approach by arguing that individual involvement through public participation reduces friction, resentment, resistence, rejection and confrontation.

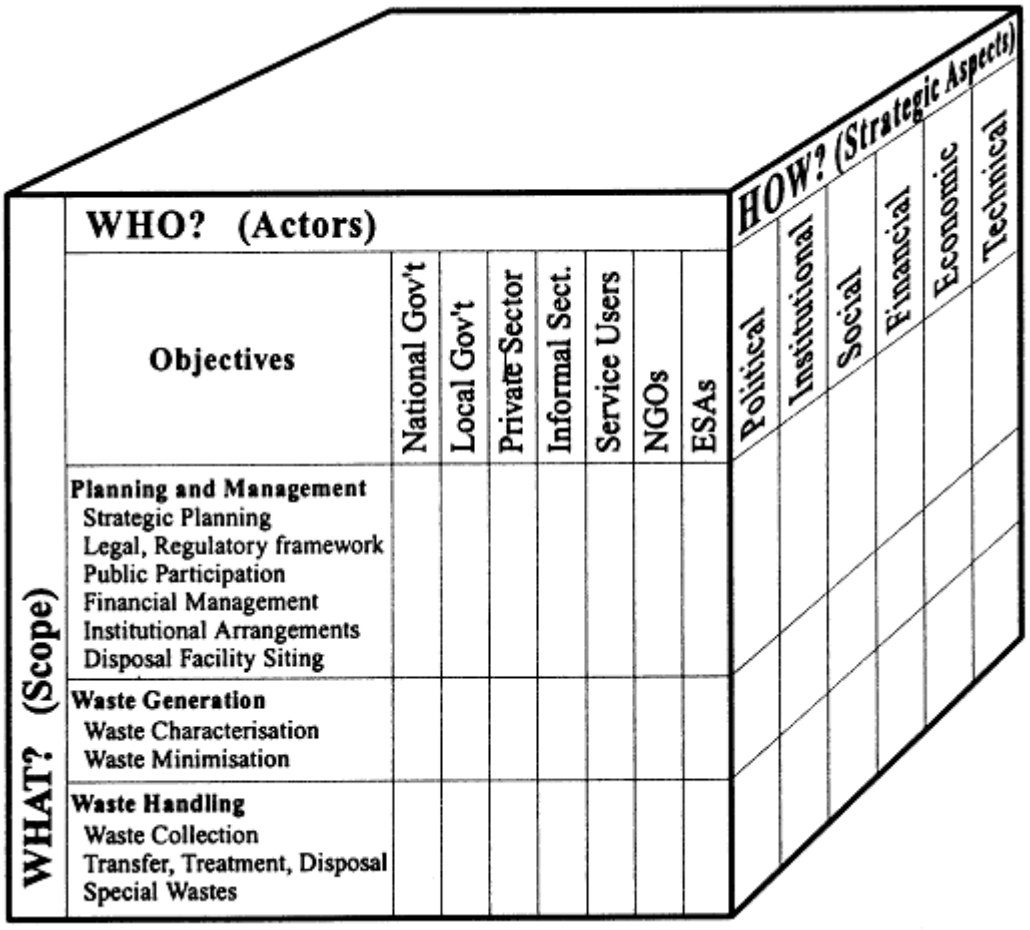


Figure 1.2: The nature and scope of solid waste management

Source: Schubeler *et al.* (1996, p.17)

Actors include a wide range of individuals, groups and organisations are concerned with MSWM as service users, service providers, intermediaries and/or regulator. Strategic

aspects of development sustainable MSWM systems imply that specific objectives be formulated and appropriate measures taken regarding a range of strategic aspects.

Sustainable strategies of MSWM require that specific objectives must be formulated and measures taken with regard to the political, institutional, social, financial, economic, and technical aspects of waste management. The scope of MSWM encompasses planning and management, waste generation and waste handling processes.

Schubeler *et al*. (1996) outlined the functions of the MSWM as follows:

1. Planning and management
    - Strategic planning
    - Legal and regulatory framework
    - Public participation
    - Financial management (cost recovery, budgeting, accounting, etc.)
    - Institutional arrangements (including private sector participation)
    - Disposal facility siting

2. Waste generation
    - Waste characterization (source, rates, composition, etc.)
    - Waste minimization and source separation

3. Waste handling
    - Waste collection
    - Waste transfer, treatment and disposal
    - Special wastes (medical, small industries, etc.)

Practical strategies for improving MSWM comprise specific objectives and measures. Therefore, sustainable ISWM practices are (Anschiitz and van de Klundert, 2000):

i. Socially acceptable: the SWM systems must operate in a way that is acceptable to the majority of the people in a community. They should involve the community to inform and educate, develop trust and gain support.

ii. Environmentally effective: the SWM systems must reduce the environmental burdens of waste management such as various emissions and effluent discharges.

iii. Economically affordable: the SWM systems must operate at a cost acceptable to the community, which includes citizens, businesses and government.

The balance need to be achieved to reduce the overall environmental burdens and the waste management systems as far as possible within acceptable levels of cost (Jaya Dhindaw, 2004).

2.3 Solid waste

Any waste that is hard or solid and not water-like or liquid for example; broken glass used plastic bags, leftover food and food remains, torn cloth, yard trimmings etc. Cointreau, (1982) defined solid wastes as non-flowing organic and inorganic materials that include residues, by-products in production, distribution or consumption of goods and provision of services that are discarded by their first owners without expecting to be compensated for their inherent value. Dyer *et al*, (1999), defines waste as unwanted by-product, damaged, defective, or superfluous materials of a manufacturing process. Synonyms to solid waste are terms such as garbage, trash, refuse or rubbish. 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 waste, street sweepings, commercial wastes and construction - demolition debris which are omitted in this study. The MSW can be divided into three types using the nature of the solid waste and these are organic wastes (combustibles wastes, plastic, wood, paper, textile, leather, rubber, etc.), inorganic waste such as (non-combustibles wastes, ferrous metal material, non-ferrous materials, glass, stone, ceramic, bones, shells, etc.) and miscellaneous wastes (Dev,2007).

2.3. I Classification of solid waste

Putrescible wastes are generated by growing, handling, preparation, cooking and consumption of food. These kinds of wastes tend to be more abundant during the summer (rainy) seasons. Non-putrescible wastes do not decompose easily; they may or may not be combustible. Because they do not break down, they persist in the environment and are often the cause of nuisance and aesthetic problems leading to land pollution, Hoornweg (2012). Table 1 shows the classification of waste according to source of the waste.

Table 1 Source and types of solid waste

Source	Typical facilities, activities or locations where wastes are generated	Types of solid wastes
Residential	Single family and multifamily detached dwellings, low, medium and high rise apartments.	Food wastes, paper, cardboard, plastic, textile, leather, yard waste, wood, glass, tin cans, aluminium, other metals, ashes, including bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil ,tires, rubber, household hazardous wastes
Commercial	Stores, restaurants, markets, offices, buildings, hotel, print shops, service stations, auto repair shops.	Paper, cardboard, plastic, wood, food waste, glass, metals, hazardous wastes.
Institutional	Schools, restaurants, markets, offices, buildings, hotel, print shops, service stations, auto repair shops.	Paper, cardboard, plastic, wood, food waste, glass, metals, hazardous wastes.
Construction and demolition	Schools, hospitals, prison, government centres.	Wood, steel, concrete, dirt, Plastic.
Municipal services (excluding treatment facilities)	Street cleaning, landscaping, catch basin, parks and beaches, other recreational areas	Special wastes, rubbish, street sweepings, landscapes, and tree trimmings, catch basin debris, general waste from parks, beaches and recreational areas
Treatment plant sites MSW	Water, wastewater and industrial treatment processes.	Treatment plant wastes, principally composed of residual sludge
Municipal solid waste	All of the above	All of the above
Industrial wastes	Construction, fabrication, light and heavy manufacturing refineries chemical plants, power plants and demolitions.	Industrial process wastes, scrap materials, etc. Non-industrial wastes including food wastes, rubbish, ashes, demolition and construction wastes, and hazardous wastes
Agricultural	Field and row crops, orchards, vineyards, dairies, feedlot and farms.	Spoiled food wastes, agricultural wastes, rubbish and hazardous wastes.

Source: Hoornweg (2012, p.120).

Hazardous wastes could be highly toxic to humans, animals, and plants; are corrosive, highly inflammable, or explosive; and react when exposed to certain things e.g. gases. Household wastes that can be categorized as hazardous waste include old batteries, shoe polish, paint tins, old medicines, and medicine bottles. Hospital waste contaminated by chemicals used in hospitals is considered hazardous. These chemicals include formaldehyde and phenols, which are used as disinfectants, and mercury, which is used in thermometers or equipment that measure blood pressure. Such hazards were not very common in the residential areas because the Municipality has a special preference to such wastes and they are well taken care of and disposed in a special way. Figure 1.3 shows the different types of hazardous and non-hazardous waste.

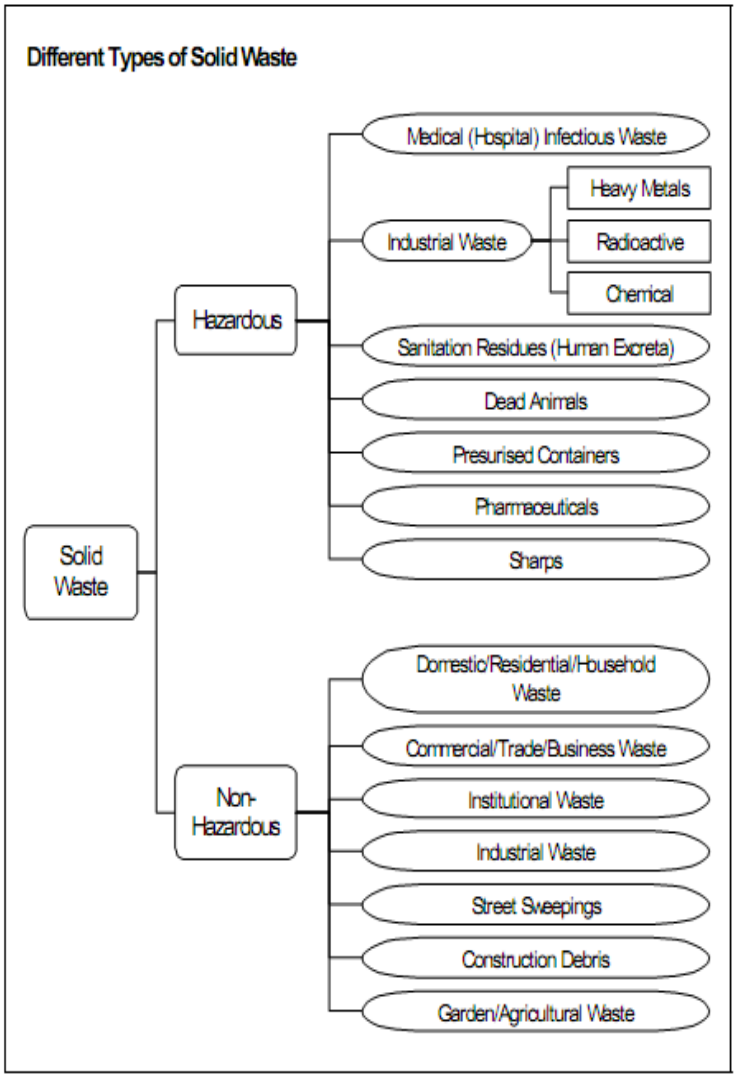


Figure 1.3: Types of hazardous or non-hazardous

Source: International Labour Organisation (2007, p.48)

Hazardous waste: These are substances that are ignitable, corrosive, reactive, infectious or explosive and toxic to human beings and the environment. Hazardous waste exhibits some of the following characteristics and is found in illegal dumpsites.

Ignitability: Ignitable wastes can create fires under certain conditions, are spontaneously combustible, or have a flash point less than 60 °C. Examples include waste oils and used solvents.

Corrosivity: Corrosive wastes are acids or bases (pH less than or equal to 2, or greater than or equal to 12.5) that are capable of corroding metal containers, such as storage tanks, drums, and barrels. Battery acid is an example.

Reactivity: Reactive wastes are unstable under "normal" conditions. They can cause explosions, toxic fumes, gases, or vapors when heated, compressed, or mixed with water. Examples include lithium-sulphur batteries and explosives.

Toxicity: Toxic wastes are harmful or fatal when ingested or absorbed (e.g., containing mercury, lead, etc.). When toxic wastes are land disposed, contaminated liquid may leach from the waste and pollute ground water posing a hazard to the environment

2.4.1 Characteristics of solid waste

Some of the characteristics which are important in the solid waste management are given by Dev (2007). This is a result of the proximate analysis of moisture content; volatile matter; amount of ash and fixed carbon of the waste produced. The ultimate analysis which involves determination of the per cent of carbon, hydrogen, oxygen, nitrogen, sulphur and ash is also important and energy content of low and high calorific value which will determine the possibility of energy production from waste.

Information on the composition of solid waste is important in evaluating alternative equipment needs, system and management programs and plans. Information and data on the physical composition of solid wastes are important in the selection and operation of equipment facilities, in assessing the feasibility of resource and energy recovery, and in the analysis and design of disposal facilities. Physical and chemical composition of each type of waste contributes major part in designing disposal facilities because some wastes cannot be treated as compared to other wastes.

Density of solid waste is important to the Municipality of Kwekwe because it gives the idea of how much solid waste to be transported. Density also gives the municipality estimates of the capacity of vehicles to be used. Density is defined as the mass per unit volume of any substance. Density data are often required to obtain the mass and volume of waste that must be managed. The density of solid waste is determined for transportation and other purposes. It should be noted that density values are different between compacted and not compacted refuse. Chemical composition of organic and inorganic waste, the information on chemical composition is quite important to design recycling, including composting, energy recovery and disposal. The important elements are carbon, hydrogen, oxygen, nitrogen, sulphur, and ash. The local or national institutes may have typical data for various types of wastes on dry-basis for these elements. That data may be utilized to calculate the composition for the collected waste.

2.4.2 Degeneration time for different types of solid wastes

The fact that some of the solid wastes take time to degenerate or decompose when dumped, they pose a potential source of land pollution.

Table 2 Average time range taken to degenerate different types of litter

Type of litter	**Approximate time it takes to degenerate the litter**
Organic waste such as vegetables and fruit peels, leftover food stuffs	a week or two
Paper	10- 30 days
Cotton cloth	2- 5months
Wood	10- 15 years
Woolen items	1 year
Tin , aluminium, and metal items such as cans	100-500 years
Plastic bags	500 and above years
Glass bottle	Undetermined

http//edugreen.teri.res.in/explore/solwaste/types 16 November 2013

2.5 Solid waste management

Tevera and Masocha, (2003) define solid waste management as decision and actions that are taken regarding the generation, storage, collection, transportation, processing and disposal of solid wastes with the intention to minimize environmental damage and protect public health. This is the working definition that shall be used throughout the study.
Accelerating urbanization has led to rapid increase in MSW generation that has dramatically expanded the burden on local governments in many developing countries to collect, process, and dispose of MSW in socially efficient ways (Beede and Bloom, 1995) and the amounts of refuse destined for final disposal rapidly consume landfill capacity. This usually results in solid waste generation and land pollution.

MSW has become a major issue of concern for many developing cities, however, especially as population increase. This problem is compounded as many nations continue to urbanize rapidly; 30-50% of the populations in developing countries is urban (Thomas-Hope 1998) and in many African countries the growth rate of urban populations exceeds 4% (Senkoro, 2003). Although developing countries do spend between 20 and 40% of their municipal revenues on solid waste management (Schubeler 1996; Thomas- Hope 1998; Bartone 2000), this is often unable to keep pace with the scope of the problem. In Zimbabwe the solid waste management is the responsibility of the metropolitan municipality and council to manage solid waste until it is finally disposed.

Solid waste management is a public good and it is a service which is non-exclusive, meaning that once it is provided to some portion of a community, it benefits the overall public welfare, not only the resident that receives the service. The service is also non-rivaled, meaning that any resident can enjoy the benefit of the service without diminishing the benefit to anyone else. Beyond this, it is not feasible withdraw services from those who do not pay, because public cleanliness and safe disposal of waste are essential to public health and environmental protection (Cointreau, 1994).

The Municipal tax and fee revenues are not charged according to the number of occupants per household or according to various age groups neither are they charged according to the income per household. A flat fee is charged per household and this may result in inefficiency and ineffective solid waste management resulting in land pollution. Due to

high rate of urbanization, many people are not employed and cannot pay the municipality taxes. Solid waste management practices in Kwekwe are primarily traditional following the steps like collection, transference, transportation and disposal. There is very limited recycling and no waste to energy practices with very limited composting. According to Zender (1999), solid waste management is the planned channeling and executing control of society's wastes from generating source to ultimate end-use or "non-use". Controlling of wastes includes collection, transferring and transporting and disposal, as well as recycling, reuse and reduction. Schubeler *et al*. (1996) outlined the goals of an appropriate waste management system as follows:

- To protect environmental health
- To promote quality of urban environment
- To support the efficiency and productivity of the economy
- To generate employment and income.

A solid waste management is required for any urban environment to carter for any adverse effects of diseconomies of scale. The simple conventional waste management that deals with storage, collection, transportation and disposal of waste may not apply present day urban societies due to the rate of urbanization.

Municipal solid waste management encompasses, planning, engineering, organization, final and legal aspects of activities associated with generation, growth, storage, collection, transport, processing and disposal in an environmentally compatible manner adopting principles of economy, aesthetics, energy and conservation (Tchobanoglous *et al.,* 1993).

2.6 Sustainable solid waste management

Sustainable solid waste management requires rich understanding of waste streams, material balance and flow along with the proper knowledge and willingness of the stakeholders (Vidanaarachchi *et al.,* 2006). The sustainable solid waste management therefore looks into managerial skills and practices that do not compromise the future generation to achieve their environmental benefits. Waste management should be approached from the perspective of the entire cycle of material use, which includes production, distribution and consumption as well as waste collection and disposal. Whilst immediate priority must be given to effective collection and disposal, waste reduction and recycling should be pursued as equally important, longer-term objectives. The principles

of sustainable waste management strategies are thus to minimize waste generation, maximize waste recycling and reuse, and ensure the safe and environmentally sound disposal of waste. Solid waste management goals cannot be achieved through isolated or sectorial approaches. Sustainable waste management depends on the overall effectiveness and efficiency of urban management, and the capacity of responsible municipal authorities.

The concept of the life cycle assessment (LCA) is an objective process to evaluate the environmental burdens associated with a product, process or activity by identifying energy and materials used and waste released to the environment, and to evaluate and implement opportunities to effect environmental improvements (JHA ARVID *et al.,* 2011). The LCA covers full "cradle to grave" impacts of a product or service (Barton *at al* 1996; UNEP 1999). The LCA evaluation is not done in Kwekwe so the municipality is not aware of how much damage residents cause to the environment.

Barton *et al.,* (1996) identified the four stages of decision making in waste management:

a) Goal definition and scoping;
b) Inventory of the materials and energy used during all stages in the life cycle of a product or process and inventory of the environmental burden throughout the product life cycle;
c) Impact assessment to examine potential and actual ill-effects related to the use of resources and environmental releases;
d) Assessment of the change that is needed to bring about environmental improvements in the product or processes.

2.6.1 Integrated solid waste management

Integrated solid waste management (ISWM) is defined as the selection and application of suitable techniques, technologies and management programs to achieve waste management objectives and goals (Tanskanen, 2000). The ISWM concept was established by the USA Environmental Protection Agency in the early 1990s to expand existing solid waste management initiatives. The ISWM is a holistic approach that focuses on preventing waste, minimizing, reusing and recycling the waste (USEPA, 1995). The ISWM put into

consideration the socio-economic, cultural and environmental factors of the city for it to achieve its objectives and goals.

Bartone, (2000) identifies the anticipated benefits of the ISWM to a city as follows:

- Low costs;
- Better cost management;
- Fewer health problems;
- Less environmental pollution;
- Conservation of natural resources;
- Better coordination and performance; and
- Improved public participation.

To achieve the above benefits, the municipality should be prepared to meet the following costs outlined in Table 3. **S**uch costs are difficult to meet especially in developing countries with poor financial base.

Table 3 Municipal costs in solid waste management

Up- front costs	Public education and outreach
	Building construction and modification
	Land acquisition and permitting
Operating costs	Normal costs such as: Operation and maintenance (O&M) Capital costs Debt services Operating costs Unexpected costs
Back end costs	Site closure Building/equipment decommissioning Post-closure care Retirement/health benefits for current employees
Remediation costs at inactive sites	Investigation, containment, and clean-up of known releases of pollutants
Contingents costs	Remediation costs (future releases of pollutants from closed sites)

Source: USEPA (1997)

ISWM is a systems approach that recognizes three important dimensions, which all need to be addressed when developing or changing a solid waste management system. The dimensions involved are mainly three as shown in Figure 1.4

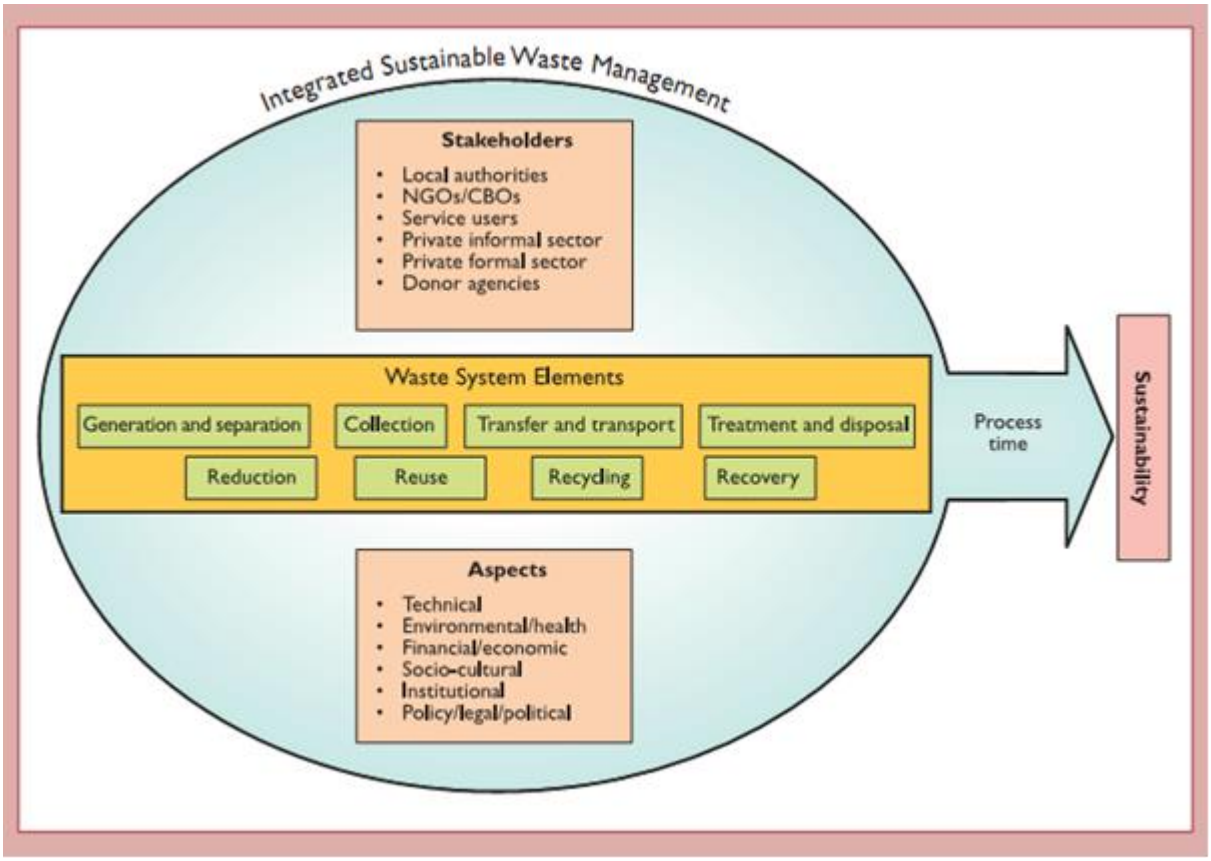


Figure 1.4: Integrated sustainable Management flow diagram

Figure: 1.4 A flow diagram of Integrated Sustainable Waste Management

Source: United Nations (2012, p.27)

The stakeholders include the local authority (mayor, city council, and solid waste department), the national environment and local government ministries, and one or two private companies working under contract to the municipality. Often unrecognized stakeholders include (female) street sweepers, (male) workers on collection trucks, dumpsite 'waste-pickers', some of whom may actually live on or at the edge of the dumpsite, and family-based businesses that live from recycling.

Other key stakeholders include the waste generators: the users of the waste management service provided by the city, including households, offices and businesses, hotels and restaurants, institutions such as hospitals and schools, and government facilities such as airports or the post office. These are the technical components of a waste management system. Part of the purpose of using the ISWM framework is to show that these technical

components are part of the overall picture, not all of it. Solid waste management consists of a variety of activities, including reduction, reuse, recycling and composting, operated by a variety of stakeholders at various scales as shown in Figure 1.4.

Aspect aspects provide a series of analytical 'lenses', which can be used, for example, for assessing the situation, determining feasibility, identifying priorities or setting adequacy criteria. For a waste management system to be sustainable it needs to consider all of the operational, financial, social, institutional, political, legal and environmental aspects.

2.6.2 Elements of sustainable solid waste management

ISWM is the linkages and interdependency between the various activities (elements), stakeholders and 'points of view' (sustainability aspects), as illustrated on Figure 2.5. Moreover, it suggests that technical, but also legal, institutional and economic linkages are necessary to enable the overall system to function.

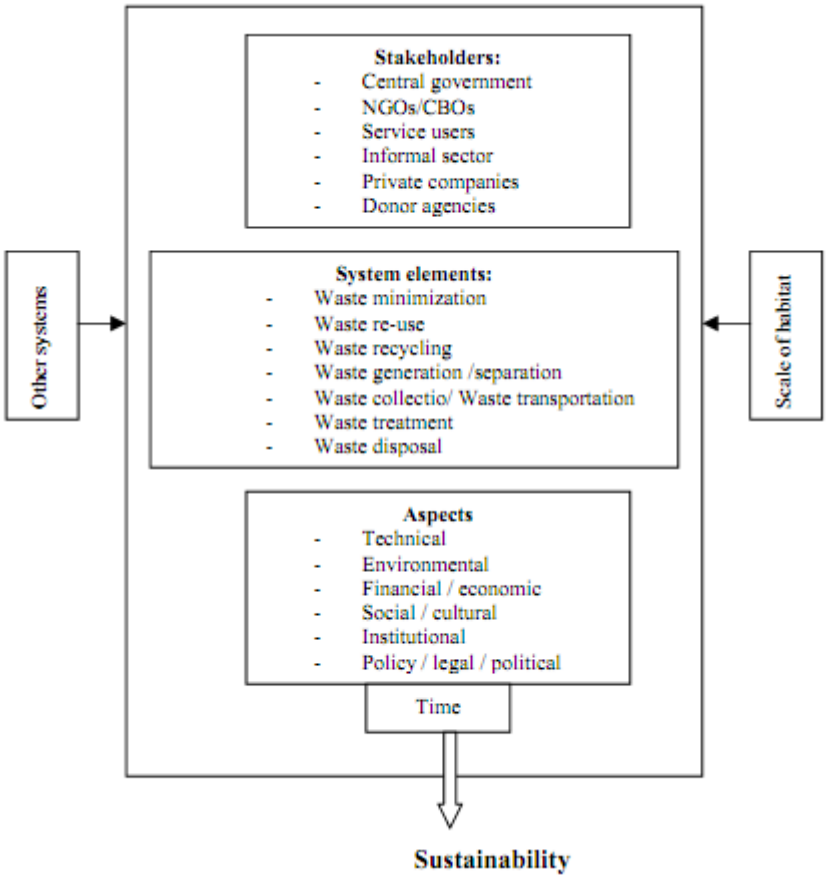


Figure 1.5: Elements of sustainable management of solid waste

Source: Zuilen, (2006, p.36)

2.6.3 Solid waste generation

This involves and the recognition of materials and substances that are no longer having any value and the designation of these for disposal. There a number of factors affecting solid waste generation as shown in Table 4. The factors shown in Table 4 are mainly physical and geographical factors. Consumption and production processes represent two major sources of waste although natural ecological cycles also generate some solid wastes. With the modern concept of "material loop closing" where the waste by- product of one consumption and or production process become the input material of another process, there is need to redefine what constitutes waste and subsequently the understanding of the waste generation.

Waste generation is greatly influenced by geographical and physical factors. These factors include; geographical location, season of the year, the use kitchen waste food grinders; waste collection frequency and the characteristics of the source area as shown on table 4. According to Johnson and Chenje (1998), main sources of waste are urban areas and major areas of development. Waste generators comprise households, industries, hospitals, and commercial and administrative establishments. MSW generation rates are influenced by economic development, the degree of industrialization, public habits, and local climate. Generally, the higher the economic development and rate of urbanization, the greater the amount of solid waste produced. Income level and urbanization are highly correlated and as disposable incomes and living standards increase, consumption of goods and services corresponding increases, as does the amount of waste generated. Urban residents produce about twice as much waste as their rural counterparts. The main reason for this variation can be attributed to less population density and the level of income or affluence.

According to Babanawo, (2006) waste generation is greatly influenced by geographic and physical factors shown on Table3. These factors include; geographic location, season of the year, the use of kitchen waste food grinders, waste collection frequency, and the characteristics of the service area. The interaction of these factors may result in land pollution in Kwekwe residential areas.

Table 4 Factors affecting waste generation

Geographic and Physical Factors	Impact on waste generation
Geographic location	This is important when different climatic regions and their impact on generation of yard and garden waste are considered.
Season of the year	The quantities of certain types of solid waste vary with seasons of the year. For example organic waste composition can increase considerable during fruit harvesting season
Use of kitchen food waste grinders	The use of kitchen food grinders normally reduces the amount of organic components of waste
Frequency of collection	When there is inadequate collection service in material recovery programs, some materials that otherwise would have been diverted, end up in materials disposed of as waste
Characteristics of service area	Within the same municipality, the amount of materials designated as waste is higher in wealthy neighborhoods than in poor neighborhoods.

Source: Babanawo (2006, p.36)

Wertz, (1976), Grossman (1974) and Medina (1997) have shown that the quantity of waste generated by a country is proportional to its population and the mean living standards of the people is related to the income levels of people hence individual household's waste generation is correlated. But in a study conducted by Bruvoll, (2001) to analyze the factors that influence waste handling and generation using the variables income and population density, it was found out that income did not influence the total solid waste generated in a municipality. The generation of household waste was found to be positively correlated with average family size, employment status, monthly income, educational level and number of room(s) occupied. This means that large quantities of solid waste were generated due to number of people in the family, number of people employed in the family, earning power of household members, their education, and the number of room(s) occupied by family members. Negative correlations were found between average age of family size and solid waste generation and between marital status and solid waste generation (Sankoh, 2012).

However, Nilanthi *at el.,* (2006) show that there is a positive correlation between income and waste generation. Dennison *at el.,* (1996) statistically analyzed the relationship between socioeconomic factors and waste generation and composition: that a clear waste difference existed between the more prosperous section in relation to the total and the individual components of the waste stream. The major factors affecting the amount and type of waste generated are household size, household age structure, household income, type of dwelling, geographical location and time of year (Rushbrook and Pugh, 1999).

2.6.3.1 Waste composition and income

Table 5 shows how the type of waste produced varies with in income levels. The low income residents produce more of organic waste and high income residents produce more of paper than any other wastes. The reason being that the low income group usually spends their income on consumable products such as vegetables, fruits and biodegradable food stuffs. The higher income earners normally buy wrapped food stuffs and they throw away the plastics and other non-biodegradables materials. Higher income earners also have a tendency of buying wrapped products which generate a lot of wastes in their residential areas.

Table 5 Income and waste composition produced in 2012 and 2025

Income level	**Organic (%)**		**Paper (%)**		**Plastic (%)**		**Glass (%)**		**Metal (%)**		**Other (%)**	
	2012	**2025**	**2012**	**2025**	**2012**	**2025**	**2012**	**2025**	**2012**	**2025**	**2012**	**2025**
Low	64	62	5	6	8	9	3	3	3	3	17	17
Lower Middle	59	55	9	10	12	13	3	4	2	3	15	15
Upper Middle	54	50	14	15	11	12	5	4	3	4	13	15
Higher Income	28	28	31	30	11	11	7	7	6	6	17	18

Source: Hoornweg, D. 2012

Total amount of organic waste tends to increase steadily as affluence increases at a slower rate than the non-organic fraction. Low-income countries have an organic fraction of 64% compared to 28% in high-income countries.

Residents in low income residential areas produce more organic waste because they are concerned with basic things such as food than high income residents in low residential areas that produces more papers as waste. The other waste refers to waste such as rubber, ash and textiles. Income level, economic growth and lifestyle have strong influence on Municipal Solid Waste (MSW) composition (Zhu *et al.,* 2008). Benjamin & Mansoor (2004) have revealed that MSW quantity and composition analysis is fundamental for the planning of municipal waste management services. Research by Hoornweg, *at el.,* (2012) shows that low income countries produce more organic wastes as indicated on table 4 , while high income countries has the bulky of their waste being paper from the current year to the future 2025 projections. This answers one of the research questions which seek to establish the relationship between income and the amount of waste produced. This regional representation of solid waste production can scaled down to city level to mean that low income residential areas in developing countries produce less waste than high income residential areas which produce more waste.

2.6.4 Generation and handling at source

This is based on population estimates and an estimated per capita waste generation. The general attitude of the people in handling the waste and indiscriminate waste disposal (dumping) is a serious cause for concern. Figure: 1.6 shows the stages of solid waste management in most developing cities.

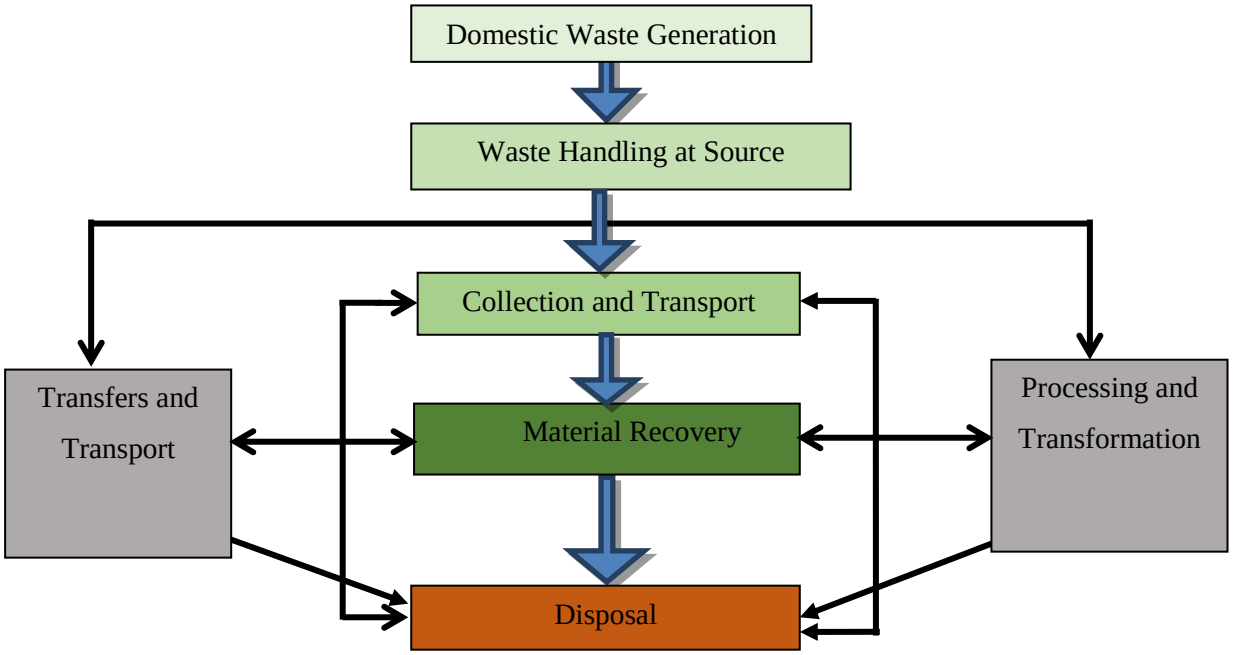


Figure 1.6: Functional elements of solid waste management

Source: Babanawo (2006, p.35)

2.6.5 Collection and transport

This involves not only the gathering of solid and recyclable materials, after collection to the location where the collection vehicles is emptied. At other households, collection can be done in cardboard boxes which are sometimes soaked by rain leading to waste spread all over the streets and sacks scavenged by stray dogs leading to littering especially in high density areas where houses have no durawalls and dogs move freely especially during the night. This is quite common in high density residential areas. Waste collection is one of important step involved in integrated waste management systems. It starts when containers are filled with refuse and ends when it is loaded into the collection vehicles.

There are many different collection systems that can be employed and these include simple emptying method, exchange method, one-way method, non-systematic collection, vacuum waste collection and scavenger force. The first four methods are based mainly on information after Bilitewski *et al.,* (1994). In Kwekwe the simple emptying method is used.

2.6.6 Informal collectors

Informal waste collectors are common in urban areas from developing countries.
They are individuals that collect recyclable refuse from streets, in commercial and residential areas and dumping areas (see Field photo 5). These people are poor and collecting and selling recyclables is their way of earning some income. According to one of the interviewee, he stated that they get US$30 to US$55 a month after selling their bales of waste materials especially plastics after transport costs from Kwekwe to Harare where there are recyclers.

The informal collectors can be organized into organizations or not, and they usually be responsible for collecting recyclable wastes such as cardboard, glass and aluminum cans. For the transport of the collected waste the scavengers commonly use carts that are pulled by themselves or by animals such as donkeys in the case of Kwekwe.

2.6.7 Storage

Solid waste storage facilities may be classified as primary (or individual) and secondary (or communal) storage facilities. Babanawo, (2006) pointed out that in developing countries, it is essential that storage facilities be as far as possible, animal proof, insect proof and weather proof, waste able and robust enough to meet the exigencies of normal use. This will greatly reduce the transmission of diseases from the bins to people and breeding of mosquitoes in the nearby storage facilities. The following factors are considered in the on-site storage of solid waste such as; type of container to be used, container location, public health and aesthetics and collection methods to be used.

To a large extent, the type and capacities of containers used, depends on the space available for the placement of containers. There may be many types of containers such as plastic containers, metal containers, rubber containers and concrete containers. But for household and curbside waste containers, the usual form is the plastic container and the lining used for this container is also the plastic bags. Field photo 9 shows the common types of bins used in most of Kwekwe residential areas.

2.6.7.1 Waste collection and income level

It is also important to note that the frequency of waste collection varies with income (Hoornweg *at el.*, 2012). In low income residential areas, the frequency of collection is very low and this can lead to land pollution in high density residential areas. In high income residential areas the frequency of collection is high and the residents can use their own vehicles to transport the waste to the dumpsites and they can also hire private waste collectors rather than waiting for the municipality to collect the waste. In the middle income earners the frequency of collection is average. This is supported by information on figure 1.7. The results shown below shown by Hoornweg *et al.* (2012) are a true reflection of what happens in the city of Kwekwe in all residential areas ranging from high density, medium density to low density residential

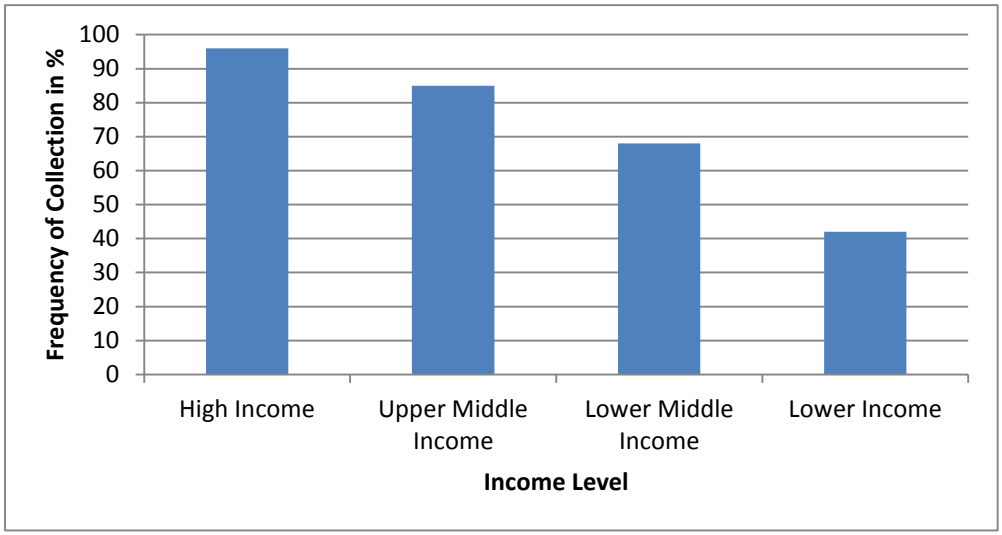


Figure 1.7: Frequency of waste collection varies with income

Source: Hoornweg *et al.* (2012)

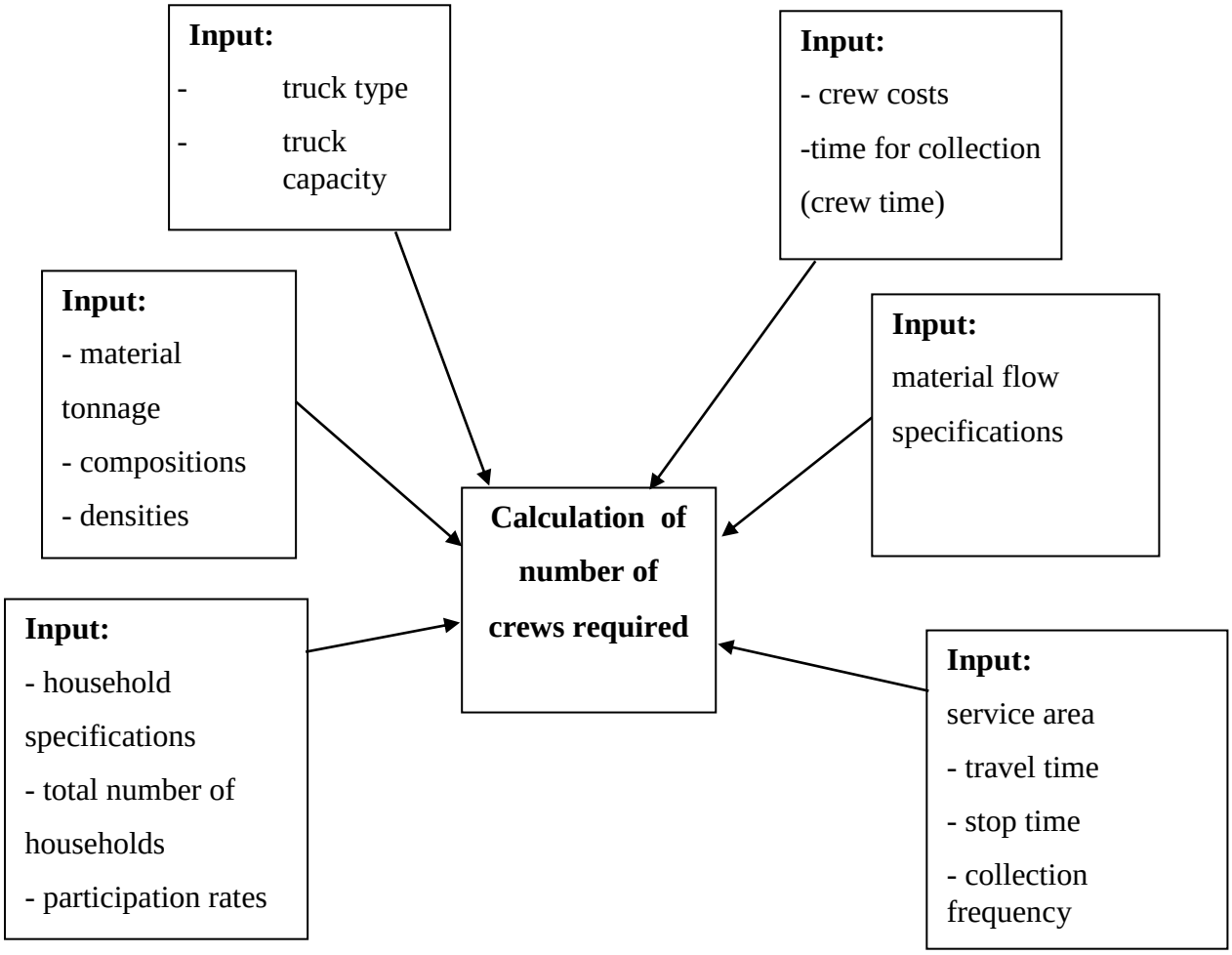
2.6.8 Transfers and transport

This involves the use of relatively small vehicles to convey waste materials to the central location for onward transport over extended distances. It is during this transfers and transportation when littering of streets and pavements occurs. The definition of transfer and transport refers to the means, facilities and appurtenances used to affect the transfer of wastes from small vehicles to large vehicles, and transport them over extended distances to either processing centres or to disposal sites. Transfer operations can be used successfully with almost any type of collection system.

The transport of collected waste is a major problem in developing countries. A high proportion of vehicle operating time is spent on transporting wastes to the disposal sites due to traffic and road conditions and a small payload. For overcoming such a situation, transfer stations should be introduced and the decision should hinge upon economics, the total cost of collection, direct haul and disposal. Transport of solid waste on highways should satisfy the following requirements:

i. Wastes must be transported at minimum cost.
ii. Vehicles must be designed for highway traffic.
iii. Wastes must be covered during haul operation.
iv. Method used for unloading must be simple and dependable.
v. Vehicle must be designed such that the allowable weight limit is not easily exceeded (Tchobanoglous *et al.*, 1993).

The input output model can be used to illustrate the costs incurred to achieve sustainable solid waste management as the one illustrated in Figure 1.8 For a successful collection of waste any municipality should consider the following costs involved in figure 1.8. The costs shown in Figure 1.8 are not usually considered by the Kwekwe Municipality hence inefficient in solid waste management leading to land pollution and environmental degradation in Kwekwe residential areas. There is no proper relationship between inputs and outputs in the solid waste management in Kwekwe.



Output:

- total cost
- truck size
- cost/ton
- cost per household
- tons handled per vehicle per year
- vehicle productivity
- labour productivity

Figure 1.8: Collection cost model to estimate the cost of collecting materials

Source: Ansems (1998); Bartone and Oliviera (1990)

Collection not only includes gathering of solid waste and emptying containers into a suitable vehicle for storage, but also hauling the waste after collection to the location where the collection vehicle is emptied. Collection is by far the largest cost element in most MSWM systems, accounting for 60-70% of costs in industrialized countries, and 70-90% of costs in developing and transition countries (UNEP/IETC, 1996).

2.6.9 Material recovery

Material recovery involves salvaging materials from the waste stream back to economic cycle. Scavengers, squatters and the street kids are the key players in this sector. The solid waste paper collectors in Harare, the capital city of Zimbabwe are rarely coming to collect the solid waste. Recovery or resource recovery is the extraction of economically usable material or energy from solid wastes. Reuse is the claim of material in form and its subsequent use in the same form, for e.g. returnable bottles. Recycling is more possible in developed countries, where settleable constituents comprise a higher fraction of collected wastes, wages are often too high to permit recovery, sorting and processing of these materials to be carried out profitably. In this case, private scavenging of solid wastes plays a vital role in the recycling process; see Field Photo 7 some of the scavengers are sorting waste material for recycling.

Fudery, (1990) defined that resource recovery/recycling is different between developed and developing countries. In developed countries, resource recovery is done mechanically and is institutionalized by the government, while in the developing countries, recycling operations are done by waste pickers or scavengers, with junk dealers, even without the encouragement and support by the government. It is noted also that most of the refuse scavenged for recycling, except paper, are non-biodegradable wastes such as plastics, glass, metal, bone, non-ferrous and ferrous materials.

A decentralized MSWM system is necessary in Third World cities to better respond to the needs of their residents. The proposed system recognizes the fact that low-income and middle / upper income neighbourhoods have different physical and socioeconomic conditions, and that the waste generated tends to be also dissimilar. Consequently, their needs diverge, and a decentralized system uses one approach for middle / upper-income areas, and another for low-income neighbourhoods.

Middle/upper income residents' lifestyle and consumption patterns tend to follow those of the developed world. In these areas, the methods and equipment for collection, transport and disposal used may resemble those of the industrialized countries. Middle / upper income neighbourhoods generally have wide, paved streets that allow conventional trucks to enter and collect the wastes generated there. Private communities and apartment complexes commonly use dumpsters that require trucks equipped with a hydraulic mechanism to load the wastes into the collection vehicles. The Not-In-My-Backyard Syndrome (NIMBY) is likely to be stronger in middle / upper income communities than in their low-income counterparts. This translates into strong opposition to the siting of any MSWM handling or disposal facility around their communities, necessitating a centralized approach. Wealthier communities are mostly concerned with having their wastes picked up, removed from and disposed of outside their neighbourhoods, preferably at a distant dump.

Low-income areas, such as Mbizo, Amaveni, Stewards and Roasting Plant, however, require a different approach, nearly opposite to the conventional solutions. Slums require decentralized solutions that actively involve the community in the decision-making process, that are low-tech and affordable, and that consider the contribution that informal refuse collectors and scavengers can make to solve the problem of MSW in Third World cities.

The first step towards improving the collection and disposal of MSW requires finding out what informal activities around waste already exist: the number and importance of informal refuse collectors and scavengers. A study employing a joint qualitative / quantitative methodology should be used. In order to identify and analyse the existing patterns in informal refuse collection and scavenging, observation and participant observation of these activities is important.

The second step in the process involves an analysis of how informal refuse collection and scavenging could be improved, which involves setting minimum standards of service and incentives for achieving those standards. For example, some informal refuse collectors simply dump the wastes they collected at their earliest convenience, in vacant areas or by the side of the road. Incentives would be necessary to prevent illegal dumping. Informal collectors, scavengers and the communities should be consulted on their perceptions of

how MSWM could be improved in their communities, as well as the residents' willingness to pay for waste collection.

The third step in the process is the promotion and support of grassroots development efforts involving informal refuse collectors and scavengers. Each community would be responsible for collecting its own wastes. Informal refuse collectors would continue operating in the areas where they already work, and their activities would be monitored by the communities, the authorities or by NGOs. In areas that lack both informal and municipal refuse collection, small loans could be made to individual entrepreneurs or to groups of informal collectors organized as cooperatives to purchase locally made collection vehicles. Another possibility is the formation of public-private partnerships between authorities and informal refuse collectors / scavengers so that, for example, collectors pick up the wastes and take them to a transfer station, from which the municipality takes over for final disposal.

2.6.10 Disposal

According to Tchobanoglous *et al.*, (1993), he cited four major ways of disposal and these are composting, incineration, landfilling and recycling. In Kwekwe, the most common type of waste disposal is crude dumping and no incineration and coordinated recycling. Financial and institutional constraints are the main reasons for inadequate disposal of waste especially were local governments are weak or underfinanced and rapid population growth. Financing of safe disposal of solid waste poses a difficult problem as most people are not willing to pay for the removal of the refuse from their immediate environment but then "out of sight – out of mind" are generally not concerned with its ultimate disposal. This is common in the high density residential areas. The present disposal situation is expected to deteriorate even more as with rapid urbanization settlements and housing estates now increasingly encircle the existing dumps and the environmental degradation associated with these dumps directly affect the population.

2.6.10.1 Alternatives of solid waste disposal by region

Most of the municipal solid waste (MSW) in developing countries is dumped on land in a more or less uncontrolled manner as indicated in the Figure 1.9. 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. This may explain the cause of land pollution in developing countries especially low income residential areas in small towns and cities. The level of economic development and income level can reflect on the disposal method used and its affordability of other sustainable methods safe disposal method.

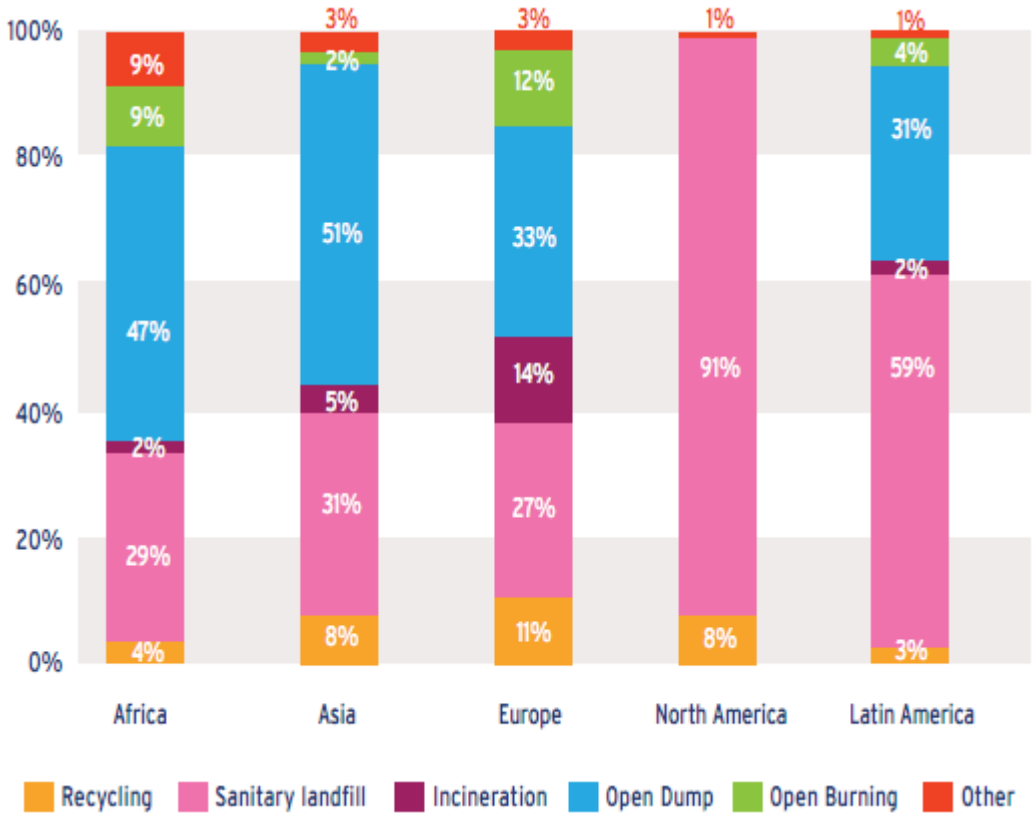


Figure 1.9: Variations in waste disposal methods by regions

Source: World Bank (2012)

Waste disposal sites are also subject to growing opposition and it is becoming increasingly difficult to find new sites which find public approval and which are located at a reasonable distance from the collection area. Siting landfills at greater distances to the central collection areas implies higher transfer costs as well as additional investments in the infrastructure of roads hence intensifying the financial problems of the responsible authorities. In addition to all this, an increase in service coverage will even aggravate the disposal problem if the amount of waste cannot be reduced by waste recovery.

Other reasons for inadequate disposal are the mostly inappropriate guidelines for sitting, design and operation of new landfills as well as missing recommendations for possible upgrading options of existing open dumps. Many of the municipal officials think that uncontrolled waste disposal is the best that is possible. Often the only guidelines for

landfills available are those from high-income countries. These are based on technological standards and practices suited to the conditions and regulations of high-income countries and do not take into account for the different technical, economic, social and institutional aspects of developing countries. The safe alternative, a sanitary landfill, is a site where solid wastes are disposed at a carefully selected location constructed and maintained by means of engineering techniques that minimize pollution of air, water and soil, and other risks to man and animals. Loans or grants to construct sanitary landfills do not necessarily result in sanitary landfill disposal. Equally important as site, location and construction is well trained personnel and the provision of sufficient financial and physical resources to allow a reasonable standard of operation, if this is not given good sites can quickly degenerate into open dumps.

2.6.10.2 MSW disposals varies according to country income level

Table 6 shows how MSW disposal varies according to country income level

Table: 6 Variation of MSW disposal with income levels

High Income		Upper Middle Income	
Dumps	0.05	Dumps	44
Landfills	250	Landfills	80
Compost	66	Compost	1.3
Recycled	129	Recycled	1.9
Incineration	122	Incineration	0.18
Other	21	Other	8.4
Low Income		**Lower Mid dle Income**	
Dumps	0.47	Dumps	27*
Landfills	2.2	Landfills	6.1
Compost	0.05	Compost	1.2
Recycled	0.02	Recycled	2.9
Incineration	0.05	Incineration	0.12
Other	0.97	Other	18

Source: Hoornweg, *at el.* (2012)

The amount of litter is influenced by the size of the household to a larger extent. There is a need to avoid littering by also setting a cap to the number of people who can occupy a housing unit. Zuilen (2006) reported that with rising incomes, urbanization and little or no waste diversion, it is being projected that the quantity of solid waste generated will continue to increase and that the amount of waste generated is positively related to

income. The validity of this assertion will be applied to studies in Kwekwe about solid waste generation and patterns of disposal.

Although from a consumptive side, low income residents do not generate a lot of waste, it also affects the capacity of residents to pay for municipal rates and levies that are meant to be channeled towards waste collection and disposal, Zuilen, (2006). The inability of residents to pay municipal rates and levies violates two environmental principles, that is, User Pays Principle (UPP) and Polluter Pays Principle (PPP) leading to land pollution. This is common in the high density residential areas of Mbizo and Amaveni of Kwekwe. The Municipality of Kwekwe reported that there are a number of residents who owe large sums of money in terms of rates and hence it stifles the collection and transport of wastes in high density residential areas.

2.7. Physical, chemical and biological waste processing and transformation

Solid waste can be transformed by physical, chemical and biological properties of the solid waste. Processing of solid waste can bring about the following (Babanawo, 2006):

i. Recover conversion products and energy;
ii. Recover materials for use and recycling;
iii. Improve the efficiency waste disposal management and,
iv. Reduce the volume and weight of weight of waste requiring disposal

Physical processes of waste transformation involves component separation, mechanical volume reduction and mechanical size reduction. This may also involve the separation of hazardous from food and organic waste which is important for biological transformation into other useful products. Volume reduction involves the use of pressure to reduce the initial volume occupied by any waste material. Some other modern vehicles are equipped with compaction mechanism. This exercise is important and applied to waste materials to obtain a final product that is reasonably uniform and considerably reduced in size.

`

Chemical transformation involves a change in the phase (e.g. solid to liquid, solid to gas). The main chemical transformation processes are combustion (chemical oxidation), pyrolysis and gasification. *Pyrolysis:* In pyrolysis, the organic fraction of MSW is degraded under pressure and in the absence of oxygen at temperatures ranging from 500-

1000ºC. This process produces solid (char), liquid (pyrolysis oil), and gaseous (syngas) products(*http://www.mbt.landfillsite.com/Pyrolysis___Gasification/pyrolysis___gasification.html*, Accessed, August, 2013).

Gasification: Gasification is the process of converting MSW at higher temperatures than that of pyrolysis and in the presence of limited oxygen to produce syngas (synthetic gas of hydrogen and carbon monoxide *(http://www.(p2pays.org/ref1110516/gas.html)*. Pyrolysis and gasification are similar thermal processes of treating MSW. They differ from incineration because they limit the conversion of MSW to form intermediates, instead of combusting the MSW directly, that are then used for energy recovery. (*http://www.wastereports.com/information)*. Pyrolysis and gasification are more expensive than combustion.

The chemical composition of each type of waste contributes major part in designing disposal facilities because some wastes cannot be treated as compared to other wastes. Chemical composition of the solid waste is important to enable one to assess what type of disposal method is to be carried out, especially with plastics, which are originally non-biodegradable in nature. Solid waste is a heterogeneous mixture of wastes. The average chemical composition of the waste varies from place to place depending upon the type of waste, economy, climate, social and cultural activities etc. Some of the waste chemical characteristics to be considered are the proximate analysis involves moisture content , volatility matter, ash content and fixed carbon content after pyrolysis. The fusing point of ash is also important to consider when transforming wastes especially through burning method. The ultimate analysis of wastes assess the percent of C (carbon), H (hydrogen), O (oxygen), N (nitrogen), S (sulphur) and ash . Finally one important characteristic of wastes is the energy content (low and high calorific value) (Joules). These characteristics are important when considering chemical transformation of the wastes.

Biological transformation is used in processing the organic fraction of municipal solid waste. The main processes are aerobic composting, anaerobic digestion and high solid anaerobic digestion. Pre–processing may be important and this involves sorting, screening, sieving, compaction, and densification, size reduction, washing and drying. Pre-processing is preparing recoverable materials from the waste stream to be used for subsequent processing without adding significant value to them. Processing and treatment is a technique to improve efficiency of SWM systems and to recover resources whether it is a usable material conversion product or energy. There are various methods for treatment out

of which incineration and composting are most widely used. By incineration, volume of waste to be disposed is reduced, whereas, by composting of wastes, organic soil substitutes can be recovered. Final disposal of each type of waste is one of the most important issues in MSW systems. It may be slightly easier to handle food and other non-hazardous wastes, but for hazardous and non-biodegradable wastes such as plastics, it becomes a lot more complicated.

2.8 The hierarchy of solid waste management

The solid waste hierarchy is an internationally accepted and recommended ranked priority of waste handling using the following order of preference: open dumping, dump, landfill, incinerate, recycle, reuse, prevent (Beukering *et al.*1999; Adams *et al*. 2000; Wright, 2000; Hansen *et al.* 2002). The first two (open burning and dump) are least preferred and actually not recommended even though the methods are highly used by many developing countries as shown on Fig: 2.1. This results in land pollution in urban areas especially in residential areas with high population densities.

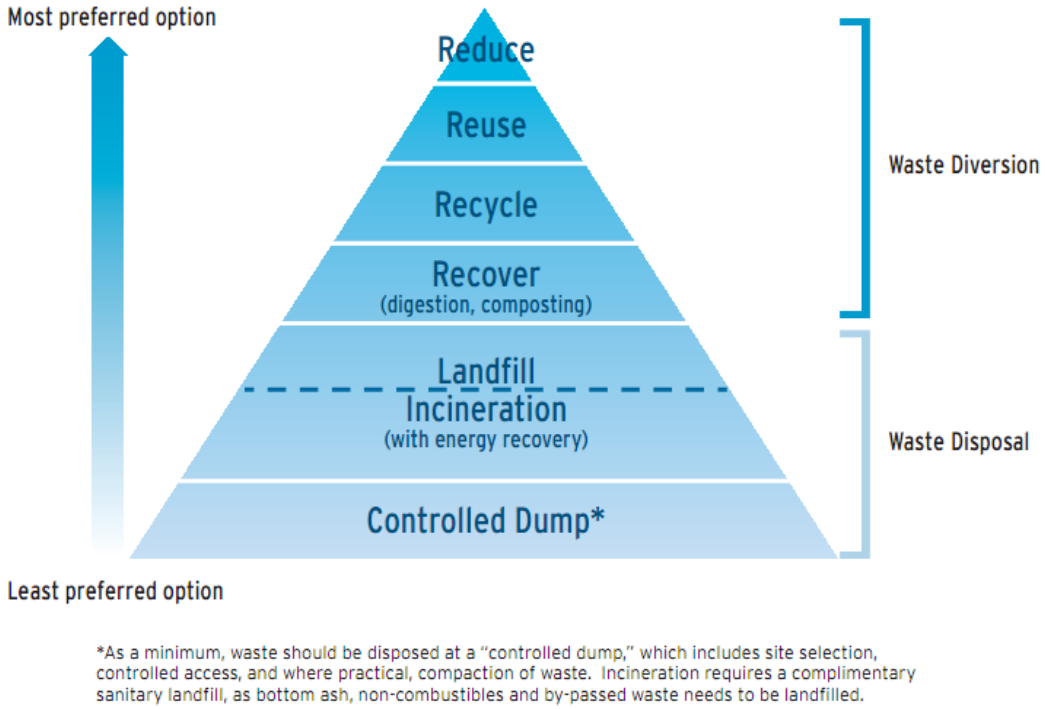


Figure 2.1: Solid waste management hierarchy

Source: Hoornweg and Bhada Tata (2012, p.27)

An integrated approach to waste management consists of a hierarchical and coordinated set of actions (Medina 2002). This approach seeks to reduce pollution, maximize recovery of reusable and recyclable materials, and protects human health and the environment. It will take into account community and region specific issues and needs and formulate an integrated and appropriate set of solutions "unique to each context" (Daskalopoulos *et al.*, 1998, Medina 2002, Zerbock 2003). Medina (2002, p. 17) states that "integrated waste management aims to be socially desirable, economically viable and environmentally sound".

According to USEPA (1997), no single solid waste management approach is perfect. Some waste cannot be successfully recycled, composted, or converted to energy. In addition, some waste will always need to be landfilled, along with any residues from recycling, composting, and waste-to-energy (WTE). It is important that a waste management option is chosen for the waste and not vice-versa. Some of the prevailing environmental legislation creates such a situation, in which we are forced to assign waste that shall be treated by the prescribed way, even if it is not the best-preferred option to treat the waste (Pongrácz, 2002).

The implementation of a promising waste management plan considering the above-mentioned options requires information related to waste composition and physical and chemical characteristics. Considering each of the above mentioned waste management options it is obvious that some of them are not affected by waste composition, while some others are heavily depending on it. The extent to which any one option is used within a given country however varies largely depending on a number of factors such as topography, population density, transportation, infrastructure, socio-economic and environmental regulations (Koufodimos and Samara, 2002; Bai and Sutanto, 2002). The success of the first three options of the waste hierarchy in developing countries is almost entirely dependent on the behavior of the citizens and the flourishing of the informal waste sector. Only the last two options are the ones that often require expensive technical equipment and are mostly under the jurisdiction of waste authorities. The hierarchy responds to financial, environmental, social and management considerations. The hierarchy also encourages minimization of GHG emissions.

Waste management can be used to describe several distinct processes: the elimination or reduction of waste; the recycling or reuse of waste material; the treatment or destruction of

waste (physically destroying, chemically detoxifying, or otherwise rendering waste permanently harmless); and disposal of waste (depositing the material into the air, water, or land). Environmental regulations have not necessarily channeled industry efforts toward the optimum choice of waste management techniques – pollution prevention. Recycling, reuse, and treatment seem to be the industry's preferred waste minimization options, even though such methods pose more environmental risks than pollution prevention. The hierarchy also encourages minimization of GHG emissions. Table 7 shows a comparison of solid waste management practices by income level.

2.8.1 Reduce, reuse and recycle

Source reduction is defined as the prevention of waste at its source by redesigning products or changing patterns of production and consumption. The definition refers to the reduction of either toxicity, volume, or weight of a material used in a product, the increase in the lifetime of a product, the substitution of reusable products for single use ones or the reduction in the overall consumption of goods (Lober,1996). The recovery of materials from waste is very dependent on economic factors.

Manufacturing costs from secondary materials are high or often higher than those from virgin materials. Only high quality materials can find a ready market. Recycling is defined) as a process of transforming recovered and sorted material into intermediate materials (such as crushed glass or ground or extruded plastic) or into final products for consumer or industrial use (Haan, 1998). Waste avoidance, waste reduction, and recycling, are the principles by which the industrialized and developed countries apply when they try to reduce their high amount of refuse. Each of the processes will directly or indirectly affect the volume, weight, composition, and economy of solid waste.

The term reuse has been employed to convey the meaning such as, further use or to use again. For the study purpose "Recycling" is considered for utilizing one or more of the components from discarded or waste material and "Reuse" is used for further use or to use again and again of material without going into its original manufacturing process. There are many ways of defining the meaning of reuse and recycling according to the practices and perceptions. The following are the concepts by Sykes (1978) and Lund (2001):

i. Reuse of a product, without alteration, to serve the purpose for which it was initially intended (e.g. refilling soft drink bottles).

ii. Reuse of a product, without alteration, to serve a purpose other than that for which it was initially intended (e.g. using old clothes as rags).

iii. Reprocessing of materials incorporated in a product to produce new products of the same type (e.g. using crushed glass bottles to manufacture new glass bottles).

iv. Reprocessing of materials incorporated in a product to produce new products of a different type (e.g., using worn out rubber tires in the production of road surfacing material).

"Recycle" and "Reuse" is the key element of an integrated waste management system. Recycling and reusing materials reduces the flow of materials into the solid waste stream and hence reduces the costs associated with the collection and disposal.

.

Table 7 Comparison of solid waste management practices by income level

Activity	Low income	Middle income	High income
Source Reduction	No organized programs, but reuse and low per capita waste generation rates are common	Some discussion of source reduction, but rarely incorporated into an organized program	Organized education programs emphasize the three 'R's. More producer responsibility and focus on product design
Collection	Sporadic and inefficient. Service is limited to high visibility areas, the wealthy, and businesses willing to pay. High fraction of inerts and compostable impact collection—overall collection below 50%	Improved service and increased collection from residential areas. Larger vehicle fleet and more mechanization. Collection rate varies between 50 to 80%. Transfer stations are slowly incorporated into the SWM system.	Collection rate greater than 90%. Compactor trucks and highly mechanized vehicles and transfer stations are common. Waste volume, a key consideration.
Recycling	Although most recycling is through the informal sector and waste picking, recycling rates tend to be high both for local markets and imports of materials for recycling, including hazardous goods. Recycling markets are unregulated and include a number of 'middlemen'.	Informal sector still involved; some high technology sorting and processing facilities. Recycling rates are still relatively high. Materials are often imported for recycling. Recycling markets are somewhat more regulated. Material prices fluctuate considerably.	Recyclable material collection services and high technology sorting and processing facilities are common and regulated. Increasing attention towards long-term markets.
Composting	Rarely undertaken formally even though the waste stream has a high percentage of organic material. Markets for, and awareness of, compost lacking	Large composting plants are often unsuccessful due to contamination and operating costs (little waste separation); some small-scale composting projects at community level are more sustainable. Increasing use of anaerobic digestion.	Becoming more popular at both backyard and large-scale facilities. Waste stream has a smaller portion of compostable than low- and middle-income countries. More source segregation makes composting easier. Anaerobic digestion increasing in popularity.
Incineration	Not common, and generally not successful because of high capital, technical, and operation costs, high moisture content in the waste, and high percentage of inerts	Some incinerators are used, but experiencing financial and operational difficulties. Air pollution control equipment is not advanced and often by-passed. Little or no stack emissions monitoring. Governments include incineration as a possible waste disposal option but costs prohibitive.	Prevalent in areas with high land costs and low availability of land (e.g., islands). Most incinerators have some form of environmental controls and some type of energy recovery system. Governments regulate and monitor emissions.
Landfilling/ Dumping	Low-technology sites usually open dumping of wastes. High polluting to nearby aquifers, water bodies, settlements. Often receive medical waste Waste regularly burned. Significant health impacts on local residents and workers.	Some controlled and sanitary landfills with some environmental controls. Open dumping is still common. CDM projects for landfill gas are more common.	Sanitary landfills with a combination of liners, leak detection, leachate collection systems, and gas collection and treatment systems. Post closure use of sites increasingly important, i e.g. golf courses and parks.
Costs	Collection costs represent 80 to 90% of the municipal solid waste management budget. Waste fees are regulated by some local governments, but the fee collection system is inefficient. Only a small proportion of budget is allocated toward disposal.	Collection costs represent 50% to 80%of the municipal solid waste management budget. Waste fees are regulated by so local and national governments, more innovation in fee collection, e.g. include in electricity or water bills. Expenditure on more mechanized collection fleets disposals is higher than in low-income countries.	Collection costs can represent less than 10% of the budget. Large budget allocations to intermediate waste treatment facilities. Up front community participation reduces costs and increases options available to waste planners (e.g., recycling and composting).

Source: Hoornweg and Bhada-Tata (2012, p.5)

2.8.2 Importance and benefits of recycling and reusing are listed as follows:

• Conservation of natural resources by utilizing waste energy.

• It improves the environment from negative impacts of solid waste dumping by reducing the amount of solid wastes.

• The use of recycled materials appears to result in a reduction in energy consumption and pollution compared with the use of virgin materials.

• Benefits on public utilities such as affordable market prices for recycled materials.

• Reduces medical expenses from possible negative impact of dumping and less pollution emission.

• Helps to establish industries of secondary materials.

• Generate income to the society because of market value of waste materials.

• Facilitate employment opportunities for people in a country like scavengers, junk men, middlemen, etc.

• Reduces the amount of waste that has to be imported, by producing secondary raw materials.

• Economic development from industrial establishments, levy collection, employment generation

According to HABITAT (1992), recycled materials have a lower environmental impact compared to the new products. For instance, the recycling of paper means a lesser demand for wood, which means lesser cutting of trees and a possibility for a sustainable use of the forests. The saving of resources has an important economic advantage since it saves foreign exchange and resources that are generated within the country. An added advantage of recycling is the lesser demand for energy in the production process.

2.8. 3 Digestion aerobic composting and anaerobic digestion

Composting with windrows or enclosed vessels is intended to be an aerobic (with oxygen) operation that avoids the formation of methane associated with anaerobic conditions (without oxygen). When using an anaerobic digestion process, organic waste is treated in an enclosed vessel. Often associated with wastewater treatment facilities, anaerobic digestion will generate methane that can either be flared or used to generate heat and/or electricity. Generally speaking, composting is less complex, more forgiving, and less costly than anaerobic.

2.8.4 Composting

Composting is a controlled natural process of decomposition of organic waste material.
It reduces the cost of waste disposal, minimize nuisance potential, and produce a clean and readily marketable finished product. Composting helps to increase the recovery rate of recyclable materials. Non-hazardous, putrescible solid wastes such as crop residues, leaves, grass and animal manures can be managed onsite by composting. Composting is a controlled process in which this type of waste is collected in an open pit or heap and is decomposed by natural biological processes. The waste is broken down by the action of a variety of microscopic and other small organisms. The waste is converted into a stabilized material that can be used as fertilizer. Composting is an environmentally friendly way of recovering value from organic waste.

Lohani (1984) indicated there are several arguments in favor of composting as a resource recovery option particularly suitable for developing countries, and these could be: simple technology, process is readily adaptable to local conditions, only a small amount of residue is left to be disposed of, compost has a low toxic substance burden, composting meets requirement concerning hygiene and refuse composition is appropriate for composting.
There are at least five conditions that are necessary for the successful operation of composting projects. These are suitability of wastes, market for the product near the compost source, support from government authorities, particularly those responsible for agriculture, price of the product which is applicable to most farmers and net disposal cost which can be sustained by local authorities.

Despite the relative simplicity of composting, its suitability for developing countries, and compelling economic and environmental benefits, several projects initiated over the past have failed due to technical, financial, and institutional reasons such as lack of appropriate technology and mechanical breakdown accompanied by poor maintenance. The operators do not have the skills and expertise to come up with sustainable compost; this is also the situation in Kwekwe. Lack of cooperation from public, municipal government and agriculture, poor quality feed stock waste, offensive odor emissions and high operating costs are some of the challenges that are encountered. Insufficient focus on management and poor marketing plans for the end product stifles this attempt.

Many composting facilities are designed to process high-quality waste consisting primarily of organic matter. Often the waste arriving at the composting facility is mixed municipal solid

waste which requires more energy to process, causes mechanical breakdowns, and reduces the quality of the final compost. Source separated organic waste is the preferred feedstock since contamination by plastics, glass, metals, and household hazardous materials is minimized. The principle source of heavy metals in MSW is often common domestic products such as batteries (mercury, cadmium, lead, zinc), leather (chromium), paints (chromium, lead, cadmium), plastics (cadmium, lead, nickel), light bulbs (lead), fluorescent lamps (mercury), paper (lead), consumer electronics (lead, cadmium), ceramics (lead, cadmium), cosmetics (cadmium, zinc), and dust from sweeping (Bertoldi, 1993; Richard *et al.*, 1993).

Households can compost their organic waste for their own use. In composting, micro-organisms decompose organic materials under certain conditions and reduce waste significantly. Composting can be applied at various scales from individual household up to large controlled facilities. Compost can be sold or even given for free to farmers in the neighbourhood. Biodegradable waste like food and yard waste from households, institutions and small businesses can be reduced via composting thus minimizing their impact on the environment. It has been argued that mechanical biological treatment (MBT) can reduce the volume of waste by 40%. This process entails a group of hybrid methods where re-assorted waste undergoes pre-treatment before disposal in landfills. MBT includes mechanical separation where recyclables like plastics and ferrous metals are removed and the organic fraction gets biologically treated. If the treated, waste may end up containing low levels of pollution. It can then be used for landscaping instead of being disposed in a dumpsite. Overall, composting produces a pathogen-free residual product that can be used for improving soil structure and the soil's water–holding capacity or adding nutrients to the soil.
Composting residuals can be used as a resource for households or municipal governments if farmers are prepared to pay for the compost. Risks such as bad smell, release of greenhouse gases and vector-borne diseases can occur if not properly managed. Composting is neither complicated nor an economically unrealistic alternative compared to dumpsites. Composting can be labour intensive and therefore generate more jobs. It too requires low investment making it particularly attractive and suitable to introduce at very small scales. It is highly suitable for community driven waste management initiatives (Barton *et al.*, 2008).

Composting reduces volume of waste to the landfill or incinerator, and emission of methane.
By composting, a significant contribution could be made towards the closing of a valuable nutrient material cycle. In most developing countries, lack of economic and environmental

motivation means that it will be very difficult, if not impossible, to explicitly promote source separation of compostable materials.

From waste management, many varied issues arise and these have multifarious and far-reaching effects on the environment such biological, chemical, physical etc. For example, decomposition of organic waste under anaerobic conditions in solid dumpsites leads to the formation of biogas consisting of 50% methane, a potent green- house gases (GHG), (IGPCC, 2006). Government should formulate and implement policies for environmental protection. Common problems for municipal solid waste management in LDCs like Zimbabwe include institutional deficiencies, inadequate legislation, resource constraints while short and long term planning are inadequate due to capital and human resources limitations. There is need for financing Municipal Solid Waste Management, training specialists and capacity building.

2.8.5 Reasons for hierarchy's limitations

Bartelings (2003) and Martin (2003) highlight the following SWM:

i. Severe disruption of existing scrap markets: saturated secondary-materials markets and marginal or negative returns;
ii. The rapid conversion of the solid-waste stream into a commodity stream: large service corporations, with greater access to capital, markets, and political influence, enjoyed a decided competitive advantage;
iii. The creation of relatively abundant and inexpensive state-of-the-art disposal capacity: as the volume of wastes flowing to local landfills and incinerators began to ebb through recycling, operators will face with the crisis of excess capacity, declining revenue streams, and unmet debt service thereby decreasing the disposal fee below the recycling cost;
iv. In general principle, socioeconomic changes, as well as significant advances in science and technology, have not been incorporated;
v. Implementing the waste management hierarchy system can be very expensive
vi. The first priority, to reduce the amount of waste, is in general accepted.

However, the other options for taking care of the remaining waste are still the topic of discussions (Finnveden *et al.*, 2005).

2.9 Global waste generation per capita

Research by Hoornweg, *at el.*, (2012) shows that low income countries produce more organic

wastes as indicated while high income countries has the bulky of their waste being paper from the current year to the future 2025 projections. This answers one of the research questions which seek to establish the relationship between income and the amount of waste produced. This regional representation of solid waste production can scaled down to city level to mean that low income residential areas in developing countries produce less waste than high income residential areas which produce more waste. Table 8 shows that as income increases, the per capita generation of solid waste also increases.

Table 8 Waste generation per capita from low, middle and high income countries

Waste generation (kg/capita/day)	**Low income**	**Middle income**	**High income**
Mixed urban waste – large city	0.50 to 0.75	0.55 to 1.1	0.75 to 2.2
Mixed urban waste medium-sized city	0.35 to 0.65	0.45 to 75	0.65 to 1.5
Residential waste only	0.25 to 0.45	0.35 to 0.65	0.55 to 1.0

Source: Cointreau *et al.* (2000).

Table 8 shows a positive correlation between solid waste generation per capita per day and the income earned. Table 8 again answers one of the objectives stated in chapter one. The above table figures can also be used to suggest that even in developing countries, high income earners produce more solid waste and low income earners produce less wastes. Income level, economic growth and lifestyle have strong influence on Municipal Solid Waste (MSW) composition (Zhu *et al.,* 2008). Benjamin and Mansour (2004) have revealed that MSW quantity and composition analysis is fundamental for the planning of municipal waste management services. Beukering and Sehker (1999) also reported that a positive relationship existed between income levels and waste generation at the household level. Table 7 below shows how income affects various activities of SWM which may result in land pollution in developing cities.

2.9.1 Waste generation and urbanization

There is a positive relationship between waste generation and the rate of urbanization. As the number of people increase in urban areas and the subsequent infrastrural growth of the city, the amount of wastes generated also increase as shown in Table 9.

Table 9: Amount of waste generation and rates of urbanization

Region	Current Available Data			Projections for 2025			
	Total Urban Population (millions)	Urban Waste Generation		Projected Population		Projected Urban Waste	
		Per Capita (kg/capita/day)	Total (tons/day)	Total Popula-tion (millions)	Urban Popula-tion (millions)	Per Capita (kg/capita/day)	Total (tons/day)
AFR	260	0.65	169,119	1,152	518	0.85	441,840
EAP	777	0.95	738,958	2,124	1,229	1.5	1,865,379
ECA	227	1.1	254,389	339	239	1.5	354.810
LCR	399	1.1	437,545	681	466	1.6	728,392
MENA	162	1.1	173,545	379	257	1.43	369,320
OECD	729	2.2	1,566,286	1,031	842	2.1	1,742,417
SAR	426	0.45	192,410	1,938	734	0.77	567,545
Total	2,980	1.2	3,532,252	7,644	4,285	1.4	6,069,703

Source: Hoornweg and Bhada Tata, (2012) p.10.

As standards of living and disposable incomes increase, consumption of goods and services increases, which results in a corresponding increase in the amount of waste generated, (World Bank, 2012). The actual per capita rates, however, are highly variable, as there are considerable differences in waste generation rates across countries, between cities, and even within cities. Wealthier individuals consume more than lower-income ones, which result in a higher waste generation rate for the former. Income and household size are the most significant factors affecting the quantity of solid wastes from household consumption (Richardson & Havlicek, 1974). Visvanathan and Trankler (2003) reported that in a family with rich socioeconomic condition, daily waste generation rates were generally higher than the lower socioeconomic families. This justification agrees with one of the hypothesis that, "Pollution is the prize of progress" as put forward by Guinness, and Nagle, (2012). Figure 2.2 shows waste generation rates of urban population by income in 2010 and 2025 projections.

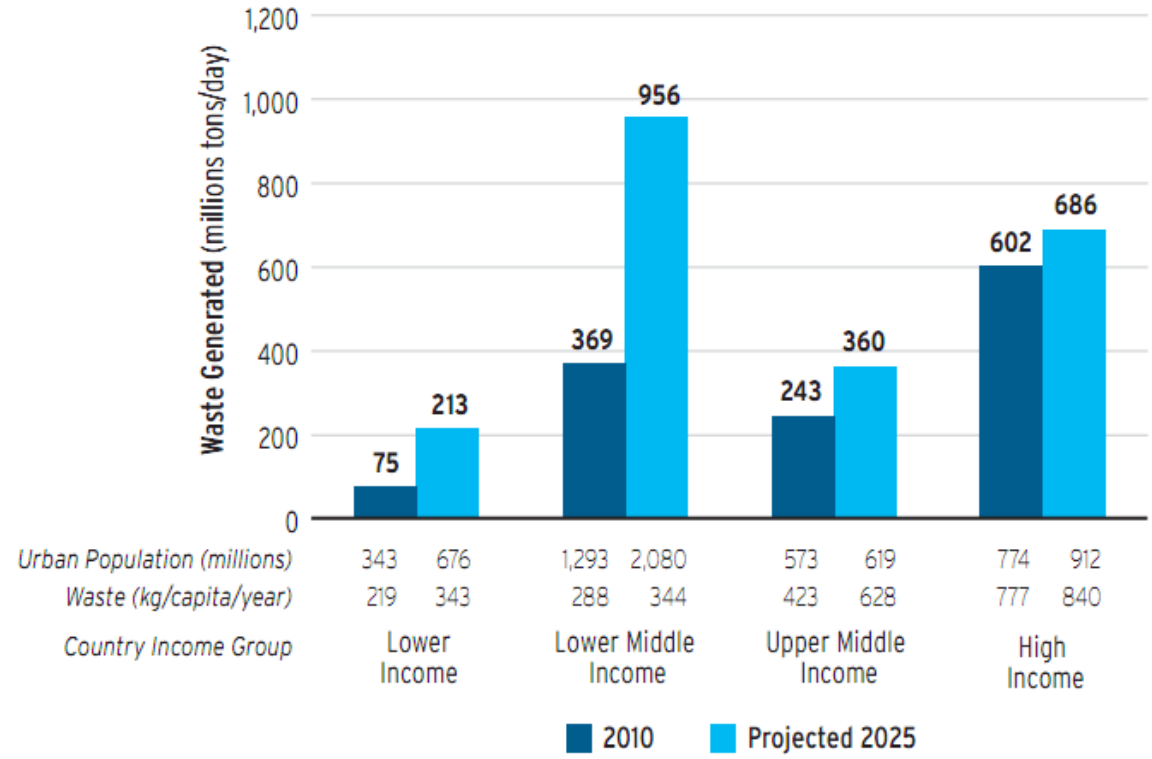


Figure 2.2 Urban waste generation rates by income

Source: Hoornweg, and Bhada-Tata (2012, p.10)

2.10 The environmental Kuznets curve

The environmental Kuznets curve (EKC) is a hypothesized relationship between various indicators of environmental degradation and income per capita. In the early stages of economic growth degradation and pollution increase, but beyond some level of income per capita, which will vary for different indicators, the trend reverses, so that at high income levels economic growth leads to environmental improvement, Crossman and Krieger, (1992). This implies that the environmental impact indicator is an inverted U-shaped function of income per capita.

This hypothesis postulates an inverted-U-shaped relationship between different pollutants and per capita income, i.e., environmental pressure increases up to a certain level as income goes up; after that, it decreases. An EKC actually reveals how a technically specified measurement of environmental quality changes as the fortunes of a country change. A sizeable literature on EKC has grown in recent period. The common point of all the studies is the assertion that the environmental quality deteriorates at the early stages of economic development/growth and subsequently improves at the later stages. The environmental

Kuznets curve (EKC) shows the correlation between income and household waste generation (Fig: 2.3).

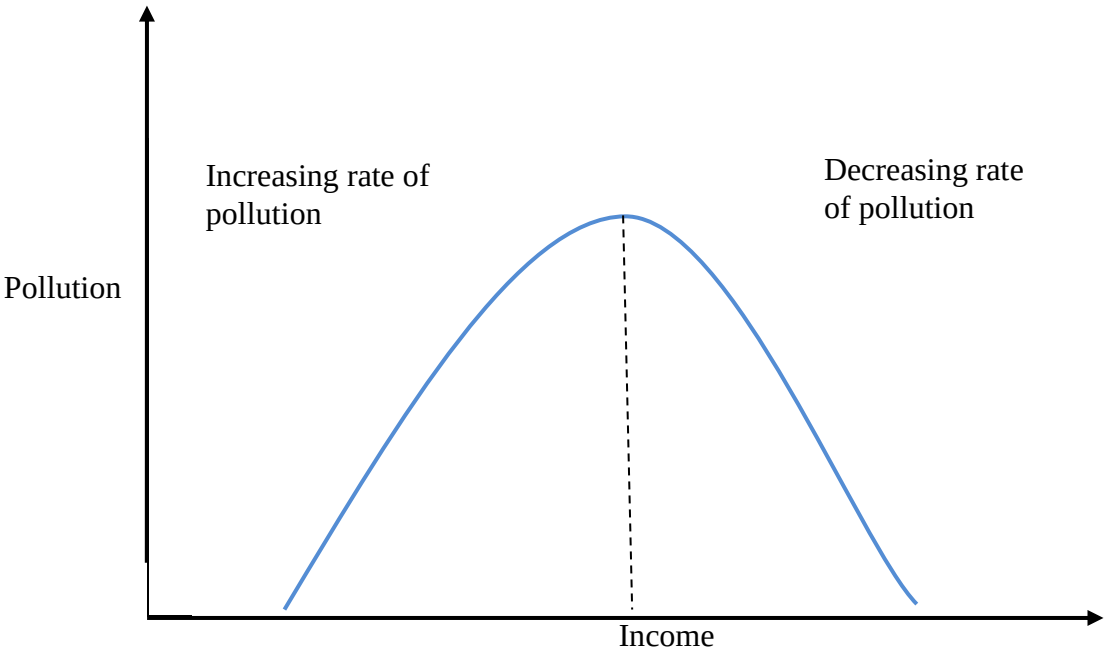


Figure 2.3: The Kuznets Curve showing the relationship between pollution and income

Source: Guinness and Nagle (2012, p.380)

A study of Johnstone and Labonne (2004), that retrieves a model of Fullerton and Kinnaman (1999) provides evidence on the economic and demographic determinants of generation rates of household solid waste that are consistent with results found in previous studies. Abrate and Ferraris (2010) noted that, using a cross-sectional time-series database of solid waste OECD countries, they estimate the burden of household waste generation on the consumer expenditure per capita, on the urbanization, on density of population and on the share of children. They find positive elasticity, but lower than one. Waste generation rates are inelastic with respect to the household consumption expenditure. Population density and urbanization degree have a positive effect on the waste generation. They conclude that the composition and size of the household seems to have an effect on household MSW generation with a significant negative influence, that is, there are household diseconomies of scale in waste generation.

A number of explanations exist for the observed inverse-U relationship. First, it could be explained by transformation from agrarian economies through industrial economies to clean service ones. At low level of economic development, the share of industry first is very low and rises with income increase. Corresponding environmental pollution first rise and then,

when there is a transformation from industry to service, falls with income growth, controlling for all other influences transmitted through income. When income grows, people presumably become both more able and more willing to sacrifice some consumption to protect the environment. Income-elastic demand for environmental quality is therefore one element that could generate a pollution path that eventually turns downward. The Kuznets Curve can be applied to the generation of waste in Kwekwe residential areas. There is an increase in pollution in low income areas up to a certain point when income continues to increase but pollution will decrease giving rise to an inverted 'U' shape.

2.11 Solid waste management in Zimbabwe

In developing countries, including Zimbabwe, the problem of Solid Waste Management is becoming more and more complicated and requires long-term and sustainable programs for its solution. Considering African cities, experience tells that less than 20% of urban solid waste is collected and disposed of properly. We can say that solid waste management is not satisfactory in developing countries (International Labour Organisation, 2007). As part of the solution, some cities and towns have privatized solid waste management services, and/or involved the communities in the management of solid waste by introducing Community Based Solid Waste Management. Like many African countries, rural people in Zimbabwe migrate to the urban centres in order to find a livelihood.

Waste management situation in Zimbabwe is approaching crisis levels. There is poor management of waste in all five aspects of waste management, ranging from the generation, storage, collection, transportation right through to the disposal of waste. This is evidenced by the illegal dumps that have become a common feature of almost every suburb in urban areas, and is particularly glaring in most high density suburbs and this poses a threat to human health and environmental well-being (International Labour Organisation, 2007).

At the generation stage the amount of waste that is produced by residents, industry and commerce is unsustainably high, as there is little in the way of integrated waste management that is practised. As a result, the local authority, which has the mandate for providing storage facilities, collecting and disposing of waste, fails to cope in a lot of cases. Research has shown that 72% of what is discarded as waste can be recycled, reused, composted or processed into other goods (International Labour Organisation, 2007).

Another major problem with the current waste generation patterns is the failure to separate waste at the point of generation. If waste is not separated at source, it becomes difficult to apply any integrated or sustainable waste management techniques, such as reusing and recycling. For the storage of waste, local authorities have the responsibility to supply bins in which waste is temporarily stored before collection. A number of local authorities have been unable to supply adequate storage bins especially in public places, and as result, littering has become one of the biggest problems in such towns and cities, turning some public places into environmental eyesores as people throw waste indiscriminately on the ground. It is important to note that even though there are inadequate bins in public places, the public at times exhibit very negative attitudes and choose to throw litter on the ground even in places where bins are provided.

The collection and transportation of waste is the responsibility of the local authority. Many of the local authorities are again failing to cope with the provision of this service, due to inadequacy of resources. In most cases, there are inadequate vehicles, and those that are there oftentimes do not have fuel to collect waste. Lack of collection of waste has resulted in the mushrooming of illegal dumps throughout the urban areas and some growth points, as people try to find coping mechanisms to counter the non-collection of waste. These are mostly rampant in the high density suburbs but now they are creeping to some of the low density suburbs.

Illegal dumpsites are favorable breeding grounds for vermin, flies and mosquitoes. They have also become sources of unpleasant odors, compromising human health. The risk of diseases such as cholera, dysentery and diarrhea increases where waste is not regularly collected and properly disposed of. In some instances, the illegal dumps are found close to market places where food is sold, as shown in Appendix 1 Field Photo 1.

One of the biggest waste related environmental problems is the state of the official disposal sites that are found throughout Zimbabwe. These official disposal sites are operated as crude dumps instead of sanitary landfills. Crude dumping is a method of waste disposal in which the waste is merely dumped and left uncovered. Sanitary land filling on the other hand involves the compaction of the waste before covering it with a soil layer so that it is not exposed. A sanitary landfill should be lined to prevent leachate from seeping into the ground, but currently, municipal dumps are not lined, thereby allowing leachate to seep into the ground and pollute groundwater resources. The dumps have no gas collection facilities, hence

methane gas that forms readily in landfill areas often cause uncontrolled fires at dumpsites. The waste at the dumps is not compacted or covered with soil; hence there are a lot of flies, vermin and unpleasant odors emanating from these official and unofficial dumpsites. Some hazardous wastes are dumped together with non-hazardous and biodegradable waste.

In Zimbabwe many households in the less economically developed countries do not recycle the wastes but simply find their way to the dumpsites. Very small quantities of wastes are used as compost. It is also evident from the figure that illegal dumping of solid waste in Zimbabwean cities is rampant which can lead to land pollution.

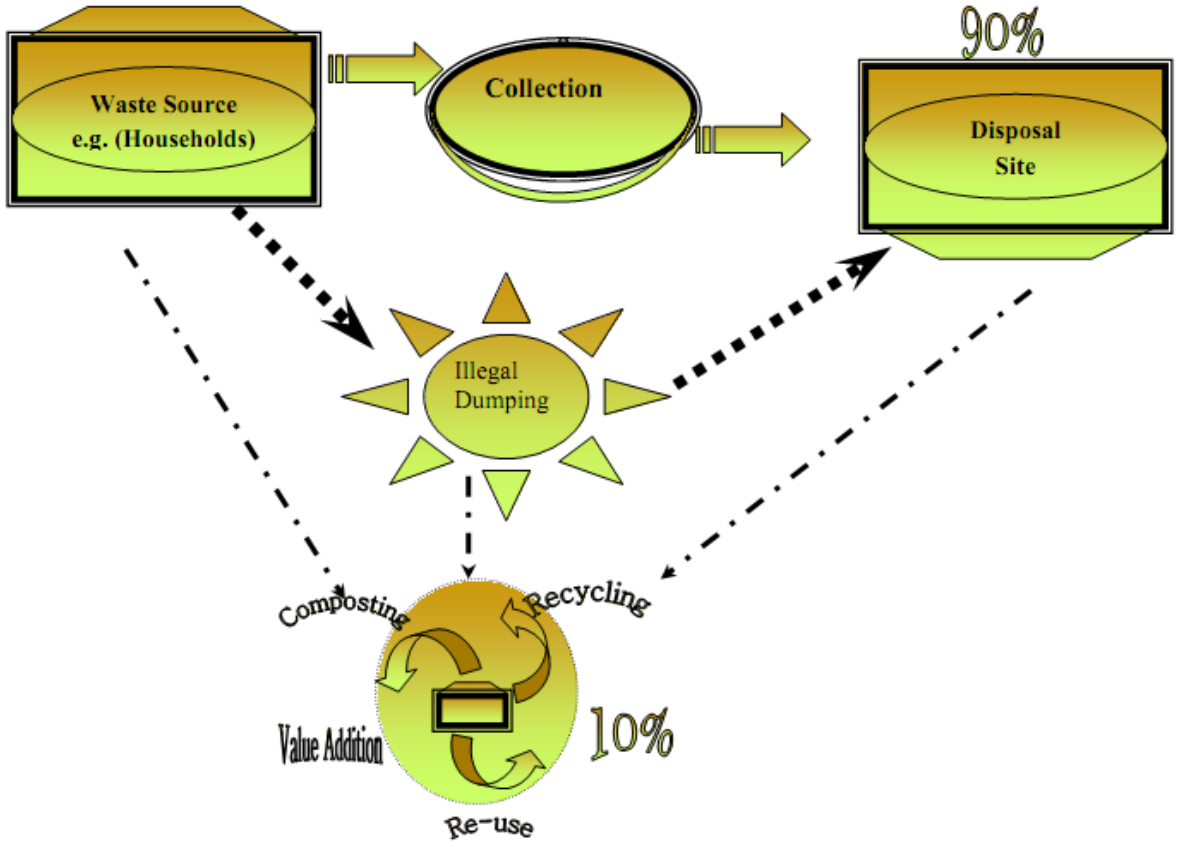


Figure 2.4: Solid waste management practice in Zimbabwe

Source: International Labour Organisation (2007, p.64)

Generators of waste often dispose of uncollected waste at illegal dumping sites. Solid waste is collected for re-use, re-cycling and value addition from households, illegal dumping sites and disposal sites. Less than 10% of the reusable waste is recycled (ILO, 2007).

2.11.1 Principles of sustainable waste management in Zimbabwe

A "Clean Zimbabwe" strategy was put in place to in 2007 to improve waste management situation in the country (ILO (2007). This strategy is based on 10 following principles (Table 10).

Table 10: Zimbabwean strategy to achieve sustainable management

Cradle – to- grave	This is a policy of controlling waste from its creation (cradle) to its final disposal (grave).
Life cycle principle	According to this principle, products should be designed, produced and managed so that all environmental concerns are taken into consideration, accounted for and minimized during generation, use, recovery and disposal.
Duty of care Principle/ Extended producer responsibility	The individual or organization that produces waste (the generator) is under all circumstances, responsible for that waste from cradle to grave.
Integrated waste management	This is an internationally accepted approach used to manage waste, which requires that waste generation should be avoided or minimized as much as possible. Any waste that is generated should be recycled or reused wherever practicable. Any waste that cannot be recycled or reused should be treated or compacted to reduce toxicity and volume. Any waste that cannot be subjected to the above should be disposed of in a properly designed and managed landfill.
Polluters Pays Principle	The person who causes pollution must pay for its clean up and for any damages caused
Precautionary principle	According to the precautionary principle, unknown waste must be treated as extremely hazardous until it is identified and classified.

Source: International Labour Orgaisation (2007, p.20)

CHAPTER THREE

STUDY AREA

3.1 Location and description of the study area

Kwekwe city lies 18°92′S and 29°81′E. Its altitude is 1,220 m above the sea level. The mean annual rainfall varies between 600 mm to 699mm. Kwekwe city has an area of 86.49 km^2. It is located in the tropics but its high altitude about 1,220 m modifies this to a warm temperate climate. The average annual temperature is 19°C. The climate is hot and wet during the summer rainy season from mid-November to mid-March, with cool, dry weather from May to mid-August in the winter season, and warm dry weather from August to mid-November. Winters are characterized mainly by their cold nights, with an average minimum temperature of 7°C.

The city of Kwekwe (Figure 3.1) was established in 1898 by the British South African Company (BSAC) as a mining town due to large gold deposits in the area. Kwekwe lies along Harare-Bulawayo highway and in the Great Dyke area, a geological formation endowed with a number of minerals.

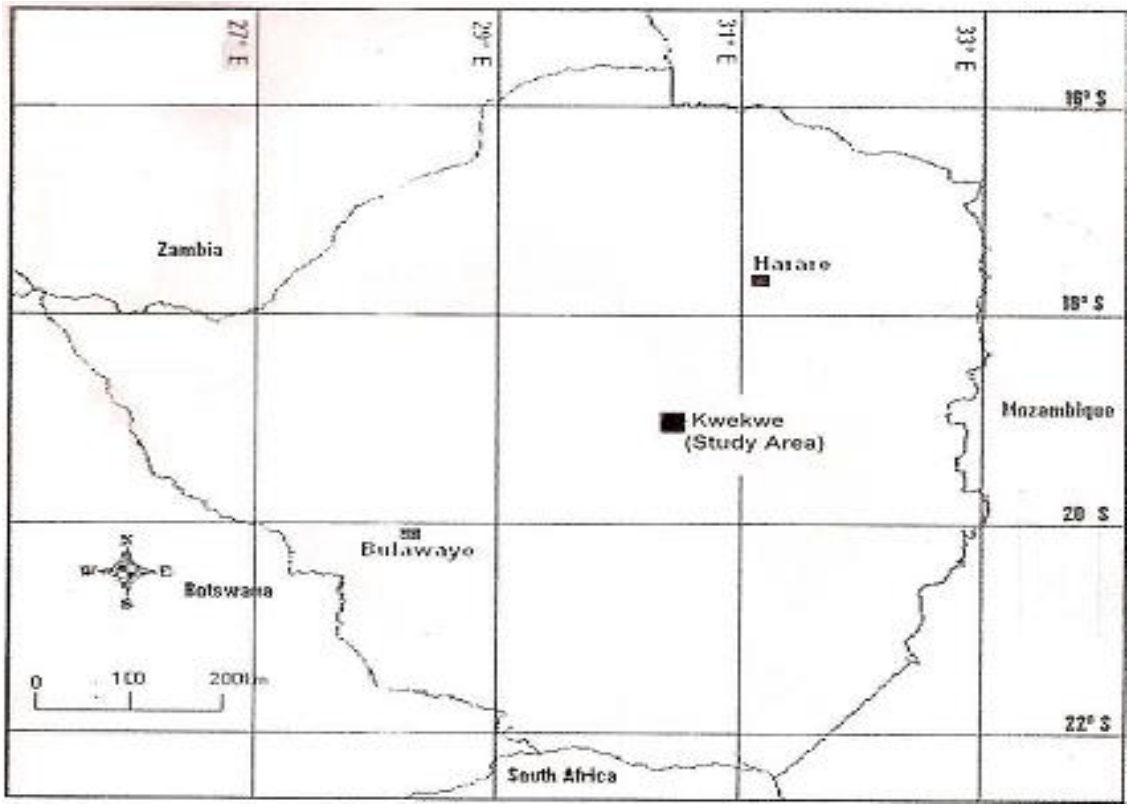


Figure. 3.1 Location of the City of Kwkwe in Zimbabwe

Source: Mangizvo R, V and R. Chinamasa R, M. (2008).

3.2 Population

The population of Kwekwe has slowed since the 1960s to date. The population increase was a result of urbanization and this led to an increase in the household density. Unfortunately, this increase in population was not equally matched with the capacity of the municipality to provide adequate housing and the necessary refuse collection and disposal leading to land pollution. According to the Zimbabwe National Statistics Agency (2012), the number of households in Kwekwe is 24 779 households. Table111 shows population figures and population growth rate for Kwekwe City from 1969 to 2012.

Table 11: Population growth rate from 1969 to 2012

Year	Population	Year	Population	Growth rate (%)
1969	33,000	1982	47,607	0.44
1982	47,607	1992	75,425	0.58
1992	75,425	2002	93,608	0.24
2002	93,608	2012	100, 455	0.71

Source: ZIMSTAT (2012)

Kwekwe is the fifth largest city in Zimbabwe. It offers a number of functions including, mining, industrial, educational, with Kwekwe Polytechnic offering even diplomas and degrees, commercial and social activities with many religions making it a cosmopolitan city.

3.3 Residential areas

Kwekwe is divided in three main residential groups according demographic and economic factors. These residential areas are: low–income, middle income and high-income residential areas**.** Kwekwe residential areas have all the characteristics of big cities such as Harare and Bulawayo. There are low income high density residential locations, medium income medium densities residential and high income low density residential locations.

The location of residential areas has been influenced by the following factors:

- Income levels, residents with high income stay in low density residential areas with spacious yards and can pay for garden servants and maids who help in cleaning their yards. Most of the houses are owned by companies occupied by their company

managers and company secretaries. The low density suburbs were previously meant for the whites minority,

- Cultural traits: people of the same culture prefer to stay in the same area such as the Chewa people whose ancestors are in Malawi who can here looking for menial employment in mines and street cleaners and tailors before independence,

Town planning: certain sections of residential areas are dominated by civil servants such as teachers, traders, nurses and soldiers.

The Street Map of Kwekwe

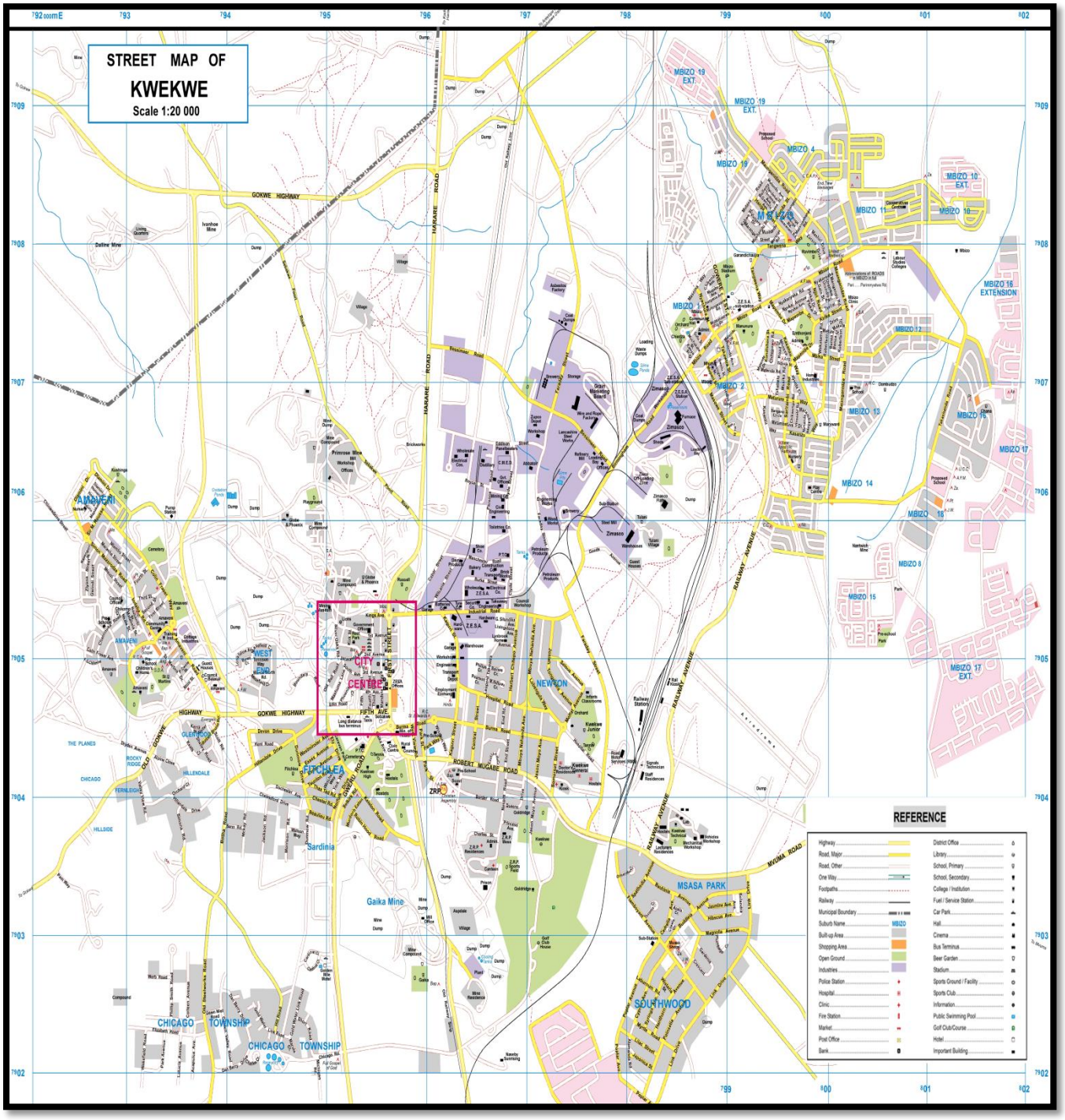


Figure 3.1a: The street map of Kwekwe

Source: Municipality of Kwekwe (2013)

The central business district of Kwekwe also produces a lot of wastes. There are number of food outlets and light industries which also produce a lot of wastes. Supermarkets , and offices generates a lot of litter.

KWEKWE CITY CENTRE

ENLARGEMENT

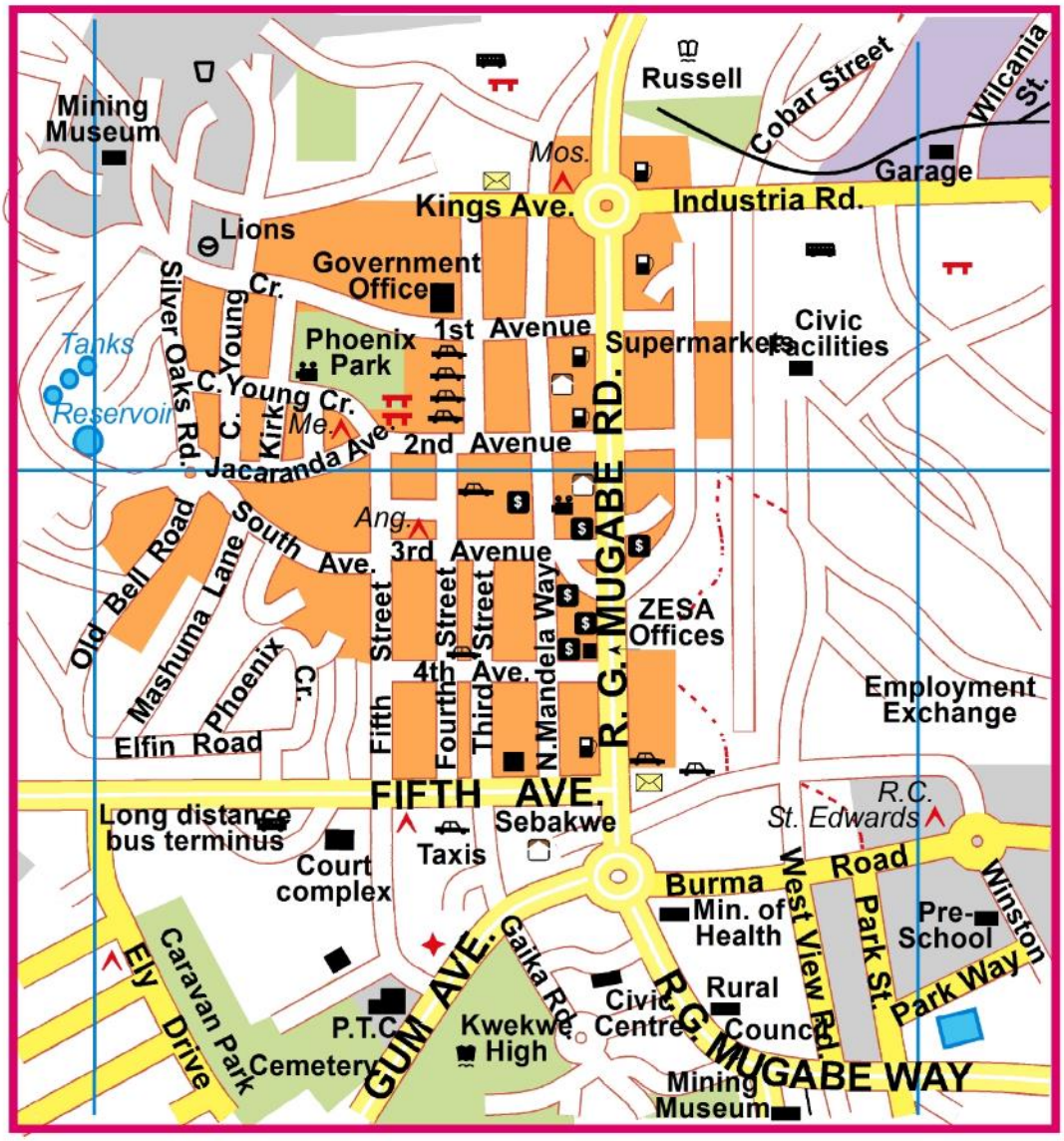


Figure 3.1b: Central Business District of Kwekwe

Source: City of Kwekwe Town Planning Department, (2013)

The Western Residential locations of Kwekwe City

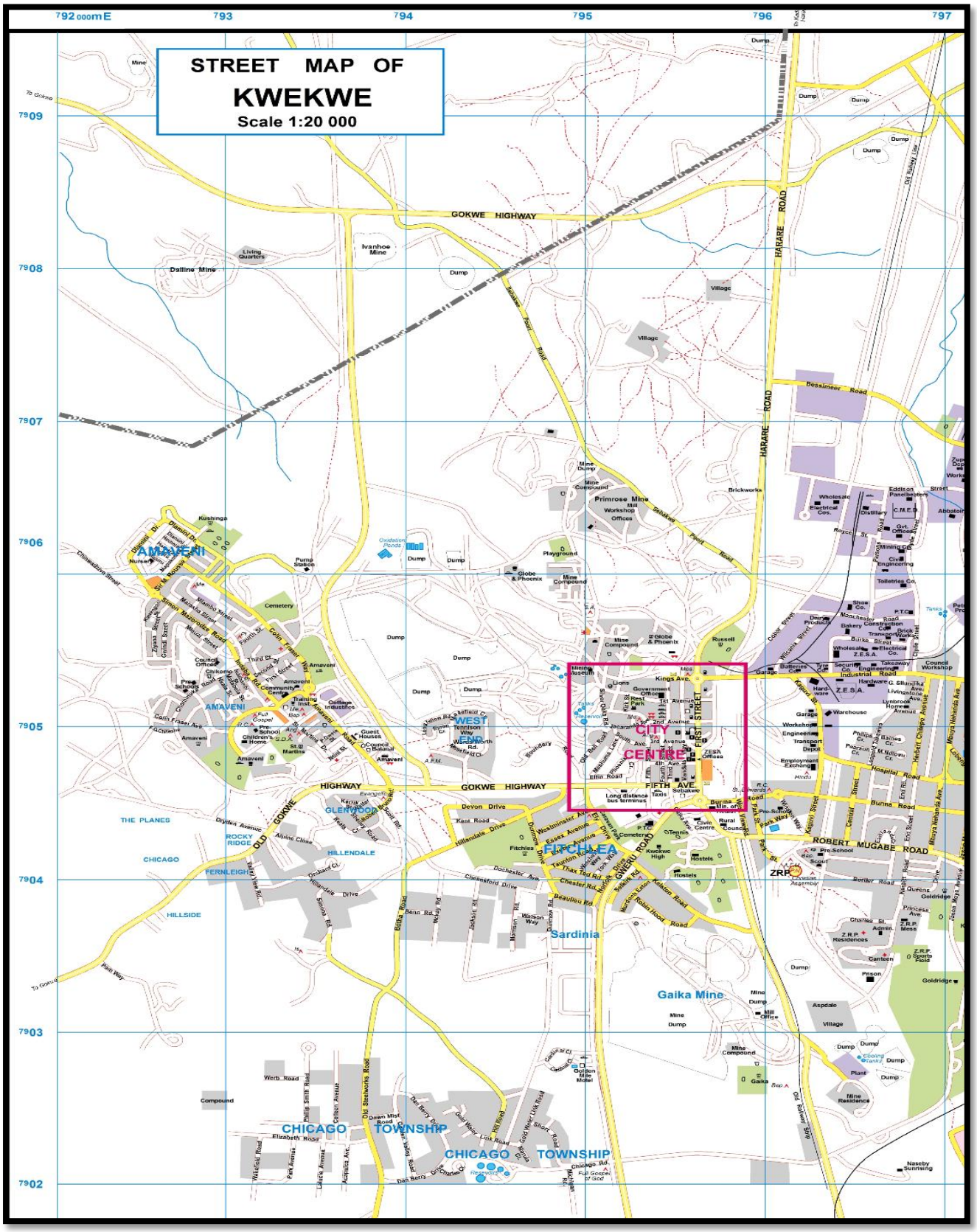


Figure 3.1c: Western Residential locations of Kwekwe

Source: City of Kwekwe, Department of Town Planning, (2013).

Kwekwe City Eastern Residential locations

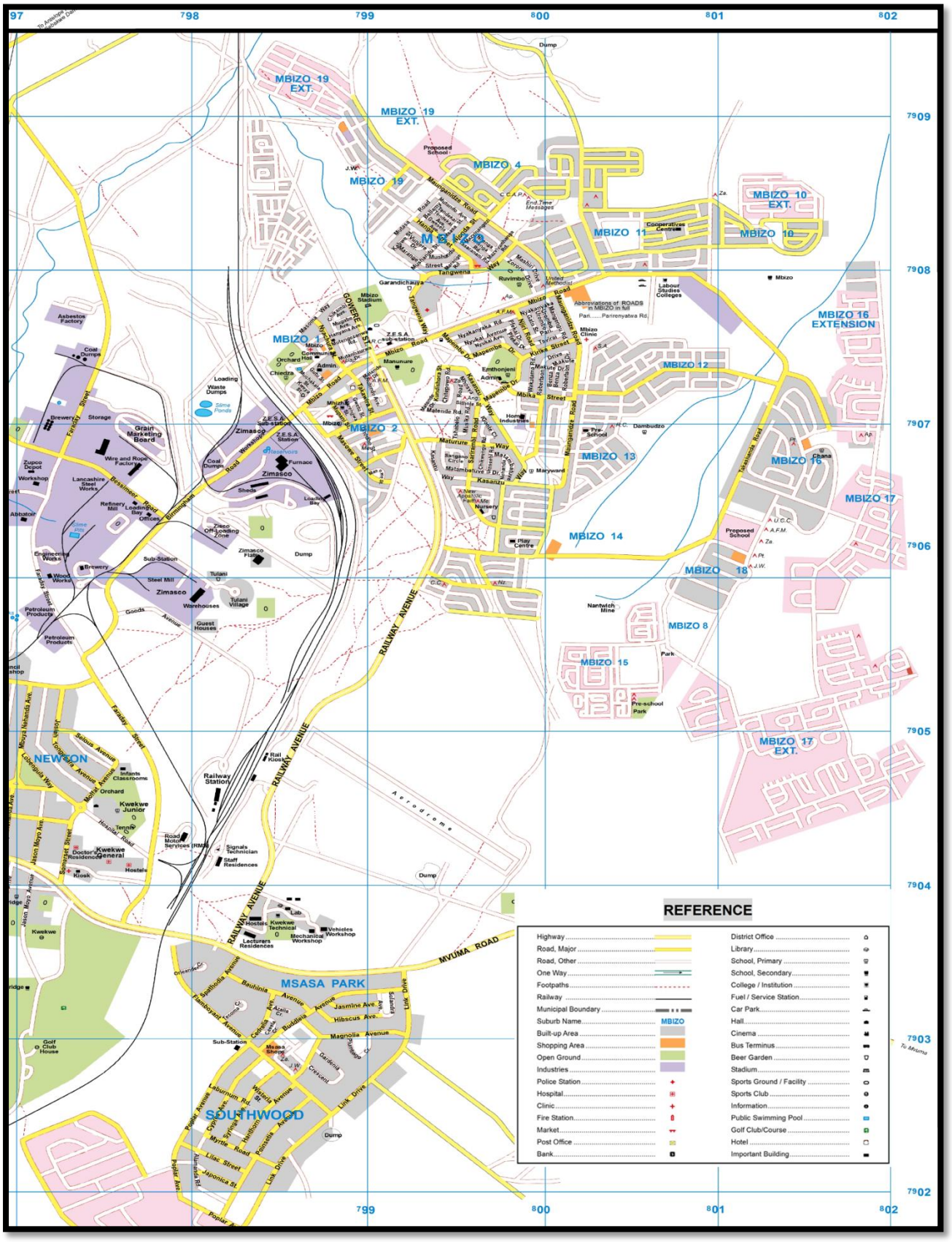


Figure 3.1d: The Eastern residential locations of Kwekwe

Source: City of Kwekwe, Department of Town Planning (2013)

3.4 Economic activities

Mining companies are involved in the mining of gold, nickel, iron and green marble, chrome, quartz and limestone. However, small scale mines are dotted around the district and these actively participate in the extraction of gold this attracted a number of people from different places to look for gold. Industry base varies from iron and steel manufacturing to agricultural fertilizer manufacturing. Apart from mining and industry, Kwekwe's hinterland is also agriculturally rich ranging from cash crop and livestock production. Kwekwe has a very strong customer base from the surrounding cotton farmers. It provides formal employment is in the form of primary, secondary and tertiary industries including agriculture sector. Informal employment is based on informal trading; mining and illegal gold panning activities (see Appendix 1, Figure5.3). Figure 3.3 shows the land use of Kwekwe.

3.5 Department of health services

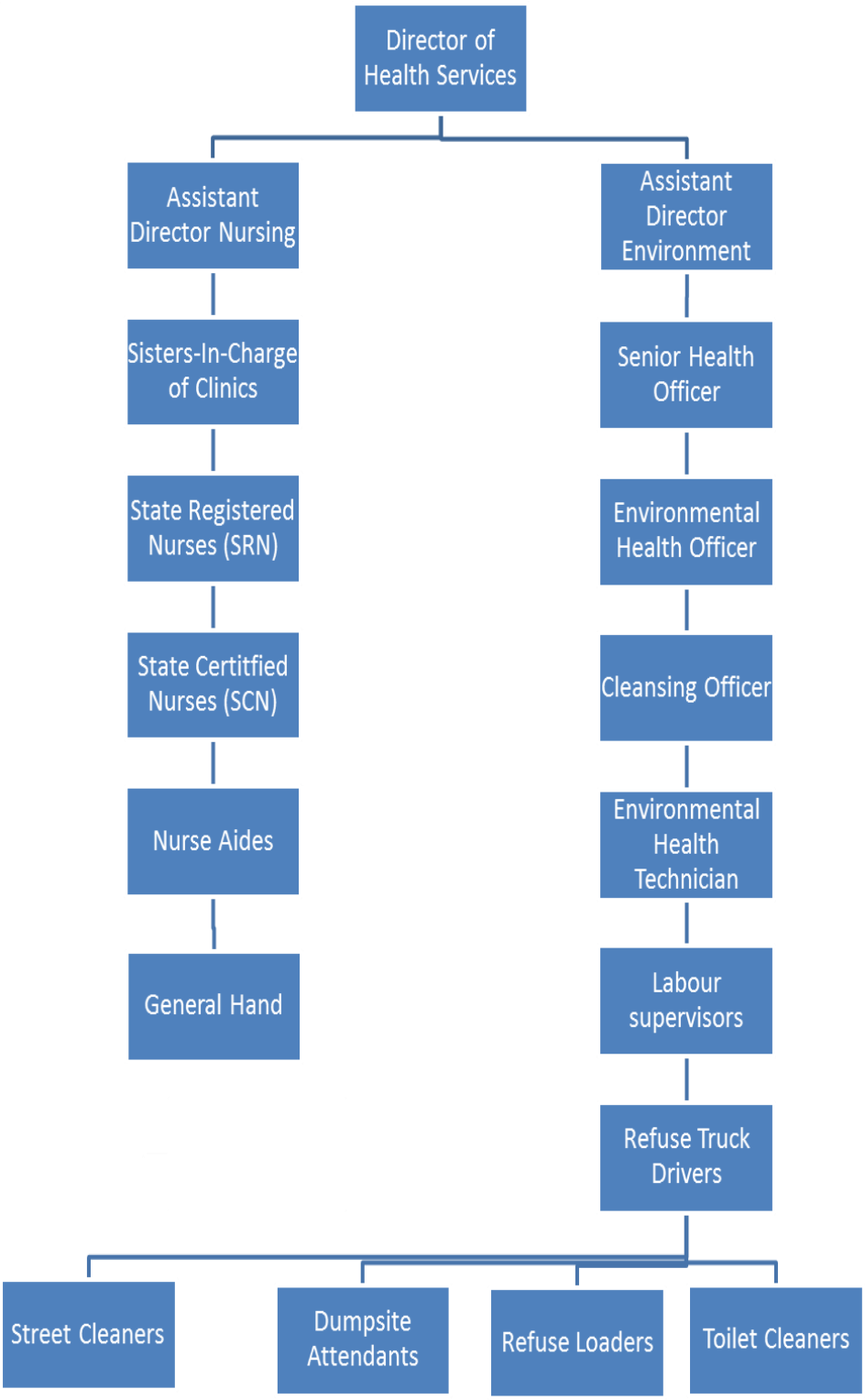


Figure 3.2 Organogram of Kwekwe Department of Health

Source: Municipality of Kwekwe (2013)

The local government employs a clumsy bureaucratic system in the running of the SWM which makes it difficult to quickly respond to the grievances of the residents. The reporting structure is too long. The director of health has the final say in the implementation of the projects in connection with the solid waste. Since this sector feels that the sole responsibility is in its hand, it always manages the system by itself. The other stakeholders, like the residents, the commercials, non-governmental organizations are mostly not asked to participate in making decisions and executing the waste related activities.

The total number of workers in the cleansing department is 53 workers consisting of street cleaners, refuse loaders and no dumpsite attendants mainly which are not enough to efficiently keep the Kwekwe residential areas clean. The Council did not have adequate personnel to closely supervise refuse collection and to enforce the existing legislation. The total number of four professional Environmental Health personnel was inadequate. The low fines charged to environmental offenders compromised the effectiveness of the waste management systems in Kwekwe leading to land pollution in Kwekwe residential areas. The information from the municipality questionnaire revealed that only one offender was fined an amount of US$20 during the whole study period, which is a too low tempting person to continue dumping waste at illegal dumpsites. Most waste workers dislike their job due to low wages and that it is a job considered menial and humiliating, hence most of the workers are old and unskilled for the job.

3.4.1 Vehicles used for waste collection

Table 12 shows the type and number of waste collection vehicles.

Table 12 Vehicles used in Kwekwe for waste collection

Type of vehicles	**Number**
Open trucks (3.5 tons)	3
Tractors (2 tons)	2
Tippers	2
Total	**7**

Source: Municipality of Kwekwe (2013)

Old unreliable fleet of vehicles is a serious challenge to the municipality of Kwekwe to transport the waste to dumpsites (see Appendix 2, Figures 5.8). Lack of spare parts which are usually imported is a serious challenge to the council workers to efficiently execute their duties. Vehicles suffer several breakdowns during the course of transporting waste to dumpsites. Unavailability of earth moving equipment and no approved landfill cells for the proper disposal of solid waste contributes to land pollution in Kwekwe residential areas. The tractors have no full cover of the waste after collection and hence there are trails of waste in the roads. Any attempt was made to calculate the amount of waste dumped at the dumpsites using the vehicle capacities given but there were records available and that there were dumpsites attendants and the weighbridge.

Zerbock (2003) points out that the vehicles used for transporting wastes in developing countries do not function efficiently and often break down, thus adding further to the problem.

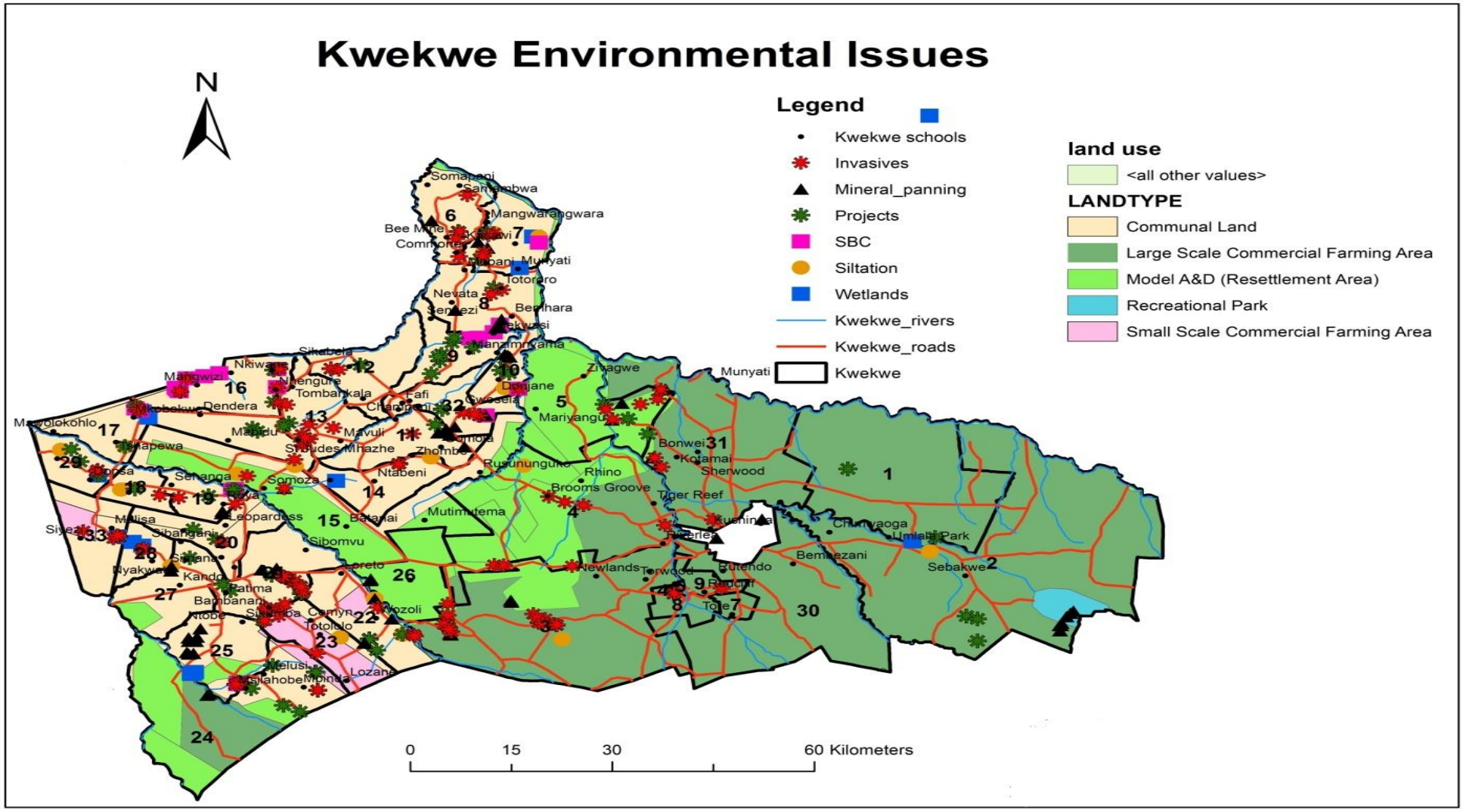


Figure: 3.3. Land use map of Kwekwe

Source: Kwekwe Environmental Management Agency (2013).

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1 Introduction

This chapter describes the research methodology, delimitation of the study, research design, target population, sampling design, data collection, data analysis, validity and reliability of the survey and ethical considerations. Cohen *et al.*, (2000) state that methodology in research refers to a systematic way of gathering data from a given population so as to understand a phenomenon and to generalize facts observed from a larger population. Methodology therefore helps the researcher and the reader to understand the process of the research thus giving a scientific merit. It is therefore clear that research methodology is an investigative technique employed to acquire answers to issues put forward for research. The type of methods used will depend on the scope, type, purpose and focus of the research topic together with the specific context in which such research is undertaken. The researcher's belief about the world (ontology) and always knowing the world (epistemology) is also linked to the type of method employed (Winchester, 2000). This study was therefore developed to understand the solid waste management system trying to identify the causes of land pollution in Kwekwe residential areas. In order to gain the knowledge of the system being studied, interviews were conducted in conjunction with methods of obtaining qualitative data. This research is based on the paradigm of critical social science. The main approach employed in this study is a qualitative case study approach of Kwekwe residential areas in Zimbabwe. The case study allows the use of inductive methods such as interviews, focus group discussions which allows general conclusions to be drawn from particular facts.

4.2 Permission to conduct study

Permission to conduct study was sought from the Director of Health Services in Kwekwe. Permission was granted on the 22 November 2012 with a condition that I produce the proposal of the research to all departments which I visit and that a copy of the final draft should be handed to the Municipality of Kwekwe (Ref PPG/*vm/A3).* Permission was also granted from the City of Kwekwe Department of works. Permission was also granted from the Ministry of the Environment and Tourism through the department of Environment Management Agency (EMA).

4.3 Pilot study

A pilot study is a trial run of the major study. Its purpose is to check the time taken to complete the questionnaire, whether it is too long or too short, too easy or too difficult and to check the clarity of the questionnaire items, and to eliminate ambiguities or difficulties in wording (Cohen, *et al.,* 2000). Ambiguous questions were rephrased to give a greater clarity and some questions were removed as they were irrelevant. A structured questionnaire was designed, pre-tested, and modified to collect household level data on socio-economic and daily solid waste traits. During this exercise, the households were grouped into the following socio-economic groups, the lower socio-economic group; the upper lower socio-economic group; lower middle group and the lower group.

A variety of complementary data collection instruments have been employed in the field survey. These include field observations and photographing, interview of key informants or stakeholders (such as the Town Planner, Town Engineer, Housing Director, Environmental Health Officers, ZIMSTAT Officer among others) and a questionnaire survey that was employed on the grassroots community members. Phase three comprises data compilation, socio-economic; upper middle socio-economic group and higher economic group. The socio-economic level of the communities was based on the housing type, (Abu Qdais *et al.,* 1997), its property value and construction characteristics (Ojeda-Benitez *et al.,* 2003). This information was confirmed later after interviewing, which gave also information on the family size, education, profession and property status. In order to identify representative study areas to be used for sampling and analysis of residential waste, a field observation was conducted. The study areas represent each of the following characteristics: density residence (high, medium, low), waste collection must exist in the area, racial distribution, family size (occupational density), and type of house: villa, modern buildings, small detached houses and logistics.

4.4 Data collection

Data collection is "a systematic way of gathering information which is relevant to the research purpose or questions", (Burns and Grove 1997:383). This study used mixed methods data collection strategies comprising qualitative and quantitative techniques. Mixed method data collection strategies are those that are explicitly designed to combine elements of one method with elements of other methods, in either a sequential or a simultaneous manner (Axinn and Pearce, 2006;. Brannen 1999a; Winchester 2000). Qualitative and quantitative methods provide both individuals and the general perspective on an issue. This triangulation

of methods is sometimes deemed to offer cross-checking of results by approaching a problem from different angles and using different techniques (Burns and Groove, 1997; Balnaves and Caputi, 2001; Creswell 2003).

4.5 Sampling design and procedures

Sampling involves a process of selecting a sub –section of a population that represents the entire population in order to obtain information regarding the phenomenon of interest. (Polit and Hungler, 1995; Burns and Grove, 1997. The target population in this study constituted all adults residents above 18 years of age mainly who are heads of households. These were able to answer questions to do with income and any household demographic statistics and also the collection of bins.

A convenient sampling was used to purposely identify and select household because it provided an easy access to respondents (Brink, 1996). According to Bryman (2004) convenient sampling includes samples selected by a researcher on the basis of ease of accessibility of the sample objects to the researcher. The method was used in both the household survey and the key informant interviews. In the household survey if a respondent was unwilling to participate, the researcher would interview the next accessible and willing participants.

During household survey and the key informant interviews samples were selected by a researcher on the basis of ease of accessibility. In applied social science research it is permissible to consider varieties of non-probability sampling alternatives where it is not practical or theoretically sensible to do random sampling (Bryman, 2004; Trochim, 2006; Bryman and Bell, 2007). For respondents who refused to participate, the researcher interviewed the next accessible and willing participants.

The city residential areas were classified into socio-economic strata as is known in official census frames and town planning records. Such classification was done with the help of the Department of Housing in Kwekwe. The classes observed were high income residential, medium income residential, low income residential and the peripherals. All households were numerically serialised, so samples were randomly selected using random number table.

A random sampling was used to select questionnaire respondents. Random samples are most likely to yield a sample that truly represents the population as each subject has an equal and

independent chance of being selected (Folarin 1999; Bryman and Bell, 2007)). This was also the same for the key informant interviews where waste management staffs

4.6 Sample size determination

According to Balnaves and Caputi (2001), there are few occasions in behavioral research where samples smaller than 30 and larger than 500 in size can be justified. In this research, the sample size (n) was determined population (N) from Table 13.

Table 13 Determination of Sample Size from a Given Population

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Krejcie and Morgan, (1960)

The sample size taken for sampling in this study is 375 households.

4.7 Collection of household waste

Polythene bags with a capacity of 60 kg each were coded and issued to 375 randomly selected households. The socio-economic groups were divided into the following categories higher socio-economic group, upper middle socio –economic group, lower middle socio-economic group. The bigger the household, the greater the amount of litter produced. Occupants in each household were to collect all their daily waste in the plastic waste bag. Household members were instructed to use the polythene bags carefully and invite neighbours to use the polythene bags. After seven days, these bags were collected and weighed and then divided by the number of the occupants in the household to get waste generated per day and per person per week. Wastes within each bag were also segregated and each segregated item was weighed separately and recorded. During segregation, collected wastes from each bag were spread on clean plastic sheets and the wastes sorted by hand, following the methodology described by Sujauddin *et al*. (2008) and Enayetullah *et al.* (2005). This method was used because it makes use of the population density of each residential area. During this exercise, waste was sorted according to type refer to table 1.

4.8 Questionnaires

Structured questionnaires and were used as data collection instruments. The numbers of household selected were 375 households. The questionnaire was selected because it enabled the investigator to be consistent in asking questions and data yield was easy to analyze with the help of the SPSS software program. The research respondents were interviewed directly to avoid misinterpretation and to ensure clarity on all issues. Face to face administration of questionnaires was done to ensure that all questionnaires are returned. Saunders, *et al*., (1997) maintain that a questionnaire is the best method of collecting data especially if the survey strategy is used and if the respondents cannot read and write. The researcher used all the three types of questions, the open ended questions, closed ended and filter questions. The questionnaire for household was divided into the following sections:

A: Background information of the respondent

B: Solid waste collection

C: Reuse, Recycle and Reduce

D: Council By-laws on solid waste

E: Environmental concerns

After preparing the list of the household head sample households were selected randomly using the random Table. The information from the household was collected with the help of a

structured questionnaire. The questionnaire was finalized after a pre-test. The pre-test was made in Mbizo section 16 and New Town. The questions were on demographic characteristics of the households, information on waste generation by types, waste disposal practices (e.g. throwing in street, river, open spaces, burning etc.), door-to-door collection systems, monthly fee, and frequency of bin collection. Family income or household income, sources of income, education level, and attitude towards the environment was also assessed.

The questions were filled by visiting the selected households from April to August 2013. The households were visited twice to complete the questionnaire. On the first day socio-economic information were collected and households requested to deposit the wastes in different plastic bags. Some households were willing to sort their waste materials; however, they stopped sorting before the end of the research period. Ten research assistants were hired to assist in the filling of the questionnaire. The questionnaire for the Municipality had various aspects concerning solid waste management. The questions and interviews were targeted at municipality employees.

4.8.1 Interviews

Structured interviews were conducted with the Department of Housing and Community Services, Department of Works, Department of Environmental Health, and the Environmental Management Agency (EMA) and ZIMSTAT to get detailed information.

4.9 Mapping

The Etrex 20 Germin Global Positioning System (GPS) device was used to locate the co-ordinates and altitude of the dumpsites. The area of pseudo dumpsites was also mapped. Maps from the town planning department were also used to locate the residential areas in Kwekwe. Also the map from the Department of Environment was used to show the environmental condition of Kwekwe in terms of land uses. The materials observed were diapers, plastic materials, tins, garden trimmings and ash. See appendix 2.The Town Planning Department in Kwekwe also provided me with a map which shows the residential areas in Kwekwe which assisted me in identifying the streets and location in all the residential areas.

4.10 Secondary Data

Secondary data sources are data that has already been collected and recorded by someone else, usually for other purposes (Blumberg, 2008). This also involves information published by the government which is publicly available. The main advantages of using secondary data are that this approach saves time and money and that the often time –consuming activities of

setting up the research, approaching the respondents, collecting information from respondents and recording any information obtained in a way suitable for analysis is not necessary. Data from secondary source is usually high quality depending on the source of the data. This includes data from non –governmental organizations, international organizations, national and research agencies with many experts involved in data collecting process and analysis.

It is because of these reasons that secondary sources were used to collect data on solid waste management in Kwekwe and statistical information from CSO on population figures. In addition to this, relevant secondary data was also used in the study such textbooks, journal articles, dissertations, and newspaper articles .The data obtained from literature review gave the researcher an overview of the extent of solid waste challenges in less economically developed countries.

Bryman and Bell (2007) assert that the use of secondary data offers the prospect of having access to good quality information with very little resources (time and money) used in the process. However, secondary data may have content problem; low ecological and temporary validity; and low impetrative validity (Johnson and Turner, 2003).The secondary data and literature review phase helped in guiding the researcher on issues worth analyzing in the policy documents analysis phase and development of primary data collection tools that were used in the primary data collection stage. Secondary data also enhanced the understanding of the problems, rules and laws pertaining to waste management and also for triangulation and verification of the primary data collected. It also helped me in ascertain the reliability of the data collected in the field.

4.11 Primary data

Much of what we know comes from observation. Observation qualifies to be a scientific inquiry because it gives instant results at a particular place and at a particular time. Observation should be supported by photographs and mapping. Usually it provides a reliable and valid account of what happened. Blumberg, (2008) states that the versatility of observation makes it an indispensable primary source method and a supplement for other methods hence the use of the triangulation method. The researcher used this method to observe litter in the streets and heaps of uncollected wastes in Mbizo and Amaveni residential areas. It was through observation that photographs were taken as evidence of land pollution in Kwekwe City residential areas. Non participant observation helped me to visualize and verifying then response of various participants; and used it to compare and analyze the existing system. It enabled me to understand the effects of demographic, cultural, social, and

economic context of communities. Ground observation helped me in forming strategies and developing policy recommendations with the help of community members.

Blumberg (2008) went on to say besides data collected visually; observation involves listening, reading, smelling and touching. Odors from waste heaps could be smelt and the degree of odour concentration varied from low, medium and high. Odour concentration also varied from low in low density residential, medium in medium density residential and high in high density residential. Sporadic fires can be seen on uncontrolled dumps in Mbizo and Amaveni high density residential locations. One advantage of observation is that original data can be collected at the time they occur and we not depend on reports by others. Respondents may give their own perception of causes of solid waste by exaggerating or failing to disclose full information, forgetting occurs but observation overcomes many of these deficiencies of questioning. Another advantage of observation is that it can capture the whole event as it occurs in its natural environment. Observation is demanding and has a less biased effect on their behavior than questioning. With observation method, it is possible to conduct disguised and unobtrusive observation studies much more easily than disguised questioning, yet it is difficult to predict when and where the event will take place (Blumberg 2008).

It is because of these advantages that the observation method was used to collect data though with some limitations. However, observation is limited in the sense that the observer must be at the scene of the event when it takes place. Observation is a slow and expensive process that requires either human observers or costly surveillance equipment.

4.12 Reliability

Blumberg (2008:455) asserts that reliability means "different things too many people, but in most contexts the notion of consistency emerges". A measure is reliable to the degree that it supplies consistent results. Reliability is concerned with estimates of the degree to which a measurement is free from random or unstable error Blumberg, (2008). Reliability relates to the precision and accuracy of the instrument. If used on similar group respondents in a similar context, the instrument should yield results, (Cohen *et al.,* 2000). Accurate and careful phrasing of questions to avoid ambiguity and leading questions ensured reliability of the tool. The respondents were informed of the purpose of the interview and need to respond truthfully. To enhance reliability, qualitative methods and quantitative were used throughout the study and also both primary and secondary data sources were used during the study.

4.13 Data analysis

Data analysis is "systematic organization and synthesis of the research data and the testing of the research hypothesis using those data (Polit and Hunghler 1995:639). It also entails categorizing, ordering, manipulating, summarizing the data and describing them in meaningful terms" (Brink 1996:178). A lot of data was accumulated, data ranging from population density, room density, and the income level of residents. Another data that was collected involves the frequency of collecting waste from the residential locations. The amount of solid waste generated by the selected household was also collected and compared with the household density. The literacy levels and amount of solid wastes produced were also analysed using bar graphs and line graphs. Data were entered in SPSS for statistical analysis. The data was classified according to the contents. The data was divided into broad categories that were developed from the review of literature. Some of these categories were: waste generation, waste collection and transportation, waste decision making process, public involvement in the decision making process and so on. The emerging trends and patterns were further elaborated upon and with the help of other experts were taken to formulate possible policy recommendations and strategies. Questions were coded for easy analysis by the computer and results were presented in the next chapter.

4.14 Ethical considerations

Scientific research is a form of human conduct and should adhere to acceptable values and norms (Mouton, 2001). Bryman and Bell (2003) add that ethical issues in research should look at four principles: whether there is harm to participants; lack of informed consent; invasion of privacy; and deception is involved. All these consideration have been taken into consideration during the study. Throughout the research these moral principles were adhered to with much closeness. Considerations were taken not to put the Municipality of Kwekwe in disrepute or its personnel, the University of Zimbabwe through my co-supervisor, University of Venda through my supervisor, the University of South Africa and all other respondents. The respondents were informed of their rights, and ethical issues observed in the study which includes "informed consent", right to anonymity and confidentiality, right to privacy, justice, beneficence and respect for persons (Brink and Wood 1998:200-209).

4.14.1 Respect for persons as autonomous individual

Every human being has a basic human right. Respondents as autonomous individuals have the right to choose either to participate or not in the research. Decision is to be made without coercion. Respondents were allowed to act independently by giving their informed consent to participate in the study. People participate voluntarily and were at liberty to withdraw. No

inducement was exercised during the questionnaire and interviews administration, participants were at liberty to answer the questions asked during data collection.

4.15 Validity

According to Polit and Hunghler (1995) states that validity is refers to the degree to which the instrument measures what is supposed to be measuring. In this study, the instrument is supposed to measure the efficiency in the solid waste management in the city Kwekwe residential areas including the processes such as collection, sorting, transporting and disposal of solid waste materials. Questions related to these processes were referred to in the questionnaires. Blumberg (2008) refers to validity as the extent to which a test measures what we actually wish to measure. In this study the relationship between income and solid waste generated has been measured and thus one of the hypothesis which was being tested. Both internal and external validity has been addressed in this study. External validity has been addressed in the sense that research findings can be generalized across persons, settings and times.

4.16 Reliability

Blumberg (2008:455) asserts that reliability means "different things to many people, but in most contexts the notion of consistency emerges". A measure is reliable to the degree that it supplies consistent results. Reliability is concerned with estimates of the degree to which a measurement is free from random or unstable error Blumberg, (2008). Reliability relates to the precision and accuracy of the instrument. If used on similar group respondents in a similar context, the instrument should yield results, (Cohen *et al.,* 2000). Accurate and careful phrasing of questions to avoid ambiguity and leading questions ensured reliability of the tool. The respondents were informed of the purpose of the interview and need to respond truthfully. To enhance reliability, qualitative methods and quantitative were used throughout the study and also both primary and secondary data sources were used during the study.

4.16 Confidentiality and anonymity

The study strove to protect the rights of the subjects including their interests, psychological, physical well-being and sensitivities (Mouton 2001).Confidentiality is "a basic ethical principle while anonymity is one way in which confidentiality is maintained. To ensure anonymity, steps are taken to protect the identity of the individual by neither giving their name and when presenting results, nor including identifying details which may reveal their identity such as work place, personal characteristics and occupation" (Rees 1997:71). In this

study, anonymity was achieved by not including names on the questionnaire; the heads of the householders were so free to answer most of the questions in the questionnaires. Participation was made voluntary; participants were not forced to take part in the research. Interviews were conducted in closed office were no third person could hear the conservation especially with the Municipality officials.

4. 17 Avoid harm

Avoiding harm is another basic human right to be considered when doing a research on human beings. According to Burns and Grove 1997: 206), risks that may be encountered in research include physical, psychological, emotional, social and financial ones. The researcher minimized the time of interviewing the participants. Maintaining privacy, confidentiality and anonymity during interviews also prevented psychological harm participants.

4.18 Justice

Justice refers to "the fair treatment of those in the study" (Burns and Grove 1997:705). During the study the participants were treated fairly by giving them information prior to participation and giving them the option to withdraw from the study if they wanted to without any negative consequences regarding solid waste management. Selection of the household was done using random sampling which gives every household an equal chance to be selected and participate in the study.

4.19 Informed consent

The aims of the study were disclosed to participants in clear, unambiguous and simple manner (Mouton, 2001). Informed consent is "a legal requirement before one can participate in a study (Brink and Wood 1998:200). After a full explanation of the nature of the study participants were asked to give a verbal consent expressing their willingness to participate in the study. The city of Kwekwe Municipality was informed of the research and the consent was given in form of a written consent.

Objectivity and integrity was maintained during the research as put forward by Mouton, (2001). The highest technical standards were adhered to during the conclusion of this scientific research. This included ensuring the findings of the research study are represented fully without falsifying data and acknowledging sources of information for the study. By doing so, objectivity was maintained in a highly subjective study.

CHAPTER FIVE

RESULTS AND DISCUSSION

This chapter focuses on the results of the research in Kwekwe city. The objectives highlighted in chapter one are fulfilled in this chapter. The amount and composition of solid waste generated and disposed in Kwekwe city is shown in this chapter. The amount and composition also varies according to income and population density in residential areas.

5.1 Profile of selected household

Table: 14 Number of households in Kwekwe residential areas

High density		Medium density		Low density	
Name	**Number**	**Name**	**Number**	**Name**	**Number**
Amaveni	1533	New Town	429	Chicago	444
Mbizo	12116	Fitchlea	242	Ashdale	105
New Flats	128	Masasa Park	215	Golden Acres	138
Old Flats	12	Southwood	254	Gaika Park	52
Globe and Phoenix	42	Westend	185	City Area	15
Total	13831		1325		754

Source: Department of Housing, Kwekwe Municipality (2013)

Table 15 shows the profile of residential areas in Kwekwe

Residential area	**Number Sampled**	**Number of households**	**Income Range (US$)**	**Average size of household**
High density	210	13831	100-1,000	11
Medium density	95	1325	1001-2, 999	8
Low density	70	754	3,000 and above	5
Total	375	15910		8

Family size was positively correlated with total waste generation rate per household, which confirms the findings of Al-Momani, (1994) and Sujauddin *et al.*, (2008). According to Jones *et al*., (2008), the relationship between waste production and household size is not a linear relationship. Indeed, also in this study, as household size increased, the rate of increase in waste generation itself declined. On the basis of studies conducted in different cities from developing countries and various regions, Hockett and Lober, (1995) did report that smaller

household sizes produced more waste per capita. This observation was true in the high income residential areas whereas low density area produces a lot of waste which however was not in the collection bins but frequently collected and dumped to the dumpsites. The residential areas which showed this pattern are Chicago, Hezeldine and Golden Acres. The relationship between per capita waste generation and household size shows a positive relationship. According to Ulrich *et al.,* (2005), the average solid waste generation rate of the low-income countries is 0.1–0.5 kg/capita/day as opposed to 1.1 kg/capita/day and above in fully industrialized countries, even though differences of generation of waste are also observed among the industrialized countries as well. Indeed, also in this study, as household size increased, the rate of increase in waste generation itself declined. The research revealed a number of outcomes which show that both the residents and the Municipality are to blame for the land pollution in Kwekwe. This dissertation has managed to successfully identify the crucial aspects of the sustainable MSW and these are financial, technical, institutional, policy and socio-economic and political.

At every stage of solid waste management from generation, collection, storage, transportation and disposal, there are weaknesses observed which lead to land pollution. From the questionnaire survey 28% of the surveyed household believes that the residents are to blame for the land pollution in the residential areas and 72% believe that the Municipality is also to blame. With regards to policies, Zimbabwe as a country has no national level waste management policy and this is one of the major problems making it difficult for the cities to manage waste adequately as noted by Maseva (2005) and Government of Zimbabwe (2004). Many towns and cities in the developing world are faced with the growing challenge of solid waste management as waste volumes are increasing due to many factors that include rapid urbanization, increase in population, and use of use of non-biodegradable plastics and bottles (Kaseke, 2003; Maseva, 2005). The increase in solid waste being generated as also noted in Chapter 1 was being met with inadequate and crumpling solid waste management systems (Yedla, 2005; and Manyanhaire *et al.,* 2009).

5.2 Composition of waste generated from residential areas

Figure 4.1 shows that the total amount of waste decreased from high density to low density. Special waste refers to a class of waste that has unique regulatory requirements. Such waste are common in low density residential areas. The potential environmental impacts of special waste need to be managed to minimize the risk of harm to the environment and human health. Special waste is a waste requiring special handling to protect human health or the

environment. A solid waste that if improperly treated or handled, could transmit an infectious disease and examples include microbiological, animal, human blood and blood products, pathological, sharps and syringes. Dev, (2007), came with a group of waste as outlined below:

Electronic waste or E-waste Electronics includes brown goods**,** "Computer-related Electronics," "Other Small Consumer Electronics," and "Televisions and Other Items with CRTs (Dev, 2007). Brown goods are generally larger, non-portable electronic goods that have some circuitry. Examples include microwaves, stereos, VCRs, DVD players, radios, audio/visual equipment, and non-CRT televisions (such as LCD televisions), photocopying; fax machines and cartridges. These are quite common in low density residential such as Chicago, Golden Acres and medium densities such as Masasa Park, Fitchlea and New Town who have a tendency of buying an electrical gadget that comes into fashion.

Computer-related electronics refer to electronics with large circuitry that is computer-related. Examples include processors, mouse, keyboards, laptops, disk drives, printers, modems, and fax machines.

Other small consumer electronics include portable non-computer-related electronics with large circuitry. Examples include personal digital assistants (PDAs), cell phones, phone systems, phone answering machines, computer games and other electronic toys, portable CD players, camcorders, and digital cameras. These are available in Kwekwe residential areas but in small quantities.

Televisions and other items with CRTs include televisions, computer monitors, and other items containing a cathode ray tube (CRT). The E-Waste can remain in the waste main stream for many years resulting in land pollution because they are non – biodegradables. These types of wastes are common in the low density residential areas which have developed a "Buy and Throw Away Culture", they buy new items and throw away the old items such as toys at higher rate than in high density areas. In Kwekwe such wastes are common in the low density residential such as Golden Acres, Chicago and Ashdale.

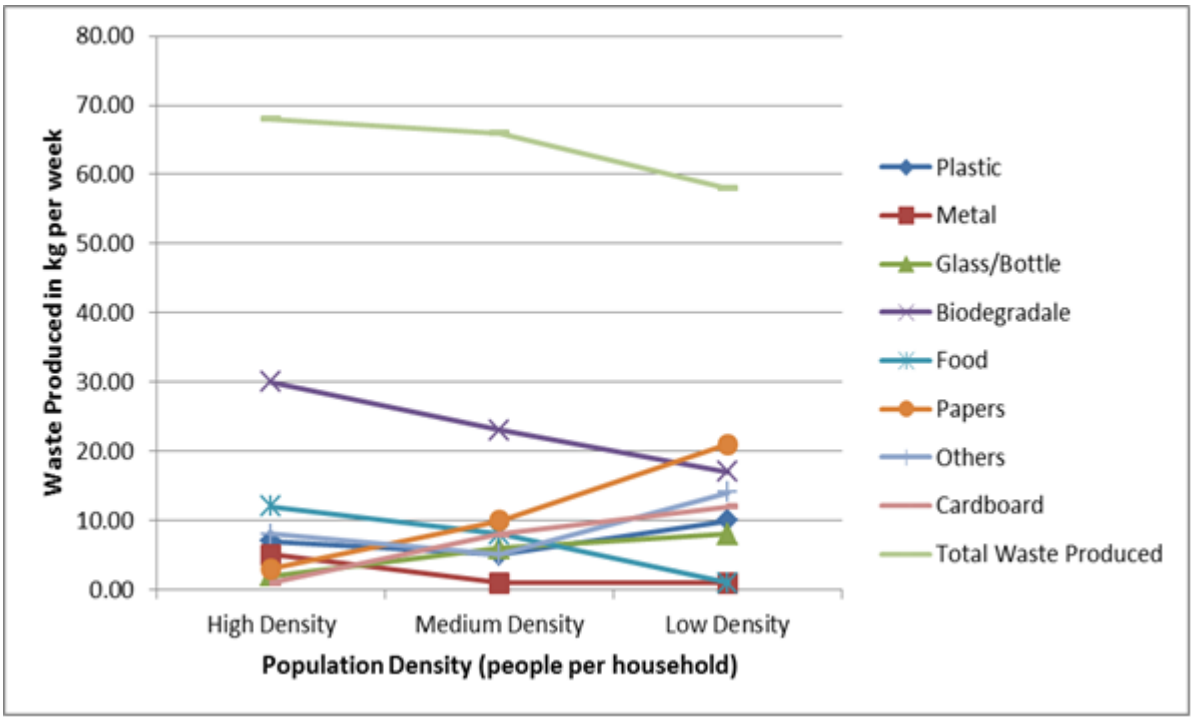


Figure 4.1: Waste fractions a generated from households

Biodegradables such as kitchen wastes are more common in the high density than low density areas. In low density areas they have refrigerators to keep their vegetables.

However, paper, cardboard and plastic wastes tend to increase from high density to low density, because residents in the low density buy their packed items and take-away foods which will then be discarded as waste. Metal wastes are quite high in high density areas due to welding activities in workshops in these areas. Iron is cheaply available in Kwekwe for informal welders because they buy if from ZIMASCO and ZISCO. Glass and bottle waste were more in low density residential because these high income earners they buy many soft drinks and wines whose empty containers find their way into the waste stream. In high density residential areas, bottles and glass are exchanged for other items with vendors and reused for other purposes in the houses.

5.3 Monthly income and amount waste generated per day

Primary stratification was by density but however, I also looked the role played by income in the generation of waste .The relationship between income and the generation of waste was a tricky one. From the samples taken, some households considered as high income according to this research were found in the high density residential and also some households in the low density residential were found to be earning very low income. The results from the questionnaire and those from the actual samples taken were slightly different in terms of the relationship between income and the amount of waste generated. Figure 4.5 shows the

difference of HSW generation rate of total waste and main compositions by income levels and the number of occupants per household.

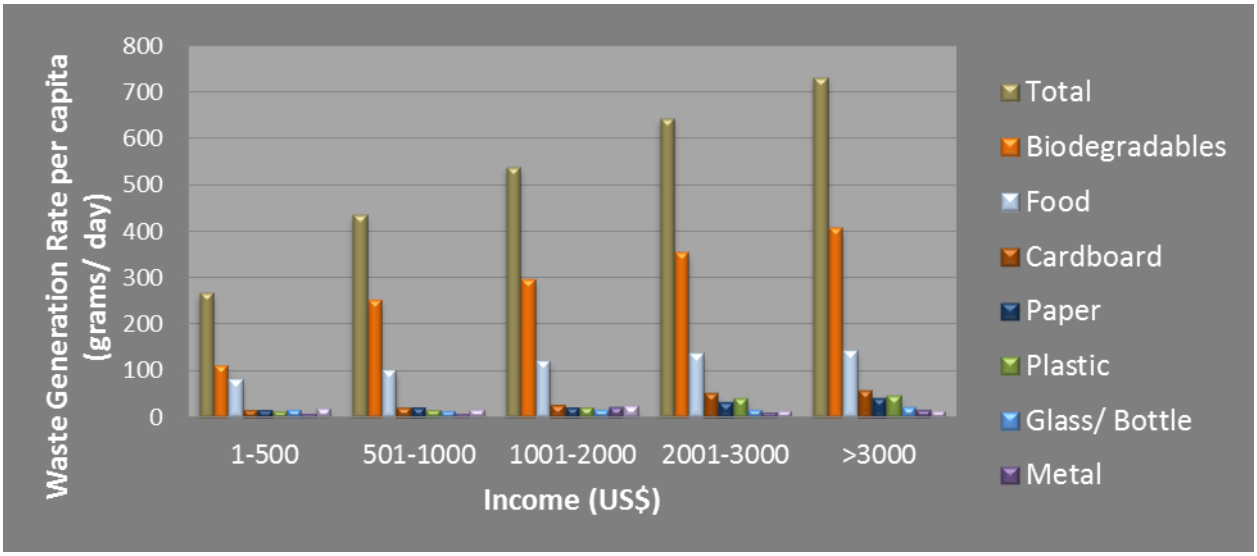


Figure 4.2 Effcect of income on household waste generated

The results presented in Figure 4.2 show that the households with higher income level generated larger amount of HSW. Many researchers mentioned that with increased household income, more household waste was generated; household income was positively related to the rate of household waste generated (Dennison *et al.*, 1996a, Bandara *et al.*, 2007). This was explained by the relatively high purchase trends of higher income group and the increased amount of HSW generated.

In addition, the positive effect of household income on waste generation can also be related to environmental conservation , high-income households tended to squander goods especially food and paper because they do have a lot of money for disposal. Al-Momani (1994) found a positive correlation between MSW generation and the income levels of people, as well as other parameters such as the number of persons per dwelling, cultural patterns, and the level of education. Richardson *et al, (*1978) also supported the view that the higher the income, the more the consumption activities and the higher the waste produced.

For plastic waste, the low-income households, people tend to reuse their recyclable waste especially plastic bags and plastic container.

5. 4 Occupational density and the amount of waste fractions produced per day

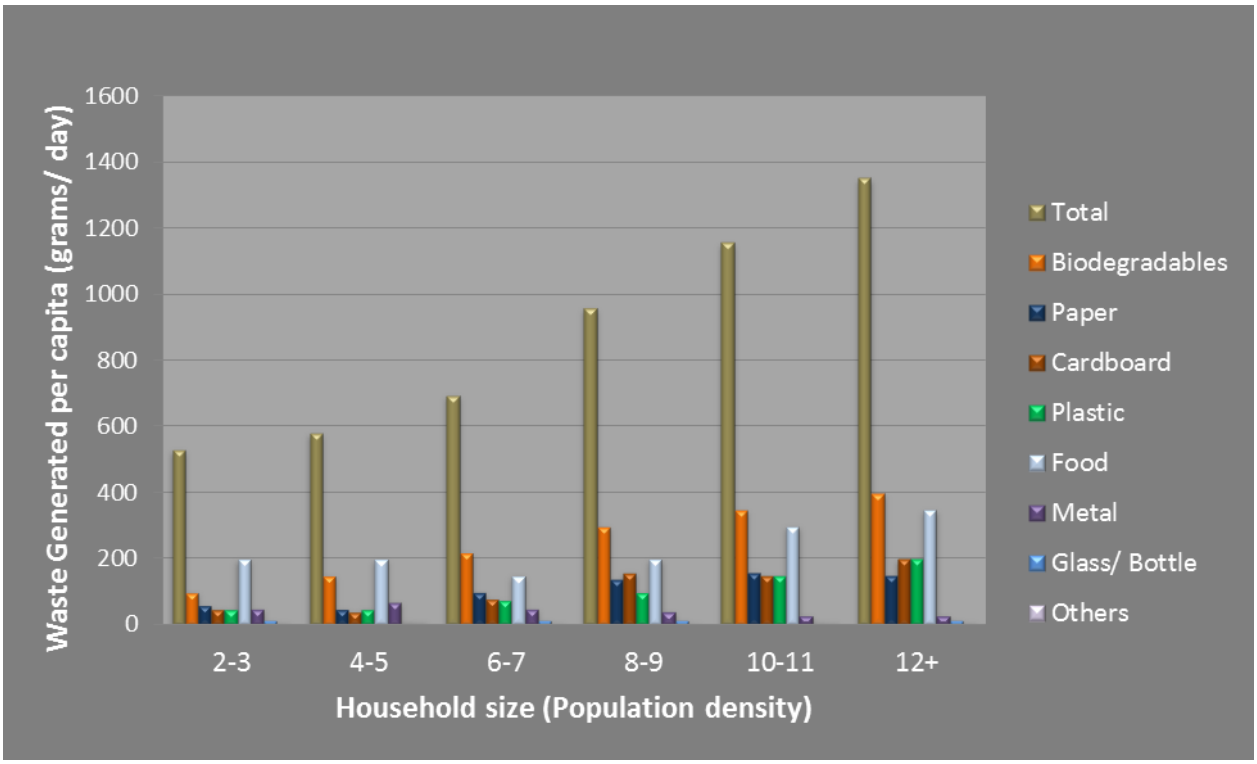


Figure 4.3: Effect of household size on solid waste generated in Mbizo high density residential surbub

Mbizo was selected for a deeper analysis and presentation because it has households with with various number of occupants as shown on Figure 4.3 and this can be representative of most residential areas in Kwekwe. Mbizo was chosen because it has many sections fromMbizo Section 1 to Mbizo Section 22. From the graph, it can be seen that households with high number of occupants produce a high number of wastes per day.

Waste generation amounts by household size HSW generation rate per capita per day (g/cap/day) were observed. The result showed that the HSW generation rate was a positive correlation between solid waste generated and population density per household. This figure also showed the waste generation rate of main compositions, such as biodegradables, cardboard, food, plastic, paper, metals and glass. The results mentioned that their generation rate were also positively correlated with the household size. This finding explained for the lower quantity of HSW generation rate of this study. The survey was conducted following the household size distribution mentioned above with the average 5 residents per household.

Waste generation was found increasing gradually with the increase of income per month by different socio-economic groups. This increasing trend was also found in the research conducted by Sujauddin *et al*., (2008). The waste generation rate shows a positive correlation

with the socio-economic groups, which is similar to what was observed in a study undertaken in Morelia in 1998 (Buenrostro *et al.*, 2001). Some samples were also taken to compare results in the figure 4.3 above for Mbizo and for the medium density residential areas; Fitchlea, Masasa Park, Southwood, New Town, Westend and Gaika and the results supported the following line graph shows the positive relations between population density and solid waste generated. Figure 4.6 shows results for the waste generated per household size. Regarding the HSW composition, the higher the population density class generated larger amounts waste produced.

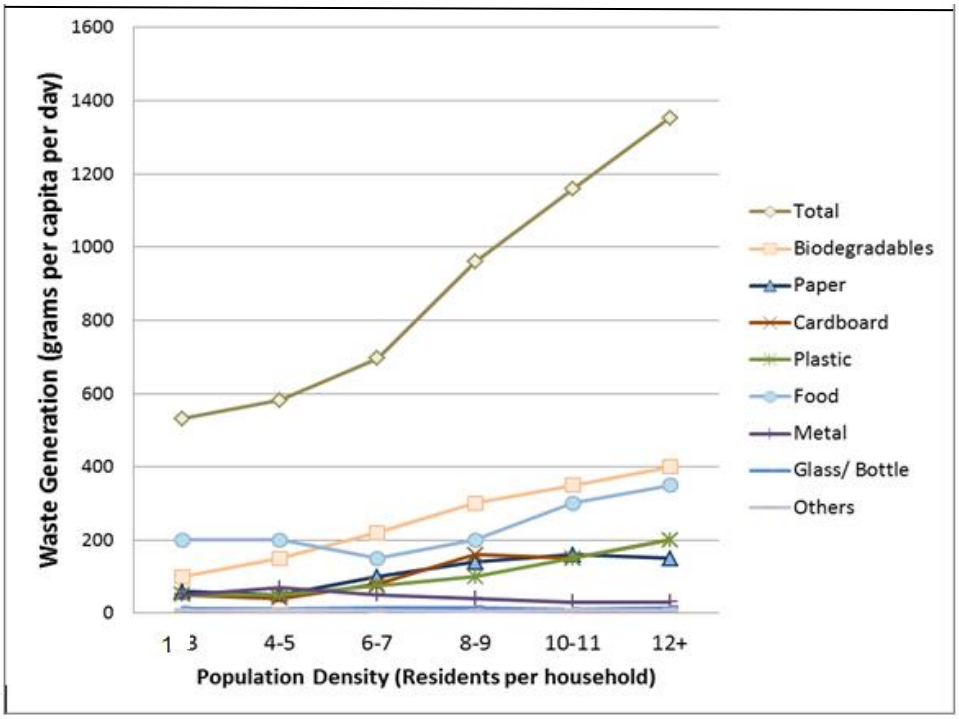


Figure 4.4: Effect of population density on solid waste generated per capita

5.5 Education and solid waste produced

Household with higher education were more careful to waste sorting and have a higher attention to environment and health. Hong (1993), Callan and Thomas (1997), Judge and Becker (1993), Reschovsky and Stone (1994) and Duggal *et al.* (1991) estimate that education increases recycling, while Fullerton and Kinnamann (1999) estimate that household with higher education generate lower refuses. In high density residential areas, the percentage of educated population is low compared to low density residential and this can explain the abundance of litter in high density residential areas, see Figure 4.5.

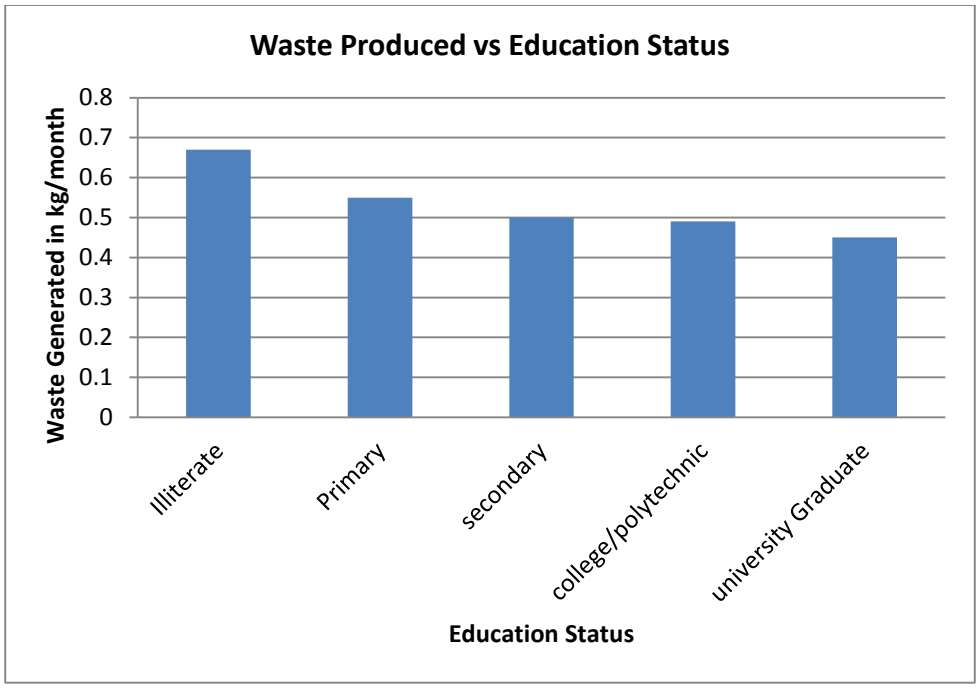


Figure 4.5: Relationship between education status and solid waste generated

In addition, family income is associated (P<0.05) with education and occupation of head of households. The value "p" refers to the sample of population size selected with various levels of education.This is probably because employment as a source of income may depend on the level of education and occupation of individual household head. Although these families showed marginally less per capita waste generation, yet total generation of waste from the educated and affluent households was larger than the noneducated, poorer households because the proportion of those people who were in the lower level of education.

5.6 Environmental awareness

There was generally lack of adequate environmental awareness campaign among residents. Information from the Municipality questionnaire showed that only two Environmental Awareness campaigns were done during the course of the study period. It is found that environmental awareness is very low among the residents, stringent regulations with environmental awareness programs for household sorting and composting can reduce the volume and quantity of waste littered. These were done during commemorations of the World Environment Day at the civic centre on the 5 June 2013. Majority of Kwekwe residents testified that the City Council is not doing enough to educate the residents about the importance of the clean environments. Some were even making reference to the cholera and diahorrea outbreaks of 2005 and 2008 to the lack of environmental awareness and the inability of the City Council to cope with the refuse.

5.7 Disposal method according to population density

According to Sibley and Liu (2003), active littering involves conscious disposal of waste in unconcerned manner (as in somebody dropping waste on the street and continuing walking) is less resistant to change than passive littering (as in somebody dropping a litter on the bench while seated and failing to remove it when leaving). It was noticed during field observation in this research that the predominant form of littering (indiscriminate waste disposal) was active littering, and hence there could be considerable improvement in public indiscriminate waste disposal with the implementation of the right policies. Figure 4.6 shows the waste disposal methods in Kwekwe.

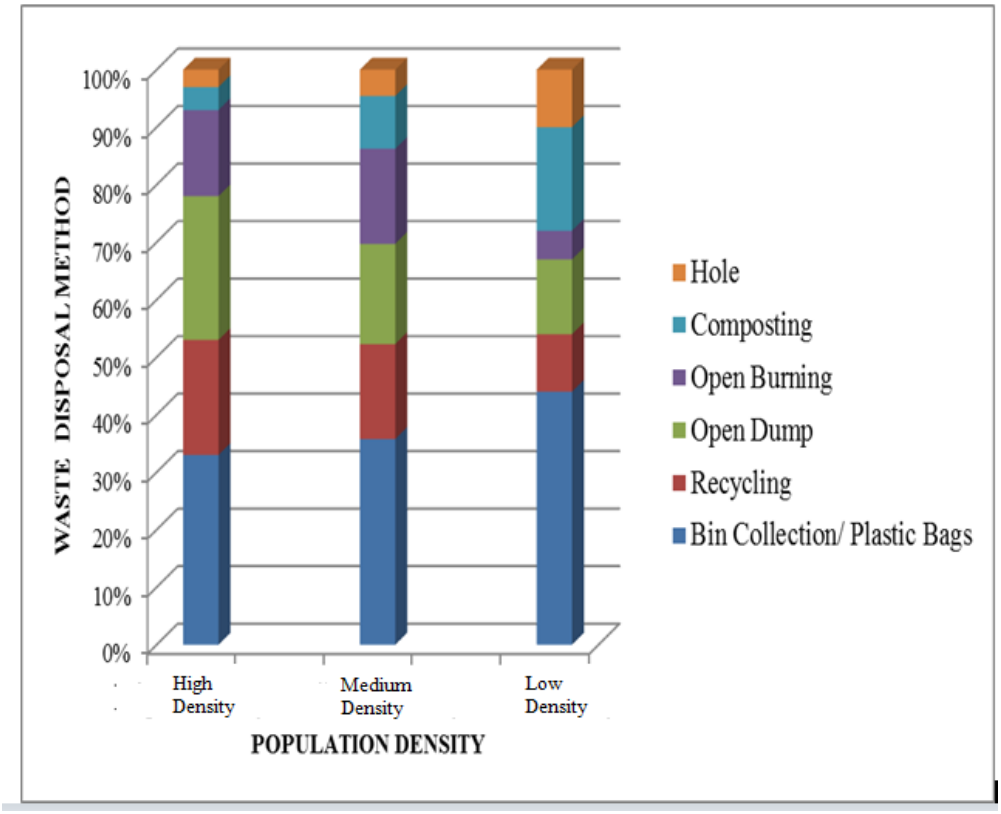


Figure 4.6 Waste disposal methods

Waste management and disposal is a pressing issue the world is facing today since a high percentage of waste is currently disposed by open dumping, (Schiopu, *et al.*, 2007; Abdelnaser and Gavrilescu, 2008; Abdelnaser *et al.*, 2009 and Narayana *et al.*, 2009). This is the case in the city of Kwekwe where open dumping increases with population density leading to land pollution especially in Mbizo and Amaveni residential areas.

5.7.1 High density population density in relation to disposal patterns

Whilst bin and plastic collection has the highest disposal method of 33%, open burning and dumping is quite significant in all residential areas, In high density residential 25% of waste

are disposed on illegal dumps and 15% of the waste are burnt in open spaces giving a total of 40% of the waste resulting in land pollution. In medium density residential15% of the waste are dumped as waste in open spaces and 15% of the materials are burnt in open spaces as waste resulting in land and air pollution. In low density residential 14% is disposed on open spaces and 4% is burnt in open spaces. From this analysis it can be concluded that land pollution increases with population density or decreases as income increases. Recycling done in high density residential such as Amaveni and Mbizo is not by choice but due to poverty, it comprise of 20%. Tins, plastic materials and bottles are reused in houses for various purposes

The 60 litre container bins provided are not used for the intended purpose for waste storage, but are used for other purposes in the house such as water containers and for storing mealie-meal. This contributes to land pollution in high density location such as Mbizo, Amaveni, Globe and Phoenix, Roasting Plant and Stewards.

5.7.2 Medium density disposal patterns

Bin collection is dominant with 35% there so many variations with other forms of disposal. Recycling and open dumping has slightly decreased. Households in the lower middle income are the ones who practise recycling and open dumping method. Of interest is composting and burying method which increased significantly. Composting is done by those who grow vegetables and other crops since their yards are slightly bigger than those in the high density residential. Some of the residents can afford hiring push –cuts to go and dump the waste at the dumpsite. The medium density residential areas include Masasa Park, Fitchlea, South wood, Westend and Glen Wood and the newly inhabited Sunrise.

5.7.3 Low density disposal patterns

Most of the municipal solid waste (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 (Zurbrugg, 2002).

Majority of the residents showed that bin collection is high as 44%. Open dumping and recycling is very minimal. Composting is very important in these areas, it constitute 18%, this because of the big yards per household approximately 1 acre in area. They have enough room for market gardening in their yards unlike in the high density areas. Residents in these areas

do not only wait for the municipality to collect the waste but they sometimes use the open trucks to carry the waste to the dumpsite.

The only legal dumpsite is at Amaveni and is not lined which is located in a water course and liable to polluting the surface water and the underground water with the leachate it produces. The one located near Mbizo section 9 was closed few years ago and this used to an industrial dumpsite. A total of forty one (41) illegal dumps (see Appendix 2) were mapped in Kwekwe residential area. Illegal dumping is common in Mbizo residential area and Amaveni area where each and every house has a dumpsite. Benchmarking of illegal dumpsites was done in Amaveni and Mbizo Extension where dumping was quite rampant and the results are shown in Appendix 3.

According to this study, the monthly family income and educational status of the waste generators have a statistically significant ($P<0.05$) relationship with the type of disposal systems applied. A higher family income and educational status is associated more with (private or municipal) waste collection and less with the application of open dumping, back yard, and open burning on figure 4.2 and 4.5.

Once waste has been collected, there are three basic alternatives for MSW disposal (Daskalopoulos *et al.,* 1998); direct dumping of unprocessed waste in a sanitary landfill or open dump, processing of the waste before final disposal (reduce waste volumes) and processing of the waste to recover resources (materials and or energy) with subsequent disposal of residue.

Simple open dumping has been the most common option because it is a cheap, fast, and a convenient mode of disposing of wastes in many developing countries (Rotich *et al.,* 2005). The open dumps are responsible for the different environmental, aesthetic and health hazards (Shekdar, 1997). Illegal dumping and open burning are frequently associated with open dumping. Illegal dumping (also known as fly dumping or midnight dumping) is the littering of waste that occurs at abandoned industrial, commercial, or residential buildings; vacant lots; and poorly lit areas such as roads and open waters (USEPA, 1998).

Affluent people dispose much and also can afford better waste management systems. Finally, the higher is the population density, the better MSW management is required due to sanitation problems and the cost of land. In most cities of developing countries, waste

management is inadequate: a significant portion of the population does not have access to a waste collection service and only a fraction of the generated waste is actually collected. Systems for transfer, recycling and/or disposal of solid waste are unsatisfactory from the environmental, economic and financial points of view.The 'controlled disposal rate' is more or less a parabolic function that goes up as GDP goes from low to high, then peaks, then drops as cities modernize and put increasing emphasis on diverting materials from disposal.

5.8 Constraints faced by the municipality

5.8.1 Financial constraints and solid waste budgets

In a developing country framework, though solid waste management accounts for 20 to 50 per cent of the municipal budget (Schübeler 1996, Bartone 2000), the service is provided to only about 50 per cent of the urban population; actual collection only accounts for around 60 to 70 per cent of the refuse (Gerlagh *et al.*, 1999, Khawas, 2003).

Solid waste management is given a very low priority in Kwekwe. Very limited funds are provided to the solid waste management sector by the government, and the levels of services required for protection of public health and the environment are not attained. Financial problems are the main reasons for inadequate disposal of solid waste especially where the ministry is underfinanced and population growth continues. The financial problem is acute at the government level where the local taxation system is inadequately developed and, therefore, the financial basis for public services, including solid waste management, is weak.
The lack of financial management and planning, particularly full cost accounting, depletes the limited resources available even more quickly, and causes several services to halt for some periods, thus losing the trust of service users. According to the questionnaire results it revealed that other residential locations can go even for over a month without collection and transportation of refuse.

5.8.2 Technical constraints

Another technical constraint is the inadequate disposal of solid waste: most of the solid wastes are dumped in an uncontrolled manner in different space locations normally called open dumps. These dumps make very uneconomical use of the available space, give waste pickers and animals free access to the dumps and often produce contamination of the environment. Lack of reliable waste statistics and waste characterization studies to define the quantity and quality of waste generated were never implemented. As a result, improving the disposal site would have little impact on the overall solid waste management effectiveness.

5.8.3 Institutional Constraints

Lack of coordination among agencies such as EMA, NGOs, and the Municipality often results in limited support to other agencies projects. This leads to wasting of resources, and unsustainability of overall solid waste management. The lack of effective legislation for solid waste management is partially responsible for the roles/functions of the relevant national agencies not being clearly defined and the lack of coordination among them.

Another problem is the lack of enforcement of existing legislation, particularly about the prevention of littering and indiscriminate dumping of waste. It should be also noted that legislation is only effective if it is enforced. Other common problematic areas are the improper quantity and quality of staff dealing with waste management related issues. Without adequately trained personnel, the projects initiated will not be continued on the long term. The government is not well equipped with technical, managerial, autonomous capacities and due to strong political wills they can hardly issue proper policies, measures, bills and/or regulations suited for waste problem's prevention and solution.

5.8.4 Social constraints

The low public awareness and school education about the importance of proper solid waste management for health and well-being of people severely restricts the use of community-based approaches. People are still throwing waste out of windows from buses and cars; others are dumping their waste in canals, along the streets and vacant plots. At dump sites waste picking or scavenging activities are common scenes, vagabonds and animals (dogs and rats) are frequently disturbing street refuse bins. The waste pickers involved have received low school education and they are affected by limited employment opportunities available. The existence of vagabonds/animals creates sometimes an obstacle to the operation of solid waste collection because they are littering the content of the waste bins. Waste collectors do not receive vocational training to obtain knowledge and skills required for their jobs so they do not understand the importance of their work and behave also in that way.

5.8.5 Routing and service schedule

Kwekwe like most developing cities in Africa faces the challenge of ensuring effective and consistent solid waste collection. As noted in the preceding chapters, population increase, urbanisation accompanied with industrialisation has resulted in an increase in the demand for waste collection and other various services. Apart from having adequate equipment in the

waste collection process, routing and service scheduling are important aspects that cannot be overlooked.

Routing in general is the process of selecting paths in a *network* along which to send physical traffic i.e. the determination of the most efficient route (s) that people, goods, materials and or means of transport have to follow. Routing in solid waste management is therefore the process of determining which is the best (cost-effective) or easiest way to collect waste from one point A (e.g. households to another point B). Routing is a practical activity, which must be conducted at the site where the waste collection and transportation will be taking place. This is important because it helps you establish factors of consideration for the overall planning of your Waste Collection Business. Some high density residential areas of Mbizo are too large and the roads are not well connected and some areas are inaccessible which makes it difficult to efficiently collect the bins. Mbizo residential location has sections from 1 to 22. However some sections like Mbizo section 14 has no well- defined roads to allow free movement of waste vehicles and this leads to land pollution.

Service scheduling in general is setting an order and time for planned events i.e. the determination of when each process or task runs, including assignment of time frames. Service Scheduling in solid waste management refers to the step-by-step determination of suitable or ideal timed schedules for the effective/efficient collection and transportation of solid waste in a certain area/neighbourhood. In any neighbourhood/locality, there are many possible routes that can be used to collect waste from the household units to the transfer stations or disposal sites. Mbizo and Amaveni residential areas have too many roads and open spaces and therefore the municipality have to come up with appropriate routes to collect the wastes. However one question that needs to be answered is, *"Which route is the best (or more cost-effective)?"* That is to say, which route is the easiest to manoeuvre on, or which one takes you to the desired destination in the shortest possible time with minimum effort and least inconvenience? As earlier mentioned in the Waste Collection, Transportation and Disposal Session, most of the costs are related to transportation of the waste. The type of route you choose therefore has an effect on the profit levels of your waste collection business.

5.8.5.1 Challenges to effective routing

The rate of growth of urban centres in Zimbabwe has exceeded the capacity of municipalities and local authorities to respond effectively to service delivery challenges. Waste management

has become one of the major challenges confronting urban local authorities in Zimbabwe. There is an increase in migration from rural areas to urban areas in search of employment. Urbanization resulted in increased social and environmental problems and an increase in the demand for solid waste management services. Because of this, effective routing and service scheduling has become a challenging waste management system activity at either community base level or municipal level. The following routing and service scheduling challenges have been observed at Kwekwe Municipal/Local Authority Level:

i. Inadequate provisions for and frequent breakdown of solid waste collection equipment;

ii. Rampant illegal dumping of waste in undesignated places; see appendix I, Figure 5.4

iii. Emergence of unplanned illegal residential areas;

iv. Centralisation of waste collection system that cannot cope with the rapid urbanisation and relatively high waste generation rates. In Kwekwe there is no other organisation or which assist in the collection of the solid waste and this makes it difficult to provide full service to the residents. One clause of the Kwekwe Municipality is to provide sufficient and efficient service to the residents; however, this has never been achieved for the past decade of years.

v. Lack of adequate expertise, information and training on how to plan and effectively manage some wastes., most of the solid waste workers in Kwekwe Municipality are unskilled and very old to effectively implement sustainable management of solid waste system.

5.8.6 Financial funding

Kwekwe is supported by gold mining activities and heavy industries such as ZISCO, ZIMASCO, Haggie Rand, Lancshire, Begom Engineering, Oliken and Kwekwe Metal. However, their ability and capability manage wastes was compromised during the national economic meltdown in 2008. In addition, these companies do not manufacture spare parts for the equipment or vehicles used in solid waste management. This results in erratic collection and transportation of solid to the dumpsite leading to land pollution.

The amount of money budgeted for the solid waste management in Kwekwe was above US $40 000 per month, this was for the period 2012 to 2013.Specific figures were not obtained during the time of the research .This figure is by far too low to cater for a sustainable management of the solid waste management in a growing city like Kwekwe. The amount of fee charged for refuse collection is US$2.10 per house household per month.

Using the city's population of 24 779 people (ZIMSTA, 2012), it means Kwekwe Council collects US$52 035.90 per month. This amount is expended on the following: workers'

salaries for approximately 53 workers excluding top management staff, and wages; repairing vehicles; fuel for transporting the refuse; detergents and other chemicals, workers' protective clothing among other expenses.

It is therefore clear that the amount charged for waste management is not enough considering the expected expenses. Also records show that there are a number of household defaulters. Collection of waste once per week is not enough to reduce solid waste dumping leading to land pollution. The demand for better services caused local government budgets to become more strained and political pressure to reduce the size and cost of government becomes more popular (Leavitt, 1994). Other constraints that have reportedly faced the public sector include excessive staff, obsolescent equipment, cumbersome procurement procedures, and inflexible work schedules, limitations on management changes, inadequate supervision, and strong worker unions (Suocheng, D. *et al.*, 2001).

The technical and administrative capacity to properly implement sound mechanisms for waste management is weak. This can be traced to lean financial, human and material resources which bedevil councils. It is worrying that Zimbabwe still lacks appropriate and effective technologies in waste management. In addition, the country's deteriorating infrastructure has resulted in poor waste management which has seen an accumulation of waste and outbreaks of diseases (Machivenyika, 2012).

5.8.7 Waste records

It was regrettable that the Kwekwe Municipality records of solid wastes were in shambles. The last records were done in 1999. There is a serious paucity of waste records in the municipality of Kwekwe .Currently no dumpsite attendants are at the only Amaveni dumpsite. It is also high time the Kwekwe .Waste Management Department to construct a weighbridge at the dumpsite because currently there is none. The Municipality is operating without clear targets as to how much should be collected, transported and disposed. At the dumpsites there were no current records of the amount of solid waste dumped at the dumpsite, neither was there any weighbridge to weigh the solid waste brought by the refuse trucks.

Creation of a waste information system (WIS) is an alternative to the lack of solid waste data because it is important and obligatory for stakeholders to know who produces what types of waste and how much of it. Reporting of this waste information must be published to the

general public on a yearly basis. The information must also be submitted to other departments (e.g. Health and Environmental department) for their data processing, their spot checks, environmental state audit - and state of environment report. The following practices are recommended for those seeking to improve their operations and maximise on profits:

i. Setting up proper administrative structures to facilitate proper planning of activities and operations.

ii. Establishing a database of waste management system/operations capturing all information relating to routing, operation area, generation rates, area maps showing infrastructure and road network system and waste types etc.

iii. Periodically reviewing performance and internal and external auditing of operations with assistance from environmental consultants.

iv. Making plans based on accurate calculations to determine suitable and adequate equipment and set up cost-effective routes, service schedules and labour distribution.

5.8.8 Kwekwe City (Public Health) By-laws of 1981

The Kwekwe city by-laws were extracted from the Environmental Management Act (EMA) (Chapter 20: 27) of 2003. The laws are basically meant to empower Local Authorities and EMA to protect the environment and control diseases. The following relevant sections of the by-laws are used by the Kwekwe City Council (KCC) to control improper waste management: Depositing or causing or permitting to be deposited refuse on any premises, public place or undeveloped land burning on premises any weeds or refuse, rubbish or paper, or other offensive matter so as to cause a nuisance and depositing on or permitting to flow to any land whatsoever, trade effluent or other dirty or offensive waste. The by- laws also stipulates embraces the polluter-pays principles (PPP) that are widely used as tools for environmental management globally. The KCC also has the mandate to serve written orders on any suspected breaches of the Act and/or adopt such measures specified in the orders to protect the environment; to regulate and monitor the collection, disposal, treatment and recycling of waste; regulating quality standards on waste management; to make model by-laws to establish measures for the management of the environment within the jurisdiction of the local authorities and to carry out environmental audits of all the projects in its jurisdiction. However, the problem of low fines and few personnel militate against its effectiveness resulting in land pollution in Kwekwe City residential areas.

5.8.8.1 Effectiveness of the City Council by-laws

Another important measure would be for both central and local governments to craft and invoke policies, regulations and laws that are meant to implement the polluter-pays principle. This would complement waste management initiatives by waste generators themselves. A portfolio policy on intervention to solve the problem would demand and dictate that resources be marshalled to solve the problem. While a legislative framework for managing waste is in place in Zimbabwe (EMA), there is no enforcement. There appears to be an apparent reluctance by government departments to prosecute local authorities that violate provisions of the legislation. The implementation of EMA has been quite lethargic as indicated by the small number of offenders who have been either fined or tried for contravening the law. Another legislative weakness is that fines prescribed are too low, rendering effective enforcement difficult. The fines and sentences imposed for flouting the law are not deterrent enough. There is need to review the current Municipal by-laws to achieve sustainable solid waste management. Interestingly, EMA provides for environmental entitlements for example the right to a clean environment, yet these rights are not enshrined in Zimbabwe's constitution and are difficult to enforce. Worse still, the intended beneficiaries of the entitlements are not aware of these rights hence the need for environmental education and awareness to ameliorate or better still circumvent the problem.

Current legislation emphasizes end-of-pipe solutions rather than tackling them at the source via waste minimization through reduced product packaging by manufacturers and supermarkets selling, rather than giving plastic paper bags free.

5.8.8.2 Weaknesses of existing laws

As the written laws' strength is in providing a framework for enforcement, the major weakness is the lack of effective enforcement in practice. This is due to a lack of resources, such as manpower and logistical support like transportation, in the institutions charged with enforcement. For example a nuisance can be reported but the personnel responsible would have no means of getting to the scene due to lack of man power or transport. Lack of concern for statutory duties: unwillingness by shopkeepers, factories, and institutions to adhere to statutory duties such as maintaining storage containers for waste. Lack of public awareness on the existing laws and regulations and a general decreasing level of sensitivity, concern to aesthetic standards and quality of the urban environment by the population, results in illegal

dumping leading to land pollution. Lack of proper guidelines on how the private sector can operate with the Council in providing effective SWM is also a cause for concern. The laws are in principle effective, as they cannot be overridden by any other laws. When fully enforced the new existing laws and the Waste Strategy can assist in putting in place an effective system of solid waste management that improves the health situation and reduces the present environmental contamination and pollution.

5.9 Effects of land pollution

Environmental degradation is quite evident in residential areas of Kwekwe. The aesthetic value of high density residential areas such as Amaveni, Mbizo, Roasting Plant, Globe and Phoenix has seriously deteriorated to deplorable levels. Environmental and health problems are quite common in high density areas were illegal dumping is rampant, see table 16.

a) Illnesses: residents expressed concerned over poor and erratic solid waste collection and dumping. Residents especially in Amaveni, Globe and Phoenix and Mbizo reported that they suffer from a number of diseases such as diahorrea, cholera, malaria, tuberculosis especially during the summer season, typhoid and dysentery. It was therefore noted that there was a causal relationship between solid waste dumping and health problems. Residents in the medium and low density residential reported that the problems and frequency of such diseases were rare in the locations. However, efforts to get the statistics of such cases were fruitless at the general hospital and the local clinics. Results of the questionnaire analysis showed that there is a positive relationship between the prevailing illnesses and the disposal methods in different residential areas.

b) Poor drainage: During the rain- season it was observed the flooding was quite common in high density residential areas due to blockage of canals, storm drains and roads. This phenomenon was common in Mbizo Section 7 and in Amaveni. The stagnant water created the breeding places for mosquitoes and frogs. Storm drains were chocked by plastic materials, empty tins, garden trimmings, ceramic materials, pots, diapers, bamboos, faecal matter, rags, ash worn out tyres and other rubber materials.

c) Pseudo dumps: This was a manifestation of land pollution in high density areas. Some of the roads were almost closed by solid waste dumped very close to roads making it difficult for vehicles to pass through leading to accidents, see Figure 5.4. This also makes routing systems in Kwekwe very difficult in roads characterized by potholes. These dumps also leak

leachate which contaminate groundwater reserves, surface water including streams. Greenhouse gases (GHGs) and carbon dioxide and methane are also emitted into the atmosphere.

Strong odors from these dumpsites were one of the major complaints from the residents. Flies, rodents, rats, mice, snakes, lizards could be seen on dumpsites. Dogs usually worsen the situation by spreading the garbage allover scavenging for the food making the area very unpleasant. The environmental impacts of uncontrolled dumping are most acutely felt at the local level. Dumpsites are usually located in or adjacent to poorer communities, where the land costs are lower, and it is politically and socially easier to locate and continue to use these facilities.; Ogawa (2005), Manyanhaire, *et al.*,(2009), Masocha and Tevera (2003) and Zurbrügg (2002) noted in their various studies that solid waste management systems in developing countries in general face challenges that include low collection coverage, irregular, inconsistent and inadequate collection services, crude open dumping, and burning without air and water pollution control.

5.9.1 Complaints by residents

Residents had many complaints against the municipality's way of operation and handling of the solid waste. Information from the questionnaire shows that low collection frequency contributes heavily to land pollution. It is also evident that the waste collectors are not very punctual in their time –table to collect the solid waste leading to land pollution as well.

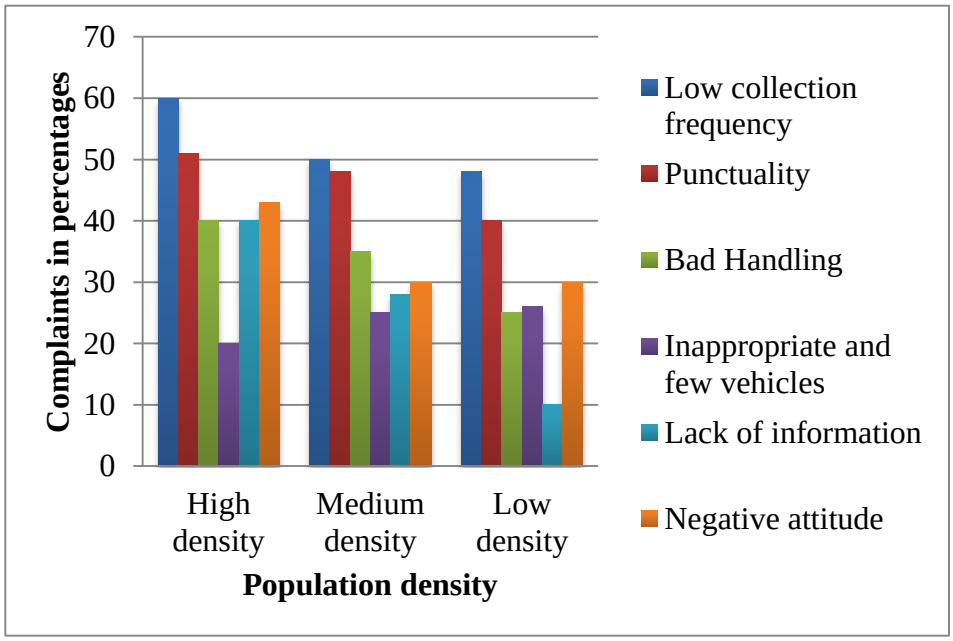


Figure 4.7 Complaints by Kwekwe residents with regard to waste management

Punctuality: Residents place their bins in front of their homesteads in the morning but sometimes it is collected in the afternoon or not collected. Dogs and chickens scattered waste around and these results in land pollution. This is common in high density residential areas where houses do not have durawalls and bins are placed by the roadside. Sometimes collectors come earlier than expected and waste which was not placed outside is left behind. Residents are not informed about the changes in the collection days and times. From the results obtained it is clear that punctuality of waste collectors commands the second position in terms of the complaints which the residents feel that it is a cause of land pollution in the residential area.

Low collection frequency: In all the three residential areas, the low collection frequency by the waste collectors has the largest number of complaints which the residents feel that it's the main cause of land pollution in the residential areas especially high density residential areas

Waste rots and produces bad smell for more than a week. Residents are forced to dump their waste elsewhere in open spaces because the bins are not big enough to contain all the waste.. In some cases one would find litter around the bins as a result of overflow from the bins.

Bad Handling: Residents complained that the waste collectors throw their bins carelessly and sometimes the break. Waste collectors spill trails of waste which they do not pick. Waste collectors do not really stop to empty the bins but they do it hurriedly spilling over litter everywhere leading to land pollution.

Inappropriate vehicles: Tractors used are sometimes too full and leave trails of waste in the roads. Tractors produce a lot of noise as they transport the waste to the dumpsite: One of the tractors does not close well to cover its waste so trails of wastes along roads.

Lack of information: No educational campaigns are carried out to educate the people about the waste. Residents would like to recycle but they do not have adequate information on how to do it. Residents in the low density residential have shown that the have the knowledge of recycling and up keeping the environment, Most of the residents in the high density have indicated that very little effort done by the municipality to educate them about the environment and campaign for anti - litter in the streets and open spaces.

Negative attitude of waste collectors: Sometimes the waste collectors are rude and disrespectful. Some of them also complain about low wages and lack of training for the job. The waste collectors usually throw the bins everywhere after they have emptied the bins. This does not show respect and some of the plastic bins are carried away by wind dropping littering. The issue of negative attitude featured prominently in all residential areas.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

For an effective and sustainable management of solid in Kwekwe, the municipality should implement the recommendations discussed below. The best way to solve the problem of pollution is to look at the source and not to treat the signs of pollution as what has been done in Kwekwe. Below is a well-developed flow diagram which shows effective management of solid waste recommended by the International Labor Organization (ILO). Solid waste management should start from the producer of the solid waste and in this case are the residents and complemented by the Municipality. Proper implementation of the solid waste hierarchy management will help improve the MSW in Kwekwe.

6.2 Conclusion

The objectives of the research have been addressed and both the qualitative and quantitative methods used in the researched show that land pollution is positively related to population density. The correlation analysis indicated that a higher family income and educational status are associated more with (private or municipal) waste collection and less with the application of open burning, back yard, or open dumping. Back yard disposal and open dumping were the most common practices among the low-income families with household heads typically being daily labourers and housewives. In contrast, private waste collectors and municipal containers were used by government employees and merchants that have a permanent and relatively higher income. This is due to their capacity to hire someone for collecting and transporting the waste to the Amaveni dumpsite and other pseudo dumpsites. This study also examined the management of MSW in different locations of Kwekwe and attributes the pressure or impetus on governments to manage the generation and disposal of wastes (called here the "MSW Index") to the product of two measurable factors: Affluence (as measured by the income per capita) and population density. A higher standard of living results in more wastes and also greater ability to invest in waste management systems; high population densities imply scarce land resources and thus more pressure to preserve land and environmental quality.

Proper management of waste requires that all the 5 aspects of waste, i.e. generation, storage, collection, transportation and disposal should be managed well – the volumes of waste that are generated should be controlled and minimised wherever possible; storage containers

should be adequate and suitable; collection should be frequent; transportation vehicles should be appropriate for the purpose; and disposal of waste should be at dumpsites.

This is evidenced by the illegal dumps that have become a common feature of almost every suburb in urban areas, and is particularly glaring in most high density suburbs such as Mbizo and Amaveni and this poses a threat to human health and environmental well -being.
At the generation stage the amount of waste that is produced by residents, is unsustainably high, as there is little in the way of integrated waste management that is practised. As a result, the local authority, which has the mandate for providing storage facilities, collecting and disposing of waste, fails to cope in a lot of cases. According to International Labour Organisation, (2007) research has shown that 72% of what is discarded as waste can be recycled, reused, composted or processed into other goods.

Another major problem with the current waste generation patterns is the failure to separate waste at the point of generation. If waste is not separated at source, it becomes difficult to apply any integrated or sustainable waste management techniques, such as reusing and recycling.

For the storage of waste, local authorities have the responsibility to supply bins in which waste is temporarily stored before collection. A number of local authorities have been unable to supply adequate storage bins especially in public places, and as result, littering has become one of the biggest problems in such towns and cities, turning some public places into environmental eyesores as people throw waste indiscriminately on the ground. It is important to note that even though there are inadequate bins in public places, the public at times exhibit very negative attitudes and choose to throw litter on the ground even in places where bins are provided.

Efficient municipal solid waste management systems require professional management, supported by an informed population and appropriate legislation and policies. The key drivers that help waste managers to plan and implement more integrated waste management systems are (Wilson *et al.,* 2001): vision and stability, waste quantity and composition, adequate funding legislation, combination of policy instruments, and public support. In the case of residential waste, the major factors affecting the amount and type of waste generated are household size, household age structure, household income, type of dwelling, geographical location and time of year (Rushbrook and Pugh, 1999).Many other researchers as Dennison *et*

al., (1996a, b), Buenrostro *et al.* (2001), Gomez *et al.*, (2008), and Qu *et al.*, (2009) mentioned that household socio-economic and demographic characteristics affect to waste generation. Land pollution resulting from mismanagement of solid waste varies from one residential area to the other due to differences in socio-economic parameters. This study also found that there is a relationship between the relevant factors, such as population density level, urbanization level, household income and household size and the HSW generation rate. These relationships are also useful for sustainable management of solid waste in Kwekwe and other cities in Zimbabwe and needed for further researches on household solid waste.

6.3 Recommended waste management strategy

Currently in cities in Zimbabwe, recovering and recycling of solid waste is a small business because:

i. The activities are a major source of income and livelihood to just less than of 1% of the total urban population;

ii. Less than 10% of waste paper, plastics and scrap metals are recycled nation wide

iii. Recycling is confined to plastic, scrap metal, paper, cardboard and glass bottles (mostly soft drinks – deposit refund systems) because of substantial demand and being a significant constituent of solid waste.

Kwekwe city council should work towards achieving the above percentages on solid waste management. Based on the research findings, it is recommended that a waste management flow diagram propounded by ILO (2007) should be implemented in Kwekwe. Figure 6.1 shows the recommended waste management.

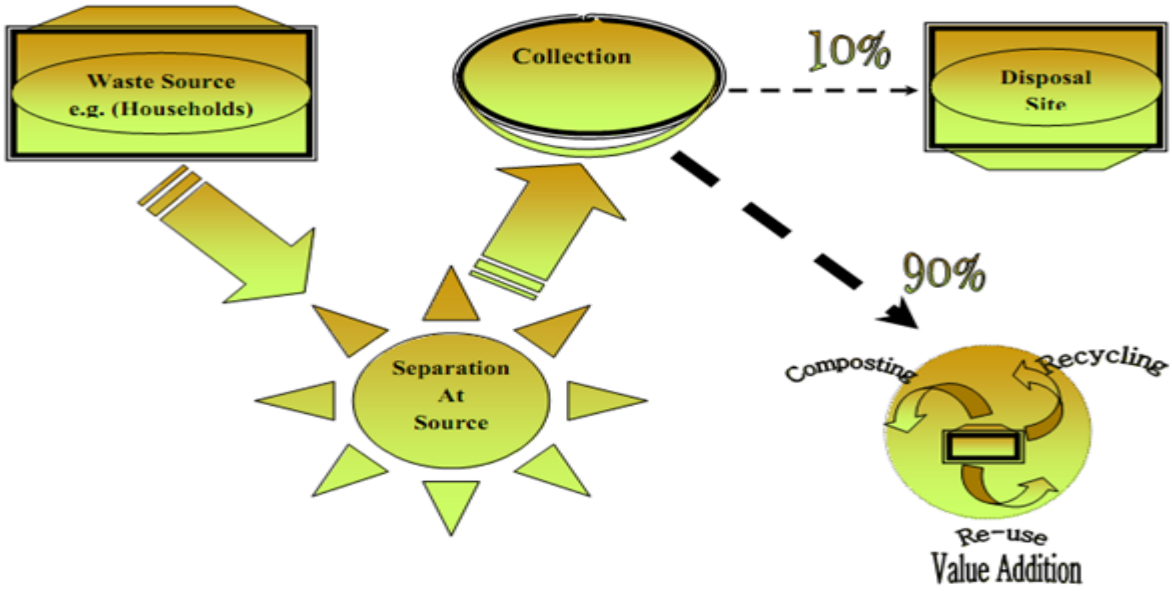


Figure 4.8 Recommended waste management

Source: International Labour Organisation, (2007, p.67)

From Figure 4.8 , we see that all solid waste must be separated and sorted at source before collection for either recycling, re-use, value addition or for disposal ; this way, Municipal Authorities and agents would collect less than 10% to the disposal/landfill sites and at least 90% of the waste will be reused and recycled; however, this requires establishing temporal storage sorting centres, awareness and incentives for public participation and there are several economic, social and environmental benefits to it.

.

However, most community-based organisations /enterprises face the challenge of improving their operations through proper routing and service scheduling. The following practices are recommended for those seeking to improve their operations and maximise on profits:

i. Setting up proper administrative structures to facilitate proper planning of activities and operations.

ii. Establishing a database of waste management system/operations capturing all information relating to routing, operation area, generation rates, area maps showing infrastructure and road network system and waste types.

iii. Periodically reviewing performance and internal and external auditing of operations with assistance from environmental consultants.

iv. Making plans based on accurate calculations to determine suitable and adequate equipment and set up cost-effective routes, service schedules and labour distribution.

Significant waste reduction takes time to achieve and requires large numbers of households to change their consumption patterns and daily habits.

6.3 Promotion of the 3Rs

The 3Rs comprise reducing, reusing and recycling of waste should be promoted as they are key principles and practices in achieving a sustainable integrated solid waste management system. The present rates of householder participation and recognition in waste minimization is too small. An approach to influence households' attitude to waste minimization is focused on two factors: waste minimization at point of purchase; named buying to reduce waste (buy long-life products, buy goods with minimum of packaging), and repair or re-use of household products; repair/re-use to reduce waste (reuse plastic/glass containers, repair objects). A deposit refund system is recommended and it will greatly help in reducing waste and ensure that waste produced by producers of certain goods becomes the producers' responsibility (Pradhan, 2008). Delta Beverages buy back empty bottles and cans and pay consumers a deposit back for the packages. Such a practice should be promoted and made compulsory to

producers who sale products to residents of Kwekwe whose packaging end up producing waste.

A recommendation is made that for products that are packaged in glass bottles, plastic bottles, card board boxes, foil and plastics (like mealie-meal) a certain percentage be charged as an deposit price refundable when consumers bring back these packages to the producers after use of the products. This system should be supported by collection cages erected and positioned at convenient points and systems and mechanisms to quickly pay back the deposit refund in Kwekwe should be established. Recycling of waste that includes paper, plastics, and metals should be promoted and efforts to encourage recycling companies to operate in Kwekwe should be put in place by the municipality. Public awareness campaigns on recycling should also be carried out vigorously.Therefore, waste minimization campaigns should focus on how minimizing waste which can help to preserve the environment and maintain a good place to live (Tonglet *et al.,* 2004).

6.4 Community based organisations

Another strategy for sustainable urban solid waste management is to adopt a community based approach. Working in partnership with community based organisations (CBOs) and local authorities, initiated projects should use an integrated approach in addressing waste management challenges facing urban settlements. Focus should be placed on improving the urban environment through developing sustainable, community-managed models for water, sanitation and waste management services. Community should be actively involved in the decision making process of solid waste management. At community level, a community based solid waste management on the basis of some guidelines could be attempted. For example, the community might collaborate to improve the level of cleanliness in their neighbourhood by establishing a compost plant, adopting their streets for sweeping, service drain cleaning and loading of household bins onto garbage trucks. At section level, segregation of waste, segregated collection, selling of recyclables, composting of organic wastes and its marketing and monitoring schedule could be adopted as project steps. This can increase public trust and the legitimacy of the initiatives. While local authorities can take a leading role to institutionalize the informal community based activities within their formal waste management, effective decentralization and stakeholder participation can make solid waste management more flexible, efficient and responsive to local requirements and potentials. The introduction of environmental watchdogs in residential areas is also another alternative to monitor environmental offenders in all residential areas. Non -governmental

Organisations (NGO) and private companies must be allowed to take part in the management of solid waste.

6.5 Separation of solid waste

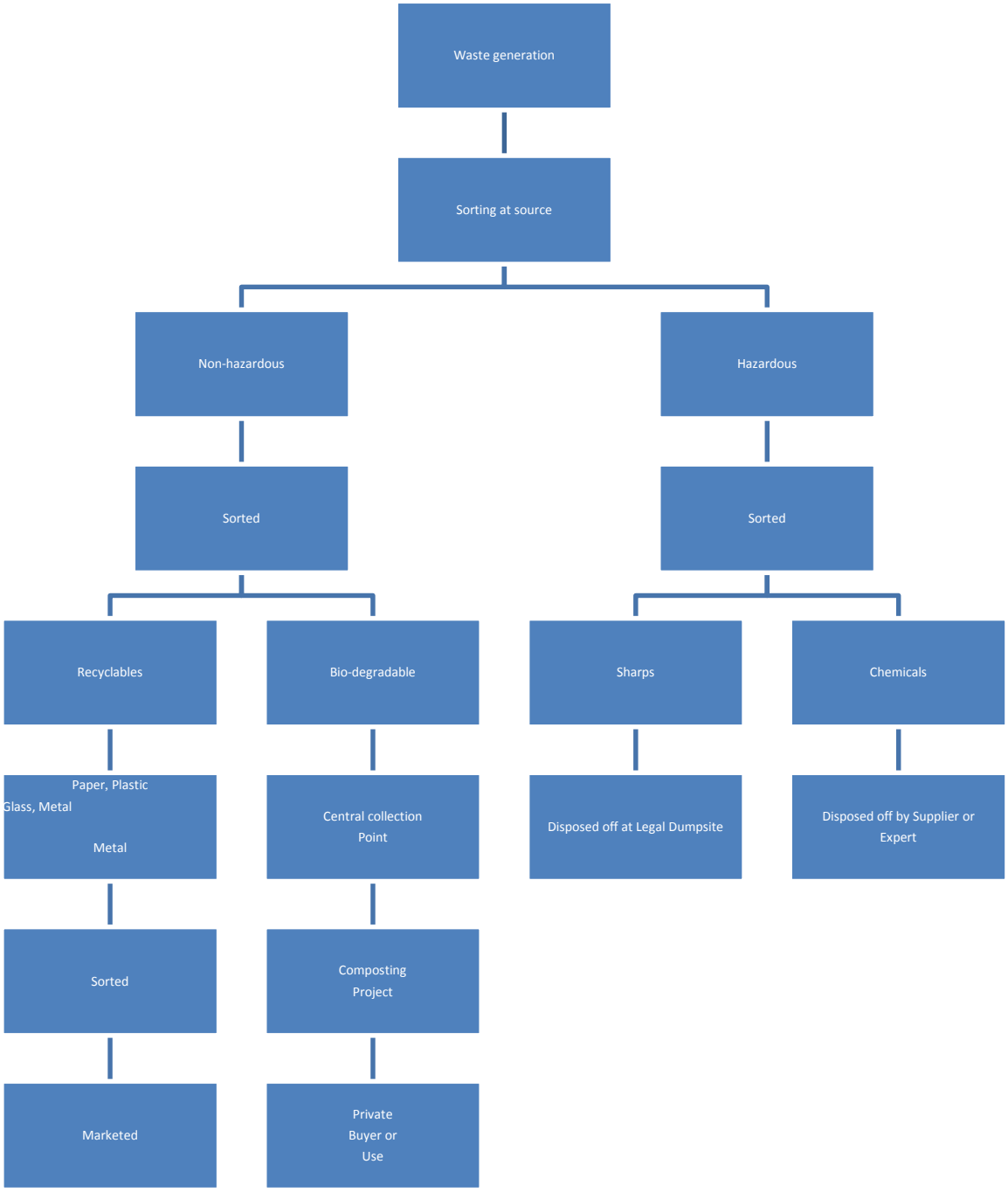
Segregation is vital to all the successive waste hierarchy components (recover, reuse, recycle and reduce). Initiatives should be put in place to ensure that segregated waste can be recycled or reused before the residual is disposed. Waste separation at source is a brilliant idea. Environmentalists are advocating for "separation at source". It involves households binning plastics, food and metal separately, a practice that is popular in developed countries. The waste disposal method is however costly since it requires more bins, yet municipalities are battling to provide just one. Residents would have to supply their bins.

Sustainable solid waste management aims at reducing the environmental impact of waste through return of useful materials in waste streams into the economic cycle. Waste separation at source provides the basis for subsequent processes involved in transforming waste into resources. Source separation of waste into bio and non-bio waste will provide the basis for the development of waste recycling (see Fig. 6.1).The main draw backs to waste separation at source are the expected increase in collection cost and the reliance on the cooperation of the general public for the integrity of the source separated components. The increase in collection cost is not expected to be any appreciable.

6.6 Effective Routing

Good routing and service scheduling significantly improves the efficiency and profitability of any solid waste collection and management operations. Designing the route for waste collection before actual collection is important because it gives you an opportunity to get rid of potential obstacles to the business and helps you to keep costs to the minimum or have a very cost-effective waste collection system. When deciding on the best and most appropriate route; certain factors typical for the particular residential area, locality/suburb/neighbourhood must be considered. These factors include some of the following:

i. Housing density and social class,
ii. Generation rates,
iii. Location of temporal storage areas
iv. The road network and
v. Availability of and type of equipment to be use



.

Figure 4.9 Recommended solid waste separation strategy

Source: International LabourOrganisation (2007, p.6)

6.6 Collection and transport of solid waste

Kwekwe City refuse trucks are too few and too old (Table 14) to effectively collect refuse within a big city like Kwekwe. This together with the bad state of roads characterised by many potholes makes it difficult for efficient solid collection. Shortage of inputs in Kwekwe has resulted in inefficiency in solid waste collection and transportation. The frequency of collection should be increased from once per week to twice per week in high density residential areas because the residents are not able to hire private waste collectors. Kwekwe residential areas have continued to grow; new sections and extensions are being built which means more solid waste is produced. So collection of once per week is not adequate to maintain Kwekwe residential areas clean.

6.7 Timing and service schedule

While one may consider all of the above factors in coming up with good routing system, it is important that a service schedule is drawn up which shows when (date and time) the waste will be collected where. A well-designed service schedule facilitates collection of waste at minimum costs because it ensures that collectors visit an area only when there is sufficient waste to collect. It also ensures that waste does not pile up in the community due to poor service scheduling. A service schedule involves simply planning time and place for waste collection. This can be in the form of a timetable, which states when specific areas will receive the service. Families and households then have to adjust to the given schedule. The collectors on the other hand have to stick to the timetable to avoid inconveniencing the community. However, local authorities should put in place collection methods that would ensure that waste is collected on a regular basis. Collection services should run as scheduled and not in erratic fashion. The frequency of waste collection recommended by the World Health Organisation is as follows:

i. Solid waste must be collected daily in the central business district.
ii. Solid waste must be collected at least twice and thrice every seven (7) days in low income and high-income residential areas respectively, to break the breeding cycle of disease vectors like houseflies.
iii. Waste should not be left standing at shopping centres for more than 48 hours.

Another proposal is the use of skip bins at designated place such as Mbizo 4 Shopping Centre, a place which is central in Mbizo residential areas. The place is central and accessible

from all sections in Mbizo, another skip bin to be placed at Amaveni Shopping Centre and one in Roasting Plant. This will enable residents to empty their full bins in the skip bins or the small trucks to off load the waste in the skin bins.

6.8 Revenue to fund waste management

Revenue generating instruments: these include the various kinds of user charges for the provision of collection, transportation and final disposal services. Revenue providing instruments: seeks to change behaviour by stimulating the private sector to improve its environmental performance, e.g. subsidies or reduction in taxes. Non-revenue instruments: include deposit-refund programmes; combine the incentive effects of charges (when a good is purchased and the deposit is made) and subsidies (when the good is returned or otherwise handled properly and the deposit is refunded) for the management of solid waste. The amount charged for refuse collection should be increased from the current USD$2.10 which is too little for the expenses incurred in the SWM system.

6.9 Packaging materials

The materials used for packaging is a serious cause for concern resulting in land pollution. The Dendairy Milk industry deserves a special mention because it uses a lot of cardboard box and plastic materials which litter the streets for packing its dairy products such as milk and yoghurt. Dendairy should consider recycling its packing materials or a refund system to limit the amount of litter from its company products. Such companies and other companies selling packed products can also contribute financially towards the upkeep of the Kwekwe residential areas. It has been noted that plastic paper bags are the most widely used carrier bags. These are non-biodegradables are seen in the street of many residential areas. I would propose that the use of plastic paper bags should be kept minimal or completely eliminated. This can be done by making them very expensive to customers who want them rather than giving them for free as done in big supermarkets such as OK, TM, Eden, Metropeech, Simrac and many others. Customers should be encouraged to bring their own bags from home. Most products are packed in large containers for marketing and for safety purposes. One scenario which shows the magnitude of this packaging is that, a packed product is marked gross weight 15 kilograms and net weight 10 kilograms, this means 5 kilograms will be thrown away as waste in open spaces polluting the environment.

6.10 Campaign and awareness on proper waste disposal

Indiscriminate waste disposal by the public (littering) is a serious problem in solid waste management in Kwekwe city. It is not enough to institutes programmes and commemorates

the World Environmental Day in schools and colleges to instil in pupils and students the habits of proper waste disposal. The general populace need to be made aware of the implications of littering. This study ascertained that awareness of association of health problems and improper solid waste disposal can have more compulsive effect on the waste disposal habit of the public than any other association or measure. Anti-littering campaigns therefore should emphasize the relatedness of proper waste management with avoidance of diseases. There is need therefore to involve the health sector in anti-littering campaigns. If the message of the impact of improper waste disposal on deterioration of public health comes from health sector workers, this is likely to carry more weight and be compelling than if it originates from some other sources. Some church denominations such as the Seventh Day Adventist and the Roman Catholic used to clean up streets in residential areas and also other public places such as the rank and shopping centres. Promotion of anti-littering campaign need to incorporate a programme directed towards the public transport system. Such a programme should oblige all drivers of privately owned and those of publicly owned vehicles in the public transport system to inform passengers about the need to avoid littering and the penalty of throwing waste from their vehicle any time they are about to start a journey. The verbal information should be accompanied by obligations for such vehicles to carry an inscription against littering. When vehicle operators are allowed to write their own message the message could be trivialised as a result the inscription for all vehicles should be standard. A sticker with the message and the fine for contravention would be appropriate.

6.11 Recommendations and directions for future research

Due to the complex nature of SWM systems extensive data for different scenarios are required. Therefore, further investigations and verification are needed. Directions for future research emerging from this study include:

- a solid waste characterization study of other sources (industrial, commercial, institutional) in the waste stream and to other locations in the country.
- a health study of waste workers: would increase knowledge about the impact on health of working with waste streams. The study could include: identifying and assessing health concerns and causes of health effects, evaluating the adequacy of protective equipment, and comparing occupational risks from various professions. Findings from the study could be integrated in the health and safety programme to increase health awareness and develop strategies to reduce health risks.

REFERENCES

Abdelnaser O.; Mahmood, A., Aziz, H.A and Robninson, M.G, (2009) Investigating households' attitude towards recycling of solid waste in Malaysia: a case study, *International Journal Environmental Management and Technology 3 (2) 275-288.*

Abdelnaser, O. and Gavrilescu, M. (2008). Environmental Engineering and Management Journal July/August 2008, Municipal Solid Waste Management in developing countries: a perspective on Vietnam, vol.7, no.4, 359 – 496.

Abrate, G and Ferraris, M., (2010). The Environmental Kuznets Curve in the Municipal Solid Waste Sector Higher Education and Research on mobility regulation and the economics of local services; Working Paper 1.

Abu Qdais H.A, Hamada M.F. and Newham J. (1996). "Analysis of Residential solid waste at generation sites" Department of chemical and life sciences, University of Northumbria at New Castle, UK.

Adams, K., P.S. Phillip and J.R. Morris (2000) "A radical new development for sustainable waste management in UK: The introduction of local authority Best Value Legislation. Resources, Conservation and Recycling 30(3): 221-44

Al-Momani, A. H. (1994). Solid waste management: Sampling, Analysis and Assessment of Household Waste in the City of Amman," International Journal of Environmental Health Research, Vol. 4, No. 4, 1994, pp. 208-222.

Ansems, A. M. A (1998). Model for the collection and processing of waste streams. Paper presented at "Systems engineering models for waste management" International workshop in Göteborg, Sweden, 25-26 February 1998. Asia. World Bank - Urban Development Technical Paper. Working paper series1, 43 p.

Axinn, W.G. & Pearce, L.D (2006). Motivations for mixed methods social research. Cambridge: Cambridge University.

Babanawo, R. (2006). Constraints to sustainable solid waste management in Ghana, PhD, Dissertation, Department of Environmental and Resource Management. Faculty of Environmental Sciences and process engineering; Cottbus, Germany.

Bai, R. Sutanto, M. (2002). The practice and challenges of solid waste management in Singapore, Waste Management, 22 (5) 557- 567.

Balnaves, M and Caputi, P. (2001). Introduction to quantitative research methods. London, Sage Publications.

Bandara, N. J. G. J., Hettiaratchi, J. P. A., Wirasinghe, S. C., & Pilapiiya, S. (2007). Relation of waste generation and composition to socio-economic factors: a case study. Environmental Monitoring and Assessment, 135, 31–39.

Bartorne J, R; Dalley D and Patel V, S. (1996) Life Cycle Assessment for Waste Management: Vol . 16, Nos 1-3, pp. 35- 50, 1996

Bartelings H., (2003). Municipal solid waste management problems: an applied general equilibrium analysis (Doctor Proefschrift, Wageningen Universiteit, Nederland), 243

Bartone C. R. and Oliviera C., (1990). A unit cost model for solid waste collection. World Bank Urban Development Infrastructure Notes no. UE-1.

Bartone, C. (2000): Strategies for Improving Municipal Solid Waste Management: Lessons from World Bank Lending and CWG Activities. Workshop on Planning for Sustainable and Integrated Solid Waste Management, Manila, 18-22 September 2000. Washington, DC: Urban Management Division, World Bank. Available online at <http://www.undp.org/pppue/pppueold/library/files/barton01.doc>.

Bartone, C. R., (2001). "Summary of the Strategic Planning Guide to Municipal Solid Waste, World Bank

Beede, D.N. and Bloom D. E., (1995). Economics of the Generation and Management of Municipal Solid Waste. MBER Working Paper Series No. 5116 p 96.

Beukering, P.V., M. Sehker, R. Gerlagh and V, Kumar (1999) "Analysing Urban Solid Waste in Developing Countries: a perspective on Bangalore, India. Working Paper No 24"

Bhada-Tata & P., Hoornweg, D. (2011). A compilation of global MSW generation rates and composition: projections and policy recommendations. In M. Alamgir, Q. H. Bari, I. M. Alamgir, Q. H. Bari, I. M. Rafizul, S. M. T. Islam, G. Sarkar & M. K. Howlader(eds.), Proceedings of the WasteSafe 2011—2nd International Conference on Solid Waste Management in the Developing Countries 13–15 February 2011, Khulna, Bangladesh.

Bilitewski, B., Härdtle, G. & Marek, K. (1994). Waste Management. Berlin: Springer-Verlag.

Blumberg, B., Cooper, D. and Sphinder, P. (2008), Research Methods, McGraw-Hill Education, USA.

Brink P, J., and Wood, J M.,(1998) Advanced Design in Nursing Research, Second Edition. University of Alberta; Edmonton, Canada, Sage Publications.

Bruvoll A, (2001) "Factors Influencing a Solid Waste Generation and Management," Journal of Solid Waste Technology and Management, Vol. 27, pp. 156-162.

Bryant, R & Graham R, MC, (2002). Advanced practice nurses: A study of client satisfaction. Research, 14(2): 88-92.

Buenrostro, O., Bocco, G., Bernache, G., (2001). Urban solid waste generation and disposal in Mexico: a case study. Waste Management & Research, 19, 169–176.

Burns N, Grove S (1997). *The Practice of Nursing Research: Conduct, Critique and Utilization.* 3rd edn. WB Saunders Company, Philadelphia.

Cambridge: Cambridge University.

Callan, S. J. and J. M, Thomas, (1999). Adopting a Unit Pricing System for Municipal Solid Waste: Policy and Socio-Economic Determinants Environmental and Resource Economics, Vol. 14 pp. 503- 518.

Chenje, M., L Sola and D. Paleczny (1998). The state of the Zimbabwean Environment. Government of Zimbabwe. Ministry of Environment and Tourism, Harare, Zimbabwe.

Cohen, J. (1988). Statistical Power Analysis for Behavioural Sciences (2nd ed.), New York. Academic Press. New York.

Cointreau – Levine, S., (1994). Private Sector Participation in Municipal Solid Waste Services in Developing Countries. Vol. 1. Urban Management Programme. Discussion paper No. 13 p 52.

Cointreau- Levine., S., (2002). Occupational and Environmental Issues on Solid Waste Management, Institute for local Self-Reliance (ILSR)

Cointreau S., (1982). Environmental Management of Urban Solid Wastes in Developing Countries. A Project Guide. World Bank – Urban Development Technical Paper No. 5 p214.

Cointreau S., (2004) Occupational and Environmental Health Issues of Solid Waste Management: Special Emphasis on Middle and Lower – Income Countries p 55.

Cointreau S., (2005) Private Sector Participation in Developing Countries Presentation World Bank, p 18.

Community Forestry Practices in India. Forest Policy and Economics 3: 137-154

Crawshaw, J. and Chambers J. (2001) Advanced "A" – Level Statistics, Stanley Thornes UK pp. 122– 123.

Creswell John W 2003: Research Design- Quantitative, Qualitative and Mixed Methods Approaches. Second Edition. SAGE Publications. Thousand Oaks.

Darjeeling Municipality. Mountain Forum.

Daskalopoulos, E. *et al.,* (1998). "An integrated approach to municipal solid waste management." Resources, Conservation and Recycling. 24(1): 33-50

David A, Cornwell D, Mackenzie L. (1998). Introduction to Environmental Engineering McGraw Hill, Boston pp. 630 – 690.

Dennison, G.J., Dodd, V.A., Whelan, B., (1996) a. A socio-economic based survey of household waste characteristics in the city of Dublin, Ireland - I. Waste composition. Resour. Converv. Recy. 17, 227-244.

Dennison, G.J., Dodd, V.A., Whelan, B., (1996) b. A socio-economic based survey of household waste characteristics in the city of Dublin, Ireland - II. Waste quantities. Resourc. Converv. Recy. 17, 245-257.

Dev, S.B., (2006). Application of 3r Principles to Solid Waste Management on the Asian Institute of Technology (AIT) Campus , Thailand

Dickerson G. W., (1999). Description and use of municipal solid waste composts in New Mexico. Circular 562, 7 p.

Dickerson, G.W. (1999). "Solid Waste: Trash and Treasury in an urban Environment" New Mexico Journal of Science November 1999: 166.

Duggal, Vijaya G.; Saltzman, C.; Williams, Mary L. (1991) "Recycling: An Economic Analysis", Eastern Economic Journal, Vol. XVII, no 3.

Dyer, *et al.,* (1999). Utilization of waste materials and by-products in producing controlled low-strength materials, Department of Civil Engineering, Thapar University, Patiala 147004, and Punjab, India.

Enayetullah, Iftekhar and A. H. Maqsood Sinha (2000). 'Community Based Decentralized Composting: Experience of Waste Concern in Dhaka' in Sinha A. H. Maqsood et al. (Eds.) *Community Based Solid Waste Management: The Asian Experience*, Waste Concern, Dhaka, Bangladesh. Environmental Technology, Asian Institute of Technology (AIT), Thailand .EPA530-R-95-023, 363 p.

Eugenia *et al.,* (2002). Solid Waste generation is an inevitable consequence of production and consumption activities in any economy experience, economics, and legislation. Policy Study no. 160.

Finnveden G., Johansson J., Lind P., Moberg Å. (2005). Life cycle assessment of energy from solid waste - part 1: general methodology and results. Journal of Cleaner Production 13, 213 – 229;

Finnveden, G. and Ekvall T., (1998). Life-cycle assessment as a decision-support tool—the case of recycling versus incineration of paper. Resources, Conservation and Recycling 24, 235 – 256.

Folarin, B.A. (1999), Survey research methods. Lagos, Ideal Press

Fudery, C., (1990). *Social Experts of Solid Recovery in Asian Cities*. BKK Environmental

Sanitation Information Centre, AIT.

Fullerton, D. and Kinnaman, T. C. (1996) Household Responses to Pricing Garbage by the Bag. *American Economic Review*, vol. 86, n: 4, pp. 971-984.

Gatot, Y., (2000). Exploring the Potential of Integrated Municipal Solid Waste Planning and Management in Developing Countries. A Case Study PhD Thesis in Planning, in the Municipal of Bandung, Indonesia with a Focus on Households (University of Waterloo, Canada), p 323.

Gerlagh Reyer, Pieter Van Beukering, Madhu Varma, P. P. Yadar and Preety Pandey, (1999). Integrated Modelling of Solid Waste in India, CREED Working Paper Series No. 26.

Gomez, G., Meneses, M., Ballinas, L., Castells, F., (2008). Characterization of urban solid waste in Chihuahua, Mexico. Waste Management, 28, 2465–2471.

Grossmann, D., Hudson, J. F., & Marks, D. H., (1974). Waste generation models for solid waste collection. Journal of the Environmental Engineering Division, 100, 1219–1230.

Guiness, P., and Nagle G. (1999) Advanced Geography: Concepts and Cases, Holder Education UK, p 483.

Haan, C.H., Coad, A. & Lardinois, I. (1998). Municipal Solid Waste Management:

HABITAT (1992). Promotion of Waste Recycling and Reuse in Developing Countries. *Seminar organized by HABITAT*, Bangkok, 3rd September, 1992.

Habitat, (1996) United Nations for Human Settlement: An Urbanizing World-Global Report on Human Settlement; Oxford University Press.

Hansen, W., M. Christopher and Verbucheln (2000). EU Waste Policy Challenges for Regional and Local Authorities, Ecological Institute for International and European Environmental Policy.

Hardoy, J.E Mitlin, D Satterthwaite, (2001). Environmental Problems in an urbanizing World: Finding Solutions for Cities in Africa, Asia and Latin America. Earthscan Publication Ltd. London.

Hassan, M.N., (2000). Policies to Improve Solid Waste Management in Developing Countries: Some insides in South East Asian Countries: Proceedings of the 2nd International Conference on Solid Waste Management, Taiwan: EPA, Republic of China pp. 191 – 207.

Hassan, M.N., Chong T. L., Rahman M., Salleh M.N., Zakaria Special Z. and Awang M. (2001) "Solid Waste Management in South East Asian Countries with Malaysia. Attention to Malaysia. Department of Environmental Sciences, University Putra.

Hockett, D and Lober, D. J. and Pilgrim, K., (1995). Determinants of per capita solid waste

in the sub eastern United States, Journal of Environmental Management, 45, 205-217.

Hoornweg, Daniel Laura Thomas and Keshav Verma, 1999: *What a Waste: Solid Waste Management in Asia,* World Bank, May. Urban Development Technical Paper. Working Series 1 p 43.

Hoornweg, D., Thomas L., and Otten L., (2000). Composting and Its Applicability in Developing Countries. Urban and Local Government Working Paper Series #8,

Hoornweg, D.L., Thomas and Lambert (1999) Urban Waste Management: Compositing and its Applicability in Developing Division, the World Bank p 17.

Hong, S.H., R.M. Adams and H.A. Love, (1993). An economic analysis of household recycling of solid wastes: The case of Portland, Oregon. J. Environ. Econ. Manage., 25: 136-146.

Hope, K. R. & Lekorwe, M. H., (1999). Urbanization and the environment in Southern Africa: towards a managed framework for the sustainability of cities. Journal of Environmental Planning and Management, 42(6):837-859.

Inter-American Development Bank, (2003). Economic Instruments for Solid Waste Management: Global View and Applications for Latin America and the Caribbean: Regional Policy Dialogue Study Series p. 72.

International Labour Organisation, (2007). Start Your on Waste Recycling Business, Technical Handouts, Scientific and Industrial Research and Development Centre, Harare Zimbabwe. *International Training Centre of the ILO*, SKAT, WASTE

Involving Micro- and Small Scale Enterprises, Guideline for Municipal Managers.

Jaya Dhindaw, (2004). Developing a framework of best practices for sustainable solid waste management in small tourist islands (MSc thesis in Community Planning, University of Cincinnati, USA), 207 p.

Jenkins, R.R., Salvador A.M., Palmer, and Podolsky M. J., (1999), The determinants of household recycling: A material specific analysis of unit pricing and recycling program attributes. Discussion Paper 99- 111.

Jha, Arvind K., C. Sharma, N. Singh, R. Ramesh, R. Purvaja & P. K. Gupta. (2011). Sustainable municipal solid waste management in low income group of cities: a review. International Society for Tropical Ecology. Tropical Ecology 52(1): 123-131.

Jones, A., Nesaratnam, S., Porteous, A., (2008). Factsheet No 2. Factors which influence household waste generation. Department of Design, Development, Environment and Materials Faculty of Mathematics, Computing and Technology the Open University

Milton Keynes MK7 6AA.

Johnstone, N.; Labonne, J. (2004) "Generation of Household Solid Waste in OECD countries: An Empirical Analysis Using Macroeconomic Data", Land Economics, Vol. 80, no. 4
pp. 529-538.

Kaseke, M. (2005).The use of deposit refunds as pollution control policy in urban areas: the case of Zimbabwe. Paper prepared for Accounting for Urban Environment Workshop: Tanzania.

Khawas, Vimal. (2003): Urban Management in Darjeeling Himalaya: A Case Study of Darjeeling Municipality. Mountain Forum.

Koufodimos G. and Samaras Z., (2002). Waste management options in southern Europe using field and experimental data. Waste Management 22, 47-59.

Krejcie, RV and Morgan D, W., (1960) Small Sample Techniques, The NEA Bulletin, Vol 38 p99

Kuniyal, J.C, A.P. Jain and. Shanningrali; (1998) Public Involvement in Solid Waste Management in Himalayan Trails in and around the Valley of Flowers , India, Mountain Forum 24 (3-4) 299-322.

Leviavtt, C., (1994). Calculating the cost of waste management. Waste Age Issue 1, April 1994

Lober, D.J. (1996). Municipal Solid Waste Policy and Public Participation in Household

Lohani, B.N. (1982). Urban Solid Waste Recovery and Recycling. *Environment and Development of the Third World (ENDA), Document No. 19*, 40-81.

Lohani, B.N. (1984). Recycling Potentials of Solid Waste in Asia through Organized Scavenging. *Conservation and Recycling, 7*, 181-190.

Lohani, B.N. *et al.,* (1984). Recycling of Solid Wastes. *Environmental Sanitation Reviews No. 13-14*. Environmental Sanitation Information Centre, Asian Institute of Technology, Bangkok, Thailand.

Lund, H.F. (2001). Recycling Handbook. McGraw Hill Inc., 2001. ISBN: 0-02-60329-4.
Management 26, 92 – 100.

Manfredi, S., and Christensen, T.H (2009).Environmental assessment of solid waste landfilling technologies by means of LCA-modelling 29 (1) 32-43.

Mangizvo R,V and Chinamasa (2008) Solid medical waste management: the case of Kwekwe city in Midlands province, Zimbabwe: Journal of Sustainable Development in Africa (Volume 10, No.3, 2008)

Manyanhaire, I.O., Sigauke, E. & Munasirei, D. 2009. Analysis of domestic solid waste management system: a case of Sakubva high density suburb in the City of Mutare, Manicaland Province, Zimbabwe.

Mapira, J. (2007). Pollution of the Sakubva River, Mutare (Zimbabwe): Culprits, Penalties and consequences Zimbabwe Journal of Geographical Research , Vol1 Numbers 33/34, p 9-19.

Martin, K., (2003). Recycling the hierarchy. Working toward a new environmental

Maseva, C., (2005). A review of the legislative and policy framework for waste management in Zimbabwe with special reference to Harare, Chitungwiza Municipality and Epworth Local Board. Harare: Practical Action Southern Africa.

Matsunaga, K. and Themelis, N.J.(2002). Effects of affluence and population density on waste generation and disposal of municipal solid wastes, Earth Engineering Center, Columbia University, New York.

Maxwell, J.A., (1996). Quantitative Research Design- An Interactive Approach. Applied Social Research Methods Series Vol 1, Sage Publications Thousand Oaks.

Medina, M. (2007). *The World's Scavengers: Salvaging for Sustainable Consumption and Production*, Alta Mira Press, Lanham, MD.

Medina, M., (1997). The effect of income on municipal solid waste generation rates for countries of varying levels of economic development: A model. Journal of

Municipal Solid Waste Management in Asia. Asian Regional Research Program on

Munowenyu, E. (1997). "O" Level Geography. Harare: Longman, Zimbabwe.

Narayana, T., (2009). Municipal solid waste management in India: From waste management disposal to recovery of resources, Waste Management 29 (3) 1163-1166.

Nguyen, P.T., Yasuhiro, M., & Takeshi, F. (2011). Assessment of plastic waste generation and its potential recycling of household solid waste in Can Tho City, Vietnam.

Nhapi, I., (2000) Environmental Pollution and Control. Module GED 410; Zimbabwe Open University p37.

Nilanthi, J. G. J. Bandara & J. Patrick A. Hettiaratchi & S. C. Wirasinghe & Smith Pilapiiya (2007). Relation of waste generation and composition to socio-economic factors: a case study Springer Science + Business Media B.V. 2007

Norusis, M. J., (1993) SPSS 16.0 for windows. Chicago, SPSS inc.

O E C D (2000) United Nations and Social Commission for Asia and the Pacific (UNESCAP) p4. Paper No. 426, Washington, DC.

Ogawa, H., (2004). Sustainable Solid Waste Management in Developing Countries. Kuala

Lumpur, Malaysia, WHO, Western Pacific Regional Environmental Health Centre, (EHC).

Ojeda – Benitez, S; Armijo de Vega C. and Ramires – Barret E., (2003) Characterisation and Quantification of Household Wastes in Mexico City pp. 211 – 222.

Ojeda – Benitez, S. and Beraud – Lozano J. (2003). The Municipal Solid Waste Cycle in Mexico: Final Disposal. Resources Conservation and Recycling p. 239 – 250.

Omuta, G.E.D., (1997) "Urban Solid Waste Generation and Management in Nigeria Habitat International, 11 (2) 77-86.

Onihokun, A.G., (1999). Managing the monister: Urban Waste and Governance in Africa. International Development Research Centre, Canada (1999) p13.

Polit, & Hungler, BP., (1995). Nursing research: Principles and methods. 5th edition. Philadelphia: Lippincott.

Pongrácz, E., (2002). Redefining the Concepts Waste and Waste Management (PhD thesis in Environmental Engineering, University of Qulu, Finland p 166. Press, Lanham, MD.

Pradhan, U. M., (2008). Sustainable Solid Waste Management in a Mountain Ecosystem: Darjeeling, West Bengal, India.

Qu X., Li Z., Xie X., Sui Y., Yang L., Chen, Y. (2009). Survey of composition and generation rate of household wastes in Beijing, China. Waste Management, Vol. 29, No. 10, 2009, pp. 2618-2624.

Read, A.D., (1999). "A weekly doorstep recycling collection, I had no idea we could" Overcoming the Local Barriers to Participation. Resources, Conservation and Recycling 26. pp. 217 – 249.

Redelinghuys, N. (2010). Population Trends and Sustainability (MOB 708). Bloemfontein: UOFS. (Study Guide MOB 708.

Rees, W., (1992). Ecological footprints and appropriate carrying capacity: what urban economics leaves out" Environment and Urbanisation (4) 2: 121-58

Richardson, R. A. (1978) Economic Analysis of the composition of Household Solid Wastes: Journal of Environmental Economics and Management Vol. 5, No. 1, 1978, pp. 103-111.

Richardson, R.A. and J. Jr. Havlicek, (1978). Economic analysis of composition of household solid wastes. Journal of Environmental Economics and Management Vol 5: No 1,103-111.

Rotich, K. H., Zhao Yongsheng and Dong Jun, (2005). Municipal solid waste management challenges in developing countries – Kenyan case study. Waste Management 26, 92 – 100.

Rushbrook P., Pugh M. (1999). Solid waste landfills in middle and lower-income countries: a technical guide to planning, design, and operation. World Bank, Washington DC.

Sankoh, P. X. Yan and A. Mohamed Hamza Conteh, "A Situational Assessment of Socioeconomic Factors Affecting Solid Waste Generation and Composition in Freetown, Sierra Leone," *Journal of Environmental Protection*, Vol. 3 No. 7, 2012, pp. 563-568.

Satterwaite, D. (1997). "Environmental transformation in Cities as they get larger, wealthier and better managed. The Geographical Journal 163 (2): 261 (4) F.

Schiopu, A., Apostol, I., Hodoreanu, M., Gavrilescu, M. (2007). Solid waste in Romania: management, treatment and prevention practices. Environmental Engineering and Management Journal 6 (5).

Schubeler, P., Wehrle K., Christen J., (1996). Infrastructure Working Paper No. 9 p 55. Conceptional Framework for Municipal Solid Waste Management in Low-Income Countries. UNDP Urban Management and development.

Seguino, S., Criner G., and Suarez M., (1995) a. Solid waste management options for Maine: the economics of pay-by-the-bag systems. Main Policy Review, Vol 4, no. 2, 49 – 58.

Seguino, S., Suarez M, Young J., McKay R., Spruce and Cruiner G., (1995) Solid Waste Management Options: the economics of variables cost and convectional pricing system in Maine, p39.

Sekher M, (2001) Organized Participatory Resource Management: Insights from *Seminar organized by HABITAT*, Bangkok, 3rd September, 1992.

Senkoro, H (2003). Solid Waste Management in Africa: AWHO, AFRO Perspective: Solid Waste Collection that benefits the Urban Poor, Dar es Salaam, Collaborative Workshop Group (CWG) World Health Organisation, African Regional Office (WHO/AFRO)services. World Bank-Urban Development Infrastructure Notes no. UE-3 September/October 2003.

Shanklin, C. W., Hui- Chun, Kyung Eun Lee, Chihyung OK, Sunny Seo, and Flores S.,(2002) Interdisciplinary modules to Teach Waste or Residue Management in the Food Chain Module 3.

Shekdar, A. V., 1997. A strategy for the development of landfill gas technology in India. Waste Management and Research 15, 255 – 266.

Sibley, C. G. and J. H Liu, (2003). Differentiating Active and Passive Littering, A Two-Stage Process Model of Littering Behaviour in Public Spaces. Environment and Behaviour p.35.

Skumatz, L. A., (1993). Variable rates for municipal solid waste: implementation, experience, economics, and legislation. Policy Study no.160.

Skumatz, L. A., (2002). Waste Management-Variable- rate or Pay-as-you throw; Waste management. Policy study no. 295, Solid Waste Management", World Bank

Songsore, J., (1997). Measures Pertaining to Environmental Health Problems in Africa: The Case of Accra, Ghana. Economic Commission for Africa, Addis Ababa.

Suocheng, D., Tong K. W., and Yuping Wu., (2001) Municipal Solid Waste. Utilities Policies 10, pp. 7 – 111.

Statutory Instrument Number 6 of (2007): Environmental Management Agency (EMA), (Effluent and Solid waste Disposal Regulations) Chapter 20:27 Government of Zimbabwe.

Sterner, T. and Bartelings H., (1999). Household waste management in Swedish Municipality: Determinants of waste disposal, recycling and composting. Environment and resource economics 13: 473- 491.

Suess, M.J., Ed (1995) Solid Waste Management; Selected Topics; Regional Office for Europe Copenhagen; Denmark, WHO.

Sujauddin, M., Huda, S. M. S., & Hoque, R. A. T. M., (2008). Household solid waste characteristics and management in Chittagong, Bangladesh. Waste Management, 28(9), 1688–1695.

Sykes, G.N. (1978). Recycling: Two Alberta Case Studies. A Master's Degree Project, University of Calgary, Alberta, United States of America, August 1978.

Tanskanen, J.H., (2000) "Strategic Planning of municipal solid waste management" Resource Conservation and Recycling 30 (2): 111-33.

Tchobanoglous G., Theisen H., Higil S., (1993) Integrated Solid Waste Management. Engineering Principles and Management issues. McGraw Hill International Editions

Themelis, N.J (2002) Integrated management of solid waste for New City. American Society of Mechanical Engineers, New York, NAWTEC

Thomas- Hope, E., and Ed (1998) Solid Waste Management: Critical Issues for developing countries: Jamaica, Barbados. Canoe Press, University of West Indies.

Tisdell, C. A., (1991). Development in Environmental Economics volume 1. Economics of Environmental Conservation: Economics for Environmental and Ecological Management. London: Elsevier.

Tonglet M., Phillips P. S., and Bates M. P., (2004). Determining the drivers for householders' pro-environmental behaviour: waste minimisation compared to recycling. Resources, Conservation and Recycling 42, 27 – 48.

Trochim, W.M.K. (2006). Philosophy of research. Retrieved from: http://www.socialresearchmethods.net/kb/philosophy.php.

Ulrich, G., Visvanathan, C., & Alamgir, M., (2005). Solid waste management in least developed Asian countries. In International conference on integrated solid waste management in South East Asian cities. Cambodia: Siem Reap.

UNEP, (2000). Solid Waste Source Book. lETC, Tokyo.

United Nations Environmental Programme (2002). State of the Environment, Mongolia. United Nations Environmental Programme, ISBN: 92-807-2145-3

United Nations Environmental Programme (2005). Selection, Design and Implementation of Economic Instruments in Solid Waste Management Sector in Kenya. The Case of Plastic Bags, p 60.

United Nations Habitat, (2010). Solid Waste Management. In The World's Cities Water and Sanitation in The World's Cities.

United States Environmental Protection Agency (1998). Illegal Dumping Prevention Guidebook EPA 905 – B – 97 – 001 p 30.

United States Environmental Protection Agency, (2005) Decision Markers" Guide to Solid Waste Management, Volume II EPA 530 – R – 95 – 023 p 363.

University of Calgary, Alberta, United States of America, August 1978.

USEPA, (1995). Decision-makers' guide to solid waste management, Volume II.

Vidanaarachchi, C.K., Yuen S.T.S. and Pilapitiya S., (2005). Municipal solid waste management in Southern Province of Sri lanka: Problems, issues and challenges, Waste Management.

Visvanathan, C. (2006) Solid Waste Management in Asia Perspectives, Asian Institute of Technology, Bangkok.

Visvanathan, C., Tränkler, J., Joseph, K., Chiemchaisri, C., Basnayake, B.F.A., (2004). Waste management in UK: The introduction of local authority Best Value Legislation. Resources, Conservation and Recycling 30(3): 221-44

Wertz, K. L. (1976). Economic factors influencing households' reproduction of refuse. Journal of Environmental Economics and Management, 2, 263–272.

Wilson, D. C. (1993) 'the landfill stepladder: Landfill policy and practice in an historical perspective', in *Wastes Management*, CIWM, Northampton, UK, pp24–28.

Wilson, D. C., (2007) 'Development drivers for waste management', *Waste Management and Research*, vol 25, pp198–207.

Wilson, D. C., Balkau, F. and Thurgood, M. (2003) *Training Resource Pack for Hazardous Waste Management in Developing Countries*, UNEP, ISWA and the Basel Convention.

Wilson, D. C., Whiteman, A. and Tormin, A., (2001) *Strategic Planning Guide for Municipal Solid Waste Management*, World Bank, www.worldbank.org/urban/

Winchester, H.P.M., (2000). Qualitative Research and its place in Human Geography, Qualitative Research Methods in Human Geography. I. Hay, Melbourne, Oxford: 1-22 Workshop for planning of sustainable and integrated solid waste management, Manilla.

World Bank (1992). World Development Report. New York, Oxford Press.

Wright, T., (2000) Report on the Alternative Waste Management Technologies and Practices Injury. Sydney, State Government of South Wales, Office of the Minister of the Environment.

Yatim, S.R. M., and Armir, (2010). Health and the Environment Journal 2010, Vol, 1 No. 2; University Technology Mara, Malaysia.

Yedla, S., (2005). Modified landfill design for sustainable waste Management.

Zender, L E., (1999). Solid waste management on Indian reservations limitations on conventional waste management engineering (PhD thesis in Environmental engineering, University of California, USA).

Zerboc, O. (2003) Urban Solid Waste Management: Waste Reduction in Developing Nations. Michigan Technological University.

Zhu, Da. P., H. Asnani, C. Zurbrugg, S. Anapolsky & S. Mani., (2008). Improving Municipal Solid Waste Management in India. A Source Book for Policy Makers and Practitioners. World Bank, Washington D.C.

Zimbabwe National Statistics Agency, ZIMSTAT (2012). Zimbabwe Government Press, Harare, Zimbabwe.

Zuilen L.F. (2006). Planning of an Integrated Solid Waste Management System in Suriname: A Case Study in Greater Paramaribo with Focus on Households. (PhD Thesis, Ghent University.

Zurbrügg (2002); Management in Low-Income Countries of Asia; How to Cope with the Garbage Crisis, Presented for: Scientific Committee on Problems of the "Urban Solid Waste Environment (SCOPE), Urban Solid Waste Management Review Session, Durban, South Africa.

Websites

web.archive.org/web

www.worldbank.org/urban/solid_wm/erm/CWG%20folder/uwp

www.mbt.landfill-site.com

www.wastereports.com

www.(p2pays.org/ref1110516/gas.html.

www.mtnforum.org/resourcs/library/khawv03e.htm>

www.socialresearchmethods.net/kb/philosophy.php,

www.unep.fr/scp/ waste/hazardous.htm

APPENDIX 1

Figure 5.1: Women roasting maize and ground nuts for sell near an illegal dumpsite

Figure 5.2 (a): A section of ZISCO showing blast furnace

Figure 5.2 (b): Zimbabwe Mining and Smelting Company (ZIMASCO)

Figure 5.2 (c): Mountain of Slag Produced as waste material from ZIMASCO

Figure 5.3: Gold panning

Figure 5.4: Road almost closed due to illegal dumping at Mbizo Section 8

Figure 5.5: Kwekwe (Amaveni) Dumpsite after compaction

Field Photo 6: Harvesters of solid waste at Amaveni Dumpsite

Figure5.6: Waste harvesters collecting wastes for resale

Figure 5.7: Sorting for recycling at Amaveni dumpsite by waste harvesters

Figure 5.8 (a): A tractor used to collect solid waste in Mbizo

Figure 5.8 (b): Trucks used for transporting solid waste

Figure 5.8 (c) Truck used for transporting waste

Figure 5.9: Bins used for waste storage waiting to be emptied in a waste collection truck in New Town.

APPENDIX 2

Benchmarking of illegal dumpsite

Name of the suburb	Coordinates of each Dumpsite	Exact location of the Dump	Coordinates Around the Perimeter of Each Dump				Type of Waste	Size of the Dump
			A	B	C	D		
Amaveni	18.55 548 029.46 923 1212	Along perimeter fence of CCAP Church –Amaveni .	18.55 547 029.46.922 1211	18.55 546 029.46 922 1211	18.55 553 029.46 925 1211	18.55 553 029. 46 925 1211	Scrap metal 10% Plastics 50% Plastic bottles 40%	5x7 m
	18.55 701 029.46657 12	Opposite Hse No. T37 Amaveni	18.55 693 029.46 652 1220	18.55 704 029.46 663 1218	18.55 715 029.46 646 1217	18.55 717 029.46 632 1215	Plastics 60% Domestic Waste 50%	10x20 m
	18.55 831 029.46 777 1223	Along durawall of Amaveni Primary school	18.55 840 029.46 786 1222	18.55 837 029.46 777 1220	18.55 829 029.46 774 1221	18.55 830 029.46 771 1224	Cans 30% Domestic Waste 50% Cans 20%	6x 8 m
	18.55 777 029.47 428 1205	At Econet booster towards Amaveni Hall	18.55 780 029.47 280 1205	18.55 779 029.47 287 1205	18.55 771 029.47 272 1205	18.55 768 029.47 768 1203	Domestic Waste Plastics Glasses	4x5 m
	18.55 717 029.47 255 1203	Opposite PEP Dembure and Families Amaveni Millers	18.55 710 029.47 250 1204	18.55 722 029.47 247 1204	18.55 722 029.47 256 1205	18.55 726 029.47 252 1202	Cans 10% Scrap Metal 80% Plastics 10%	12x5m
	18.55 505 029.47 136 1202	Adjacent to Flat 6 F (Flat Shade Amaveni)	18.55 506 029.47 137 1207	18.55 503 029.47 141 1205	18.55 501 029.47 140 1203	18.55 495 029.47 128 1205	Papers 30 % Bottles 20% Domestic Waste 50%	7x5m
	18.55 365 029.47 048 1205	Opposite Hse No.W I9 Amaveni	18.55 367 029.47 051 1206	18.55 368 029.47 049 1205	18.55 366 029.47 044 1206	18.55 362 029.47 043	Pampers 35% Plastics 40% Domestic Waste 25%	10x7m

						1206		
	18.55 098 029.46 807 1210	Adjacent to Hse No. W65 Amaveni	18.55 106 029 46 809 1208	18.55 096 029.46 811 1207	18.55 094 029.46 803 1206	18.55 092 029.46 805 1208	Domestic waste 60% Plastics 20% Papers20%	7x4m
	18.55 261 029.46 656 1221	Behind Supprete Bar Amaveni	18.55 261 029.46 658 1221	18.55 257 029.46 657 1218	18.55 257 029.46 653 1219	18.55 262 029.46 650 1220	Domestic Waste 40% Plastics 10% Cans 50%	4x5m
	18.55 271 029.46 560 1219	Along Amaveni Dumpsite Rd Opposite Hse No. 197	18.55 261 029.46 560 1219	18.55 264 029.46 557 1220	18.55 283 029.46 558 1220	18.55 285 029.46 583 1219	Pampers 10% Domestic Waste 60% Plastics 30%	20x5m

Name of the suburb	Coordinates of each Dumpsite	Exact location of the Dump	Coordinates Around the Perimeter of Each Dump				Type of Waste	Size of the Dump
			A	B	C	D		
Mbizo Extension	18.54 324 029.50 048 1119	Along Chiedza Primary School Durawall	18.54 325 029.50 048 1200	18.54 326 029.50 047 1200	18.54 306 029.50 027 1200	18.54 309 029.50 023 1200	Plastics 40% Cans 10% Domestic Waste 50%	10x3
	18.55 543 029.46 914 1214	Behind Chiduku Tuckshop	18.55 541 029.46 916 1212	18.55 540 029.46 911 1212	18.55 548 029.46 905 1210	18.55 543 029.46 900 1212	Domestic waste 50% Plastics 20% Pampers 20%	10x5m
	18.54 803 029.49 946 1197	Cnr Muchogela Street. Near Hse No.1334/1	18.54 203 029.49 947 1199	18.54 205 029.49 944 1198	18.54 202 029.49 944 1197	18.54 197 029. 49 937 1197	Domestic Waste 30% Plastics 30%	3x5m
	18.54 139 029.49 972 1196	Adjacent to Hse No. 13352/1 Mbizo	18.54 136 029.49 977 1196	18.54 139 029.49 976 1196	18.54 132 029.49 960 1194	18.54 128 029.49 967 1193	Pampers 20% Cardboard boxes 30%	8x 16m
	18.54 104 029.49 932 1194	Along Hse No.13496/1 Durawall	18.54 105 029.49 935 1195	18.54 103 029.49 937 1196	18.54 105 029.49 930 1194	18.54 103 029.49 929 1194	Plastics 30% Domestic Waste 70%	5x 4m
	18.53 919 029.49 923 1192	Opposite Hse No. 13545/1	18.53 919 029.49 923 1192	18.53 918 029.49 932 1192	18.53 918 029.49 941 1192	18.53 921 029.49 944 1192	Pampers 20% Domestics Waste 80%	4x7m
	18.54 028 029.50 009 1194	Opposite Daizy and Donald Play Centre	18.54 026 029.50 007	18.54 017 029.50	18.54 018 029.50 012 1195	18.54 028 029.50	Plastics 30% Cans 50%	10x9m

			1194	008 1194		015 1194	Pampers20 %	
	18.53 888 029.49 893 1188	Opposite Hse No.13515/1	18.53 889 029.49 893 1189	18.53 891 029.49 890 1189	18.53 887 029.49 894 1189	18.53 886 029.49 889 1190	Plastics 30% Scrap 40% Domestic Waste30%	4x5 m
	18.90 332 029.83 501 1196	Open space along Zesa Power line	18.90 332 029.83 504 1196	18.90 332 029.83 512 1195	18.90 316 029.83502 1196	18.90 332 029.83 497 1196	Domestic 40% Tins and Cans50% Paper 10%	10x8
	18.90 233 029.83 560 1194	Opposite Hse No. 13046/1	18.90 237 029.83 553 1195	18.90 236 029.8356 9 1196	18.90 237 029.83 555 1195	18.90 240 029.83 5 556 1195	Domestic waste 80% Plant residue 5% Plastics 15%	20x12m
	18.90 233 029.83 560 1194	Opposite House 13046/1 Mbizo Extension	18.90 236 029.83 569 1196	18.90 237 029.83 553 1195	18.90 240 029.83 556 1195	18.90 230 029.83 560 1194	Domestic 80% Plant Residue 5% Plastics 15%	20x12
	18.90 089 029.83 607 1193	Opposite House 13057/1 Mbizo Extension	18.90 097 029.83 607 1193	18.90 088 029.83 603 1193	18.90 086 029.83 615 1192	18.90 095 029.83 612 1192	Domestic 70% Scrap metal 20% Plastics 10%	8x11m
	18.90 017 029.83 539 11911	Opposite Hse No.13113/1 and 130624	18.90 027 029.83 543 1188	18.90 012 029.83 557 1192	18.90 002 029.83 540 1191	18.90 005 029.83 524 11911	Domestic 80% Pampers 5% Bottle 5% Scrap metal car	30x20m

							wreakage5 %	
	18.89 823 029.83 441 1190	Opposite No. 13625/1 Mbizo	18.89 840 029.83 433 1191	18.89 834 029.83 446 1184	18.89 823 029.83 483 1189	18.89 834 029.83 446 1184	Domestic Waste 70% Plastics10 % Pampers 10% Cardboard boxes 10%	30x30m
	18.89 767 029.83 318 1190	Adjacent to Hse No. 383 and Mespeck Shopping Centre	18.89 772 029.83318 1191	18.89761 029.	18.89 775 029.83 323 1191	18.89 752 029.83 321 1189	Plant residue 30% Domestic Waste 70%	15x12m
	18.89 547 029.83 323 1189	Opposite No. 784 Mbizo Extension	18. 89 530 029.83 321 1188	18.89 560 029.83 327 1188	18.89 506 029.83321 1188	18.89 504 029.83 328 1187	Domestic 80% Plastics 10% Papers 5% Pampers 5%	30x12m
	18.89 513 029.83 238 1186	Opposite Hse No. 13761	18.89 511 029.83247 1188	18.89 520 029.83 238 1187	18.89 516 029.83 238 1185	18.89 505 029.83 2 240 1188	Domestic Waste 85% Plastics 10% Plant Resdue 85%	6x15m
	18.89 226 029.83145 1179	Next Hse No.13678 Mbizo Extension	18.89 227 029.83 148 1180	18.89 228 029.83 144 1197	18.89 213 029.83 142 1177	18.892 19 029.83 139 1176	Domestic 70% Plastics30 %	6x15m

APPENDIX 3

QUESTIONNAIRES

HOUSEHOLD QUESTIONNAIRE SURVEY

This research is only for academic purposes and the information obtained and answers given will be treated in strict confidence and anonymously. Feel free to answer all the questions.

Location of the house: _

House No and street_ _

_ _

Interview date: _

Questionnaire number_ _

SECTION A:

BACKGROUND INFORMATION OF THE RESPONDENT

1. What is your age? Tick the appropriate.

18-29 Years ☐
30-39 Years ☐
40-49 Years ☐
50-59 Years ☐
60+ Years ☐

2. What is your highest level of education? Tick the appropriate.

Primary level ☐
Secondary level ☐
College ☐
University ☐

3. How many people stay in this household? ☐

4. How many people who are employed? ☐

5. Approximately how much income in US$ is generated at this household per month? Tick the appropriate.

US$0-500

US$501-1000

US$1001-2000

US$2001-3000

US$3000+

6. What are the major types of waste produced from this household?

Food remains/leftovers

Cardboard boxes

Metals

Glass

Other specify

7. How has the composition of solid waste generated at this household changed over the past twelve months? --

----

----

8. Which of the following do you think causes land pollution in Kwekwe?

Industrial operations

Household,

Decaying,

Institutions and

Mining

9. Do you separate your waste before disposal?

Yes No

If yes how and why? ____

____

10. Do you know the weight of waste that your household generates per week?

Yes No

11. Where do you dispose the waste that your household generates per week?

____

Are there other methods you use to dispose your waste?

Yes No

If yes, specify.

_ _ _ _ _ _ — _ _ _ _ _ _ _ _ _ _ _ _ _ — _ _ _ _ _ _ _ _ _ _ _ _ _ — — _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

SECTION B:

SOLID WASTE COLLECTION

12. What type of container do you use to collect waste from the house?
    a) Bin
    b) Carton
    c) Plastic bag
    d) Tin/can
    e) Old bucket

13. Where do you usually put away this waste?
    a) In the public bin
    b) By the valley/stream side
    c) By the wad/street side
    d) On the open space/bush
    e) In the hole in the compound

14. Who usually removes and carries away the waste from the house?

a) Father
b) Mother
c) Maid/gardener/guard
d) Other specify

14. Is your bin usually full before collection

Yes No

15. How would you describe the attitude of the waste collection team?

a) Respectful
b) Fair
c) Disrespectful

16. Can you give the approximate percentages of the solid waste which undergoes the following

Compositing
Recycling
Open dumps
Open burning
Illegal dumping
Incineration

17. What type of solid waste generated from your house and to what extent?

	Not much	Quite	Much	Too much	Don't know
Paper and cotton	1	2	3	4	
Plastics(bag/bottles)	1	2	3	4	
Food waste	1	2	3	4	
Bottle glass	1	2	3	4	
Tins/cans	1	2	3	4	
Fibre glass	1	2	3	4	
Other specify	1	2	3	4	

18. Who is responsible for collecting your waste from home to the dumpsite?

_ _

19. Have you ever taken any initiatives to reduce your household waste?

Yes No

20. How often is your bin collected for disposal? Tick the appropriate

Once a week

Twice a week

Once a fortnight

Once per month

Other specify

21. Do you know waste collection days in your area?

Yes No

22. What mode of transport do they use to transport the wastes?

_ _

23. Do you pay for refuse collections?

Yes No

24. If yes in questions 23, how much per month $

25. Do you think if waste charges are increased the service will improve as well?

Yes No

26. Are you satisfied with the frequency and ways waste is collected form your homestead? Tick the appropriate.

Don't know

Happy

Very happy

Dissatisfied

Strongly dissatisfied

27. Are you willing to pay for the waste collection services?

Yes No

28. State the areas of improvement which you suggest.

_ _

_ _

29. Is dumping of litter common in your area?

Yes No

30. Do you sometimes carry the waste for disposal?

Yes No

31. Most dumping usually takes place on

	Yes	No
the road sides		
open spaces		
drainage ditches		

SECTION C: REUSE, RECYCLE, REDUCE

32. Have you ever heard of the 3R?

Yes No

33. What do you do to reduce the amount of waste generated by your household?

_ _

34. Have you taken part in any environmental programme?

Yes No

35. Do you reuse, sell, give as presents, or receive as gifts, any of the following old things.

a) Bottles
b) Tins/cans
c) Plastics
d) Bags
e) Metal
f) Shoes
g) Clothes

Yes	No

36 .What do you do with the food wastes, leaves and trimmings that come out of your house?

a) Make compost
b) Apply directly to the farm/garden
c) Throw away with other waste
d) Burn
e) Other specify_ _

37. Would you like to separate decomposable food/vegetable waste from non-decomposable manufactured waste?

Yes No

38. If yes above, why would you like to separate?

_ _

39. If no why would you not separate?

a) I have no use
b) It is a difficult exercise
c) Other specify_ _

40. How do you evaluate the state of solid waste management in your city?

a) Has improved
b) Remains the same
c) Has deteriorated

41. If it has improved, how has the situation improved? _

_ _

42. Which of these may have a contributory factor to waste management deterioration and to what degree?

Factor	Not at all	Not very	Quite	Very	Extreme
1. Organisational	1	2	3	4	5
2. Finance related	1	2	3	4	5
3. Non collaboration parties	1	2	3	4	5
4. Lack of sensitisation	1	2	3	4	5
5. Technical know-how	1	1	3	4	5

43. Is there any evidence of poor waste management in Kwekwe? State the evidence.

_ _

44. In your opinion, what are the major challenges being faced by the council in collecting, and disposing solid waste in Kwekwe?

_ _

_ _

_ _

45. What do you think are the solutions to the problems identified above?

_ _

_ _

SECTION D: COUNCIL BY-LAWS ON SOLID WASTE

46. Do you know any waste management law or policy?

Yes	No

If yes, specify._ _

47. Do you think most people in Kwekwe are aware of solid waste management policies?

Yes	No

48. Do you think the laws and policies on waste management are fully implemented?

Yes/ No

If yes explain_ _

_ _

49. Is there anyone whom you know who has been fined for dumping waste in Kwekwe?

Yes /No

50. Did the council make any efforts to educate the people on solid waste management?

Yes/ No

51. Whom do you think is to blame for environmental degradation in your location? Tick most appropriate box.

City council	
Residents	
Both of the above	
None of the above	

52. Are you aware of the polluter pays and user pay principles?

Yes/ No

53. How do you rate the Zimbabwe legislation in relation to the waste management?

Tick the appropriate box

Excellent : Comprehensive and efficient	
Good : Minor gaps and inadequacies	
Satisfactory : Some gaps inadequacies	
Poor : Significant gaps and inadequacies	
Very poor : Fundamental flaws and weakness	
No opinion : Insufficient basis and experience for which to judge	

SECTION E: ENVIRONMENTAL CONCERNS

54. Do you ever notice the presence of the following in and around the waste bin or waste dump?

	Yes	No
Dark flowing water		
Odour		
Mosquito/Cockroaches		
Fire		
Domestic animals		
Rats/Rodents		
Scavengers		

55. Which illnesses diseases are common in your residential area?----------

---

56. How would you rate the sweeping in location streets?

Good	
Average	
Fair	
Bad	
Non-existent	

56. Did you receive any environmental awareness information from the city's department of health?

Yes	NO

57. The main problem of the Kwekwe's Municipality to maintain a clean environment can be

one of the following: Tick the most appropriate in table below.

Lack of money to carry out their duties	
Shortage of vehicles to transport waste	
Residents are mainly to blame for the poor environment	
Too many people in Kwekwe	
Poor management system by the city authorities	
I don't know	

58. What suggestions do you have to improve solid waste management in the city of Kwekwe?

THANK YOU FOR YOUR COOPERATION

This research is for academic purposes and the information obtained and answers given will be treated with strict confidence and anonymously. Feel free to answer all questions. Thank you.

Areas and services

Please fill in the gaps, boxes, table below, to answer the following questions

Date----------

1.What is your position in this department of solid waste management?

----- ----------

2. What type of vehicles do you use for waste collection and how many are they?

Specify

Type of Vehicle	New	Old
Open truck		
Tippers		
Carts		
Tractors		
Other Specify		

3. How often do you collect waste from residential areas?

Once a week	
Twice a week	
Once per fortnight	
Once per month	
Other, specify	

4(a). What is the total number of households in Kwekwe?

b). What is the average number of persons per household for the following residential areas?

Residential Area	Population Density/ Household
High Density Residential	
Medium Density Residential	
Low Density Residential	

4. How much money do you charge for refuse collection per household per month?

$

5. Do you think this amount is sufficient to carry out your operations successfully?

Yes	
No	

6.(a) Are there some households with refuse fees arrears?

Yes	
No	

b) If yes, what is the total amount owed?

US$

c) How much money was allocated for solid waste management per month? Tick the appropriate

Below US$ 10 000	
US$ I0 000 to US$ 20 000	
US$ 20 000 to US$ 30 000	
US$ 30 000 to US$ 40 000	
US$ 40 and above	

7. Do you think the amount of money allocated to you is enough to carry out your duties efficiently?

Yes	No

8. Did you set any standard for solid waste collection?

If yes, do you reach these goals?----------

If no, why?----------

---

9. What is the total amount of waste produced per month\per week?

Per week……. tonnes

Per month…… tonnes

10. How many dumpsites do you have in Kwekwe?

11(a) Do you think culture has an impact on the people's attitude towards waste management?

Yes	
No	

(b) If yes, explain why?----------

---

12. In your own opinion how do you think the following factors affect the amount of solid waste generation in Kwekwe and to what degree?

Factor	Not at all	Not very	Quite	Very	Extreme
Income level	1	2	3	4	5
Population density	1	2	3	4	5
Culture	1	2	3	4	5
Education level	1	2	3	4	5
Age	1	2	3	4	5
Other, specify	1	2	3	4	5

13. In some parts of the residential areas, heaps of refuse are seen on road sides and other open spaces. Whom do you think is to blame?

Residents	
Municipality	
Institutions	
Industries	
Other Specify	
Don't know	

14. Do you think residents have the environmental knowledge that they should have?

Yes	
No	

15. How many environmental awareness campaigns did the municipality hold with the residents from last year to date?

16. Do you have enough land for waste disposal?

Yes	
No	

17. What other methods are there for waste disposal? ----------
---

18. Do you think the amount of solid waste generated varies with the following factors and explain why?

(a) Age----------

(b) Population density----------

(c)Income levels----------

(d)Cultural habits----------

19(a) Do you ever fine or charge the polluters? People/industries/institution

Yes	N0

a) If yes, how much money was charged?

$

20. Are you satisfied with services that you offer to the residents?

Tick the appropriate

Not satisfied at all	
Somewhat satisfied	
Satisfied	
Highly satisfied	

20 (a) Do you normally experience outbreak of diseases as a result of poor waste management?

Yes	
No	

b) If yes, name the diseases----------

---

21. How do you disseminate the information on environmental awareness?

Radio	
TV	
Magazine	
Road shows	
None	
Other specify	

22. How best can you describe the attitude of the residents towards their environment?

Positive	
Negative	
Mixed attitude	

Yes	

23. (a). Did you ever think of sub-contracting or privatizing your services?

No	

(b) If yes, explain why?----------

---

24. How would you rate as a percentage your waste management system?

Give the percentage

%

25. Do your solid waste workers have protective clothing?

Yes	No

26. What are your main challenges in the delivery of the solid waste management?

---

27. What do you think is the way forward to achieve an integrated sustainable solid waste management system in Kwekwe?

Thank you very much for your cooperation.