Characterisation and management of non-formal solid waste management disposal sites in Harare, Zimbabwe.

By

CASTON MAHAMBA

Submitted in accordance with the requirements

For the degree of

MASTER OF SCIENCE

in the subject

ENVIRONMENTAL MANAGEMENT

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROF TM RUHIIGA

FEBRUARY 2015

TABLE OF CONTENTS

DECLARATION

I, CASTON MAHAMBA, hereby declare that this dissertation is purely and wholly a product of my own creation.I further declare that the work herein is virtually my own original work and has not been previously partially or wholly submitted to any university or any institution of higher learning. Where consultations were sought, relevant acknowledgements have been dully conferred to in the way of referencing and citations; therefore, any material that may be found to be similar to any published work will be mere coincidence.

DEDICATION

I dedicate this dissertation to my late father and my mother, who instilled in me a culture of hard work from a tender age and never stopped to remind me of the power of education. I also dedicate it my wife Tsitsi, who made sure that I never got time off from my books until I completed this dissertation. Furthermore, with great love, I dedicate this work to my daughters Rumbidzai, Zivai, Wadzanai and son Tawanda; I hope will inspire them as they pursue their academic endeavours.

ACKNOWLEDGEMENTS

This dissertation might not have seen the light of the day or probably would have taken much longer to complete if it was not for the expert and untiring support of my most esteemed supervisor Professor TM Ruhiiga, to whom I am greatly indebted. His amazing knowledge and consummate mastery of the study area were manifested as he walked with me along the seldom trodden ground of research and opened my eyes as he fed me with the healthy milk of academic wisdom. My sincere gratitude also goes to Mrs N SMlilo, whose undisputable knowledge of statistics made my data analysis and hypothesis testing easily surmountable. I also acknowledge the efforts of Mr F Makarati,for his invaluable assistance during the compilation of this dissertation (especially on issues of academic writing). Special thanks also to Mr M Sibanda, who helped me with computer skills – especially on the two models of waste management hierarchy and sustainable waste management. The city of Harare and the Department of Waste Management receive special mention for their cooperation during my data collection, which was most encouraging, while the Zimbabwe Central Statistical Office is greatly thanked for their assistance with the demographic data of the city of Harare.

ABSTRACT

The study focused on the characterisation and management of non-formal solid waste disposal sites in Harare, the capital city of the Republic of Zimbabwe. In many developing countries, increasing urbanisation surpasses the development of urban infrastructure and this has led to the proliferation of informal settlements, illegal dumping sites and uncontrolled vending in cities like Harare. The researcher investigated the prevalence of non-formal dumping sites in Harare, including the composition, locational attributes and internal linkages of solid waste. Practices regarding the management of non-formal solid waste disposal sites were examined and areas of good practice and conformity to international standards were complemented while recommendations and suggestions were made on areas that were found wanting. An integrated management system was recommended for the sustainable management of solid waste. To support this recommendation, management window of responsibilities (EMWR) model was created so that the Harare City Council can enhance stakeholder participation. The research results show that most residents used non-conventional ways to store waste, like mealie-meal bags and sacks, and this posed a danger to human health. It also emerged that the city of Harare has not updated some of its by-laws, some of which were enacted about 33 years ago while others remained drafts for decades. This made it difficult for the city to effectively implement them.

Key terms: characterisations, solid waste, solid waste management, integrated solid waste management systems, non-formal solid waste disposal sites, Harare, municipality, environment, household, solid waste disposal

LIST OF FIGURES

TABLES **Page**

LIST OF ABBREVIATIONS

CBD	central business district
CSO	Central Statistical Office
DRC	Democratic Republic of Congo
EACs	East African countries
EMA	Environmental Management Agency
EPA	Environmental Protection Agency
EMWR	environmental management window of responsibilities
ISWM	integrated solid waste management
P	(Botswana) Pula
PDL	poverty datum line
R	(South African) Rand
RSA	Republic of South Africa
UK	United Kingdom of Great Britain and Northern Ireland
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
US	United States
USA	United States of America
US$	United States Dollar
ZESA	Zimbabwe Electricity Supply Authority

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND TO THE STUDY

As countries continue to industrialise, a number of challenges inevitably emerge and most of them impact heavily on the environment. Chief among the urban problems is solid waste management. Like many other cities in Sub-Saharan Africa and developing countries elsewhere in the world, Harare has been conspicuously unable to effectively manage its solid waste disposal sites. According to Bere(2013:24), the severity of solid waste management challenges in Zimbabwe (and Harare in particular) is clearly manifested in the prevalent accumulation of garbage in public places, on streets and in back alleys in many residential, industrial and commercial areas of the city.

Harare is the capital city of Zimbabwe and is located in the northern part of the country. The location of the city was influenced by the availability of water from the Mukuvisi and Manyame rivers, rich agricultural soil, gold deposits and relatively cool temperatures compared to most parts of the country. Harare receives an annual rainfall of over 1500mm. Abundant flat land was another attraction for the establishment of Harare, since this made it cheaper to construct structures of various designs and sizes without having to stabilise them with special foundations as is the case with undulating landscapes. Pioneer column (led by Cecil John Rhodes), which established the city in 1894, also considered the security offered by the surrounding kopjes. Harare is also the economic hub of the country, headquartering many of the companies operating in the country. In the 1960s, the city of Harare enjoyed some notable growth, as it was the administrative centre of the federation which comprised northern Rhodesia (Zambia) and Nyasaland (Malawi). It is also the current national administrative centre of Zimbabwe, where all the government ministries are located. Harare is also home to some of the country's institutions of higher learning, like the University of Zimbabwe, Belvedere Teachers' College, Seke Teachers' College, Harare Institute of Technology and Harare Polytechnical College. The city of Harare is predominantly inhabited by Shona-speaking people because it is surrounded by

provinces where these people live, including Mashonaland West, Mashonaland Central and Mashonaland East.

The position of Harare is also very strategic because it is the communication nodal point from where all the major roads in the country radiate; this means that the country is well connected with its neighbours. National roads and railway lines connect Harare to Zambia, Mozambique, Botswana and South Africa. Figure 1 shows the position of Harare in Zimbabwe.

Figure 1:Position of Harare, Zimbabwe

(source: http://www.google.co.za/search q=free+downloadable+map+Zimbabwe

Waste management, particularly solid waste management, is one of the most readily visible urban services whose effectiveness and sustainability can be used as an indicator to measure the competencies and commitment of a municipality. It is with this reason that one does not need to be a qualified environmental manager to see how the solid waste management system in Harare has collapsed. According to Manyanhaire and Munasirei(2010:69), Harare is currently ranked very low in the area of solid waste disposal compared to other African cities. They observe that the population growth has not been matched with the expansion of infrastructure, especially water reticulation and solid waste disposal; hence, the city has been cited by the Economic Intelligence Unit as one of the most unliveable cities in the world. According to the Zimbabwe National Statistical Agency(2012), the population of Harare is was 1 468 768 in 2012.The city cannot cope with such a big population and this results in residents dumping waste in undesignated areas, causing phenomenal environmental pollution. There is also no evidence of solid waste quantification, as more attention is focused on the effects of poorly managed solid waste like odour, rodents, sewer blockages, contaminated ground water and the general public nuisance caused by garbage.

According to Makarati and Chikobvu(2011:51), illegal dumping of solid waste has been cited as the chief cause of sewer system blockages (especially from plastics and sanitary waste).The poor management of solid waste (particularly the non-characterisation of non-formal solid waste dump sites) was seen by the same authors as contributing to the accumulation of heavy metals like lead, copper and zinc at non-formal disposal sites. These metals heavily pollute ground water and since most of the people in Harare depend on borehole water, there have been incidences of sickness caused by drinking contaminated water. Non-formal solid waste disposal sites have become a common sight in the streets of Harare, especially in the residential areas and the CBD. Littering has been attributed to the absence of enforcement of municipal by-laws and general despondency among residents due to ever-falling standards. According to the city of Harare's Department of Waste Management (2014), from 2005 to mid-2009, waste was not collected by the municipality due to economic hardship. It is assumed that some children who were born during that time grew up for more than five years without seeing any

waste being collected, which possibly led to a culture of littering and dumping. The exodus of qualified and experienced personnel from the country to neighbouring countries and abroad due to the economic doldrums that hit the country from 2005 to 2008 did not spare Harare's city council– an occurrence which also contributed to the collapse of the Department of Waste Management.

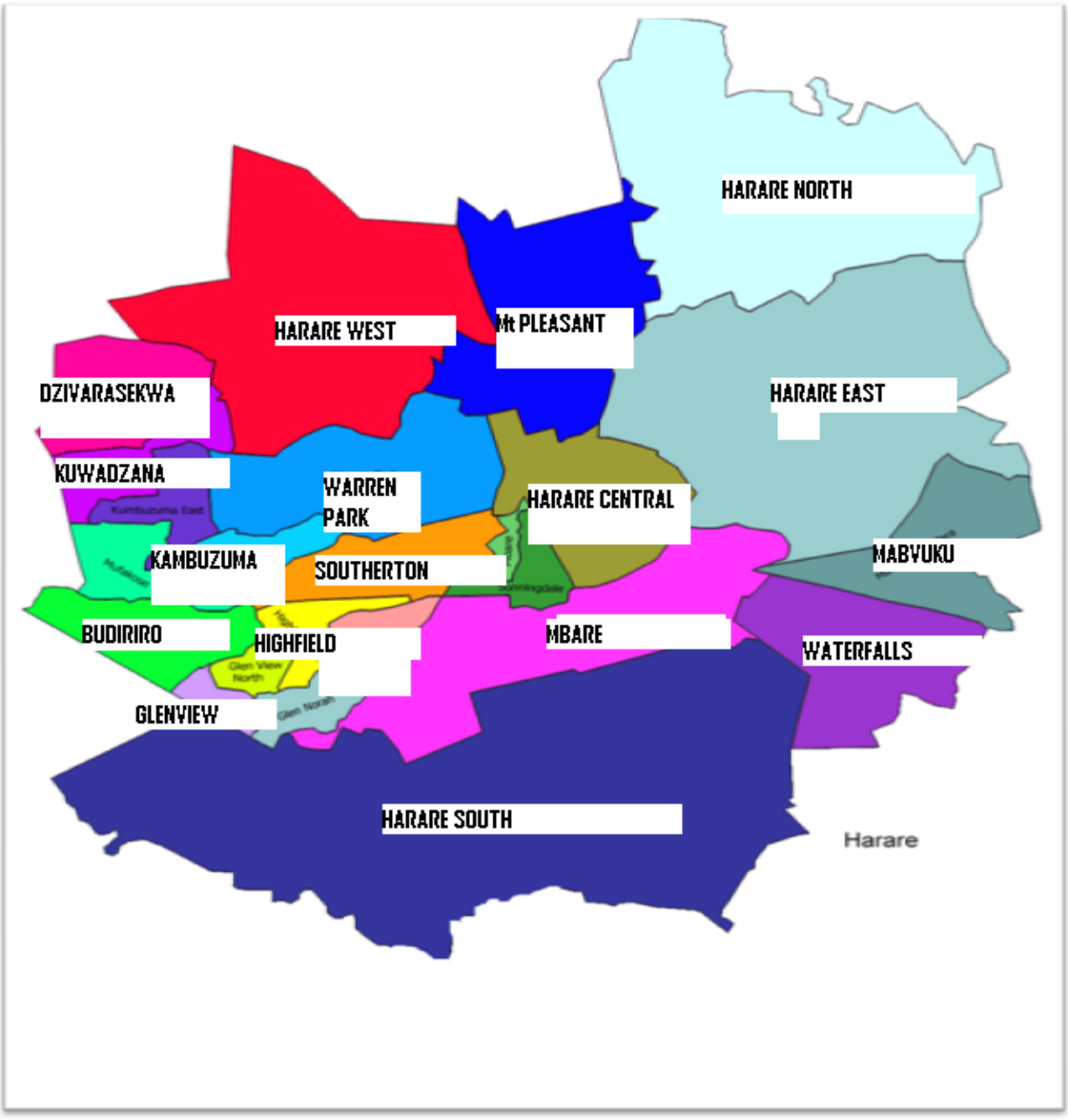


Figure 2: Districts of Harare(source: City of Harare 2014)

The districts re mainly designed to map out political boundaries and within these districts, wards are created to make the management of the city easy. They are named using directions (like Harare South, Central, West and East) and the names of some suburbs. Within these districts, there are various land uses. The main land-uses in Harare include residential use, industrial use and the central business district as shown in Figure 3.

Key

Central business district (CBD)

Industrial area

Low-density residential area

Low-income residential area

Medium-density residential area

Figure 3: Land use zones in Harare(source: City of Harare 2014)

Figure 3 illustrates urban land-use zones, especially residential areas. It shows that income influences the type and value of the house one will occupy and the distance from the CBD.High-income groups reside in more affluent areas with expensive houses that are usually away from the CBD since they can afford the high costs of rent and transport. The CBD contains the major shops and offices; it is the centre for commerce and entertainment, and the focus of transport routes. Low-density residential areas are characterised by high-class housing that are occupied by wealthy families who can afford expensive properties and the cost of commuting. These areas include Borrowdale, Highlands, Mandara, Chisipiti and Avondale. Medium-residential areas have high-quality housing and a lot of space. These include Waterfalls, Cranborn, Hatfield and Houton Park. The high-density residential areas are where the low-income groups reside. They are close to industries and town to enable workers to walk from and to town and work. Examples of these areas are Mbare, Glenview, Dzivarasekwa, Mufakose and Kuwadzana. These areas are characterised by poverty, overcrowding and illegal dumping of solid waste. Industrial areas are where the industries are located.

1.2 PROBLEM STATEMENT

The city of Harare displays the typical mix of formal and non-formal solid waste dumps. These are distributed across the different urban land-use types at various levels of intensity. While formal solid waste dumps are planned, strategically located for accessibility, adhere to national waste management guidelines and are regularly serviced, non-formal solid waste dumps do not share similar characteristics. They are illegal and therefore not planned by the city authorities; hence, they do not receive regular services and are not regulated. As a result of this, they cannot be easily managed using the same protocols as apply to solid waste dumps. The problem of illegal waste dumps is a multifaceted phenomenon in both a spatial and a temporal context. The dumping of solid waste on undesignated areas has become a topical issue, especially in developing countries. According to Chung (2010),dumping of waste at undesignated sites is mainly caused by the inability of municipalities to effectively collect waste on time, lack of enforcement of municipal laws, and lack of technical and financial capacity.

Much of the research efforts on urban waste management has focused on formal solid waste disposal sites, partly because of the availability of records, the ease with which they can be mapped, management practices that are aimed at meeting national waste guidelines and their location in high priority areas (such as residential, commercial and industrial districts). This means that not much is documented in the literature about the physical attributes of non-formal waste dumps, especially in developing countries. Yet an understanding of these attributes should provide important insights into the design of appropriate management interventions.

1.3 OBJECTIVES OF THE STUDY

The objectives of this study are as follows:

- Measure locational attributes of non-formal solid waste dumps.
- Analyse internal linkages of locational attributes.
- Classify waste by type across the study area.
- Analyse the variations in the profiles of waste in the study area.
- Describe current waste management approaches usedin Harare.
- Generate advice on sustainable waste management strategies.

1.4 PURPOSE OF THE STUDY

The purpose of this study is to measure and analyse the physical attributes of non-formal waste dumps at selected sites in the city of Harare as a basis for assessing current waste management practices. The research will generate information on the characterisation and management of non-formal solid waste disposal sites in Harare, and how it can be used to achieve sustainability. The information can also be used to reduce waste and its impact on the environment. The research findings are rooted in the contemporary urban issues of solid waste

management and sustainable cities, which makes the information invaluable for the city of Harare.

1.5 HYPOTHESES

The hypotheses of the study are as follows.

(1) There is a statistically significant relationship between the location of dump sites and the proximity of the dominant land-use type. The land use is on the x-axis (independent variable) while the location of the dump site is on the y-axis (dependent variable).
The data inputs to consider for this hypothesis are:
- distance of dump site from position of land use
- amount of waste
- type of waste
- size of dump site
- main land-use

(2) The actual size of a dump site is closely related to the land use within a specified radius.
The data inputs to consider for this hypothesis are:
- number of dump sites
- type of land use
- size of dump site

1.6 JUSTIFICATION FOR THE STUDY

This research has been necessitated by the seeming absence of a coherent strategy for a successful and sustainable solid waste disposal system in Harare. The study is aimed at trying to come up with sustainable and cost-effective solid waste disposal mechanisms. It is envisaged that the proper and monitored characterisation of solid waste, together with its sources, will go a long way in improving the management of solid waste. The research will provide city officials

and planners with an empirical justification for any proposed policy on domestic solid waste management.

The residents of Harare, the Ministry of Environment and Natural Resource Management and the Environmental Management Agency(EMA) need advice on efficient, affordable and integrated environmental management systems and environmentally-friendly ways to manage solid waste. The significance of this study is also to facilitate the exchange of information among cities in Zimbabwe and in the region at large. It is also meant to demonstrate the importance of integrated solid waste management. Teachers will be encouraged to come up with cleaner and green environment project-based learning through solid waste management awareness where the intellectual, emotional and social needs of a child are developed. Parents will gain more helpful information on parenting practices to teach their children about solid waste management. The research findings will also act as a seed bed from which other researchers and advocacy groups that are doing similar research may tap valuable information for their studies.

According to Musademba, Musiyandaka, Muzinda, Nhemachena and Jambwa(2011:15), the city of Harare faces widespread criticism from residents and regional and internal watchdogs on solid waste management. It is this that has prompted the researcher to contribute meaningfully to both theory and practice to the debate and to offer practical solutions to environmental management challenges. The business sector will also benefit from the research findings.

1.7 ASSUMPTIONS OF THE STUDY

As stated previously, dumping solid waste in undesignated areas has become a topical issue, especially in developing countries. According to Chung (2010), dumping waste is mainly caused by the inability of municipalities to effectively collect waste on time, lack of enforcement of municipal laws, and lack of technical and financial capacity. Dumping waste mainly occurs in residential areas and streets where vending has become the order of the day. According to

Faccia (2011), dumping waste is caused by a lack of environmental education (especially in developing countries). The same author observes that agricultural-based economies produce a lot of waste when preparing food, which makes it difficult for municipalities to cope. For the purpose of this study, the following assumptions are specified:

- The city of Harare has mechanisms in place to deal with the collection, storage and disposal of solid waste.
- Every household, business entity and institution has access to refuse bins for the temporary storage of solid waste.
- The city of Harare has designated waste collection points across all the land-use types.
- The residents of Harare have little knowledge about the benefits of good solid waste disposal and the dangers of poor waste disposal habits.

1.8 LIMITATIONS

The study only focused on the characterisation and management of non-formal solid waste disposal sites in Harare. While the locational attributes of non-formal solid waste disposal sites were measured and the waste classified according to type, the chemical and physical aspects of the waste were not analysed. The population sample that was chosen for the study (i.e. 50 dump sites) was too small to be reflective of the true state of solid waste management in Harare, let alone regional or global, to make watertight generalisations. The political situation in the country during the research was riddled with polarisation; hence most of the participants in the interviews and the staff of CSO were not very generous with the truth and held the researcher in suspicion. Some respondents were very impatient due to time constrains. Some members of the Department of Waste Management who were interviewed were not at liberty to disclose weaknesses for fear of reprisals from the state agents who suspect researchers of exposing failures and corruption, hence some of the information obtained during the interviews was sugar coated. The fact that the research was carried out in 12 months means that the

researcher did not have time to cross the length and breadth of the city to visit every illegal dump site.

1.9 DELIMITATIONS OF THE STUDY

The research was limited to the city of Harare, which is the capital of Zimbabwe. It is located in the northern part of the country and is 439 km from Bulawayo, which is the second largest city in the country and is located to the southwest. The city of Harare borders the towns of Chivu to the south, Marondera to the east, Bindura to the north and Norton to the west. Chitungwiza, Ruwa and Epworth were established as dormitory towns for house workers who worked in Harare, but are now regarded as satellite towns of Harare and have their own municipalities. The urban population of Harare excludes those of the satellite towns and currently stands at 1 485 231 people. The average population density is 2540 people per k$\mathbf{m^2}$ and the time zone is + 2 hours to the east of the Greenwich Meridian Time (GMT).The geographical coordinates are17^0 51 “50” S 31^0“47” S. The city of Harare covers an area of 960.6 k$\mathbf{m^2}$,with an elevation of 1.49m. There are 46 municipal wards in Harare, with an average population of 32 288 people per ward (Central Statistical Office 2013).).The study focused on the characterisation and management of non-formal solid waste disposal sites in Harare. A total of 879 dump sites were identified through out the study but only 50 dump sites were chosen for the study. The focus of this study is mainly on the residential areas, the CBD and industry, and the characterisation of non-formal solid waste disposal sites. The street map in Figure 4 shows the main streets and landmarks of Harare.

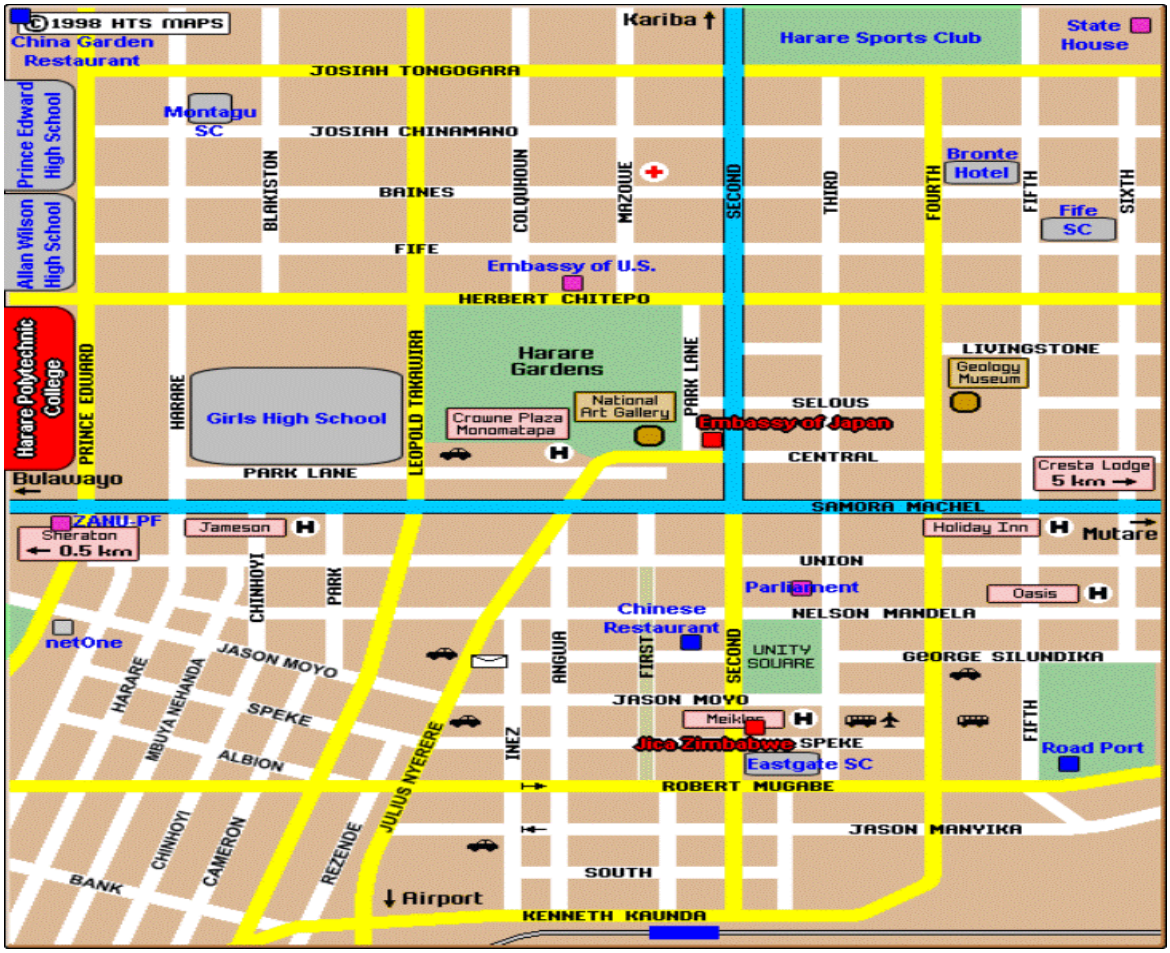


Figure 4: Street map of Harare (source: City of Harare 2014)

The streets are well designed and spaced for easy access to the CBD, some start from the south going to the north while others are from the west going to the east. The layout also enhances communication and vehicular transport.

1.10 CHAPTER BREAKDOWN

The chapters of this dissertation are arranged as follows:*Chapter 1*: This chapter contains the introduction to the study, including the background. The problem statement and the

justification, aim, objectives and hypotheses of the study are also presented. Lastly, the chapter breakdown and definition of terms are supplied.

- *Chapter 2*: This chapter reviews the literature that relates to the characterisation and management of non-formal solid waste disposal sites. Aspects of solid, such as the generation and transportation of solid waste, are investigated. The researcher examines and borrows from what other researchers have said on the topic.
- *Chapter 3*: This chapter covers the research design and methodology, the data collection methods and instruments, and the sample population.
- *Chapter 4*: The research results are presented and analysed in this chapter. The data is presented in frequencies, percentages, pie charts and bar graphs.
- *Chapter 5*: This chapter presents the data sets and results of the analysis. The data is presented in the form of frequencies, percentages, pie charts, bar graphs and photographs.
- *Chapter 6*: This chapter contains the conclusion and recommendations of the study. This is followed by the references and appendices.

1.11 DEFINITION OF TERMS

Characterisation: This is the process whereby the composition of waste streams is allocated to a particular descriptive label.

Harare: This is the capital city of Zimbabwe

Household: This is a family that exists as a separate entity.

Integrated solid waste management: This is a combination of a variety of management strategies that are interlinked to deal with solid waste in a holistic manner (Puorideme 2010).

Population: This is the total number of elements that one can investigate.

Solid waste: Any materials that are not prime products; for which the person who is generating the material has no further use in terms of his or her own purpose of production, transformation or consumption; and which he or she wants to dispose of but does not intend to dispose of by using a pipeline (UNEP 2010).

Solid waste management: This refers to all the activities of handling, treating, conditioning, transporting and disposing of waste (Government of Republic of South Africa 2006). [RSA 2006].

Urban area: Any built-up area of a country that is under the jurisdiction of a municipality.

Waste disposal: This means the burial, discharge, abandoning, dumping, placing or releasing of litter into or onto land, air or water.

Waste generation: This describes all the activities that produce waste, for example food processing, construction and office work.

1.12 SUMMARY

In this first chapter, the research topic was introduced. The background to the study was explored, the statement of the problem was elaborated, and the aim and objectives of the study were explained. The rationale behind and the justification for the study were expounded. The chapter ended with the delimitations of the study and the definition of terms.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This literature review was aimed at bringing to the fore a picture of the seemingly unending solid waste management problems in Harare. It focused on the severity of the problem, its scope and public views, and the paradigms on the problem of the characterisation and management of non-formal solid waste disposal sites in Harare. To achieve this, the researcher made use of books, journals, dissertations, newspapers, and government and municipal periodicals.

Non-formal solid waste dumps have become a persistent and topical issue in Zimbabwean cities – particularly in Harare, where there seems to be no observable evidence of proper management of these dumps. According to Mbanga (2011:121), the city of Harare is battling with problems caused by the ever-increasing number of illegal solid waste dump sites in undesignated areas. These non-formal waste dump sites pose a threat to both human and animal health. According to Mawire (2010:36), these illegal dump sites add an additional strain to the already overstretched municipal budget – hence most of them are rarely managed, especially in the low-income residential areas like Mbare, Mabvuku, Kuwadzana and Mufakose. Musademba et al(2011:63)state that the proliferation of non-formal solid waste dumps also creates an ugly and unsightly environment across the city. The non-collection of waste at these dump sites has also been linked to air pollution since the waste decomposes *in situ*, exuding offensive odours into the atmosphere. According to Okot-Okumu (2012), municipalities (especially of African cities) find it difficult to manage non-formal solid waste dumps due to the high rates of rural–urban migration and ineffective legislation on the illegal dumping of waste.

2.2 WASTE CHARACTERISATION

Waste characterisation can be defined as a process of determining the percentages of the different constituents of waste, for instance how much paper, glass, food waste and others is

discarded in one's waste streams. According to Munzwa (2010:54), waste characterisation is a process whereby different waste streams are analysed. Waste characterisation plays an important role in the treatment of waste; developers of new waste technology must also take into account what exactly waste streams consist of in order to fully treat the waste. The biological elements of the waste stream are crucially important in the use of systems such as composting and anaerobic digestion.

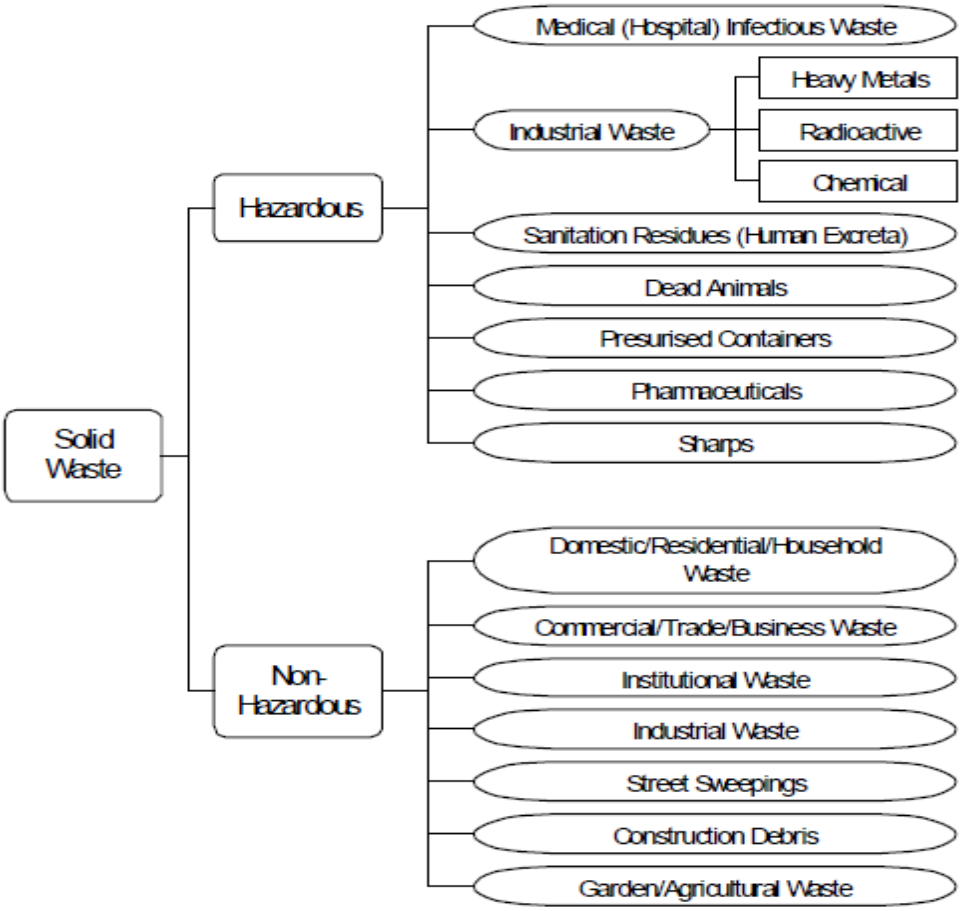


Figure 5:Characterisation of solid waste (source: http://www.google.co.zw/maps)

It also involves the chemical, microbiological or radiological constituency of waste material. Waste characterisation is mainly done with the purpose of reducing waste, recovering some material that can be reused, recovering energy, minimising the impacts of waste on the environment and reducing the costs of waste management. Information gathered helps in planning how to reduce waste, set up recycling programmes, and conserve money and energy. Saungweme (2012:39), defines waste characterisation as a process whereby the composition of

different waste streams is analysed. The same author describes it as a way of identifying the chemical, microbiological or the radiological constituents of waste material. The biological element of the waste is vitally important in the use of systems such as compositing or anaerobic digestion. Figure 5 illustrates how solid waste is characterised.

The segregation of solid waste has a number of benefits, including better and easy handling of was. The information helps in planning to reduce waste as well as setting up recycling programmes. According to UNEP (2007), the characterisation of industrial waste helps in determining whether the waste is classified as hazardous or non-hazardous for disposal purposes. The method depends on the analysis or interest, such as the potentiality of a toxic metal, chloride and the matrix of waste (such as solid or sediments)**.**

2.2.1 Benefits of waste characterisation

Waste characterisation has a number of benefits if it is carried out effectively. According to the USEP (2010), solid waste characterisation leads to less environmental pollution and conservation of natural resources since a great deal of materials will be recycled or re-used. There is also better coordination between waste generators and waste managers, leading to better performance by municipalities. Mader (2011:29) notes that there will be increased public participation, leading to improved public health and high cost recovery.

2.2.2 Waste classification

Wastes are classified into groups that pose similar risks to the environment and human health, and this can be used to facilitate their management and appropriate disposal. According to Fuggle and Rabbie (2006:231), waste can be grouped into various classes including special waste; waste with infection characteristics; and waste that can cause ill-health to humans and animals due to their toxicity, corrosiveness, volatility, in flammability, explossivity or radio-

activity. Liquid waste includes process water, wash water, cooking water, storm water, spills and sanitary waste. Hazardous wastes are all waste that contains asbestos and/or lead, which poses a great danger to human beings and other animals. Restricted solid waste is general, putrescible or non-putrescible Waste is classified on generation sites before disposal by using colour-coded bins. Some wastes are also classified on disposal sites in terms of easy measurement of variables like weight, moisture content and biodegradability

2.2.3 Waste profiles

According to UNEP (2010), a waste profile includes all the information about the waste from its generation to its disposal. In Harare – like any other city in the world –waste differs in the way that it is generated, transported, stored and disposed of. Generator and site information is used to establish the generator of the waste, the physical address where the waste is being generated and the activities that produce the waste. The material that makes up the bulk of the waste also needs to be known, as this helps in categorising the waste. The categories of the waste must be established in order to determine its biodegradability and toxicity, and the ease with which it can be handled. For ease of measurement and to record variables to generate primary data, the type of waste found on each dump site must be known. The transporters of waste must also be known, together with the equipment that they use to handle waste so that the safety of the workers and any persons who may have contact or are exposed to the waste on transit can be guaranteed.

2.2.4 Waste management protocols

A number of protocols govern the generation, storage, transportation and disposal of waste in Harare.EMA is responsible for all environmental concerns in Zimbabwe, including solid waste management. The Environmental Management Act of 2002 seeks, among other concerns, to enforce laws to protect the environment. The Environmental Management Efficient and Solid Waste Disposal Regulation Statutory Instrument 6 of 2007 controls the management of solid waste in Harare and other cities in Zimbabwe. Solid waste management in Harare is also guided

by international conventions and protocols which Zimbabwe has ratified (e.g. the Montreal Protocol of 1987, which seek to protect the ozone layer from harmful substances, the Kyoto Protocol that was signed in Japan in 1997, which seeks to reduce the emission of greenhouse gases into the atmosphere which cause global warming. Zimbabwe is also a signatory to the Rio-Declaration Agenda 21, which aims to curb unsustainable consumption patterns that cause environmental degradation and poverty. According to the government of Zimbabwe (2002, the Environmental Management Act also helps to guide the city of Harare on how to carry out environmental impact assessments.

2.3 DYNAMICS OF WASTE GENERATION

According to Makarati and Chikobvu (2011) waste generation differs from place to place around the world and is dependent on the economic activities of the country. Poor characterisation of solid waste leads to poor disposal methods, which result in poor waste management. In Harare, there is very little evidence of characterisation and segregation of waste – hence the homogenous nature of all the waste found at non-formal disposal sites. Currently, the Harare City Council's solid waste management leaves a lot to be desired, especially since most emerging economies are investing heavily in municipal solid waste management that is generated from agricultural activities in and around the city and the city council has not been able to manage the waste. The emergence of the informal business sector in the city due to the economic meltdown from 2000 to 2008 has meant that too much solid waste is generated at undesignated and unregistered premises, hence the irregular collection and management of solid waste. According to UNEP (2010), the global amount of municipal solid waste was 202 billion tonnes in 2006, representing a 7% increase since 2003. According to Momoh and Oladebeye (2010) in the same year, Africa produced about 172 million tonnes of solid waste, the global municipal solid waste rose by 3.3% to about 8%.According to Practical Action Zimbabwe (2010:13), Zimbabwe generates about 2.5 million tonnes of solid waste per year, both domestic and industrial.

The city of Harare has seen a large increase in the amount of solid waste, about 278 000 tonnes per year (Practical Action Zimbabwe 2013) especially. because urban agriculture has increased as a result of the economic meltdown and the demolition of houses in 2005 under the so-called Operation Restore Order (Murambatsvina of 2005). This produced massive volumes of demolition waste which the government had no capacity to manage. This wanton destruction left behind a trail of tonnes of rubble, earning the city the nickname "Garbage City". About 25 % of waste is also generated from agricultural activities in and around the city, and the city council has not been able to effectively manage this waste. The emergency of a more vibrant informal sector that has overtaken the formal sector means that a lot of solid waste is generated and dumped at undesignated points, thereby aggravating the already unacceptable level of litter in the city. The hardest hit areas in this regard include Mbare's Mupedzanhamo and Magaba, which have become synonymous with garbage. The types of solid waste that is generated in Harare are shown in Figure 6.

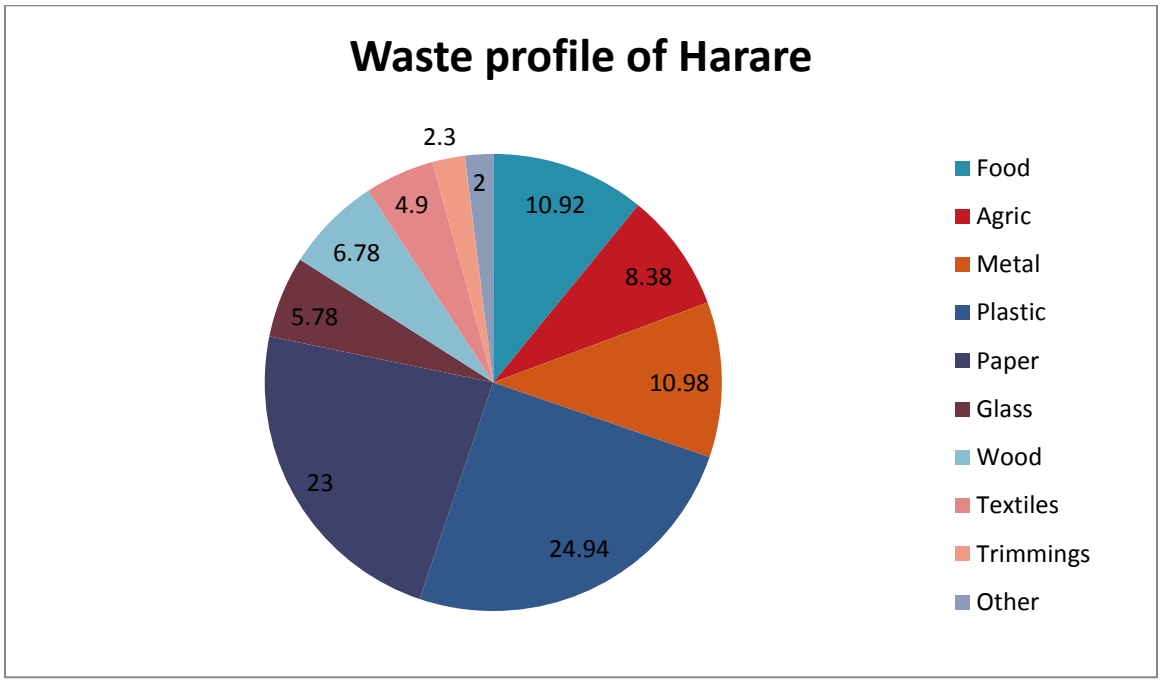


Figure 6: Waste profile of Harare (source: City of Harare 2014)

The above figure shows that more than 50% of the solid waste is biodegradable. This is comparable with other cities in emerging markets. In the European Union, the average

biodegradable waste generated by households was 40%, for Nairobi in Kenya it was 40% and for Marondera in Zimbabwe it was 43%. Poor characterisation of solid waste leads to challenges in disposal methods with adverse effects on waste management. In Harare, there seems to be no evidence of segregation of the waste – hence the homogeneous nature of the waste found on all the non-formal disposal sites. Currently, the Harare City Council's solid waste management leaves a lot to be desired, especially since most emerging economies are investing heavily in municipal solid waste management**.**

2.4 NON-FORMAL SOLID WASTE DISPOSAL SITES

According to Jambwa (2011:33), illegal waste dumping is dropping or placing waste at areas that are not designated for this purpose by the municipality. The waste is usually dropped off at open spaces in residential areas, street corners, road junctions and even backyards. In Harare, illegal dump sites can now be seen at bus ranks, notably in Mbare and Road Port. Some illegal dump sites are at the back of buildings, in recreational parks and in thoroughfares. According to Nyakudya and Stroosnijder (2011),the illegal dumping of waste is mainly caused by the sporadic and (in some cases) non-collection of waste by the municipality, the inability of municipalities to regularly collect waste from generation sources due to financial constraints and the absence of clear legislation on waste disposal. If the fines for illegal dumping are not prohibitive enough the problem may not be curbed. Irresponsible residents also contribute to the illegal dumping of waste. Some residents lack both environmental education and environmental responsibility, hence most think that the municipality is responsible for waste management in the city. Rapid population growth in Harare also leads to the illegal dumping of waste, since the municipality cannot cope with the influx of people. According to Mapira (2012:47),the illegal dumping of waste in Harare is also caused by the increasing number of squatter settlements. These settlements are not officially recognised by the municipality; hence the waste that they generate is not managed by the municipality.

UNEP (2002) defines non-formal dump sites as undesignated areas where people drop off waste; these sites are not officially recognised by the municipality, and they are rarely serviced or not serviced at all. Dropping waste off at these sites is illegal, and so are the sites themselves. According to Mapira (2012), informal dump sites have become a huge problem in recent years as they now compete with human beings for land and financial resources. Unlike formal dump sites, non-formal dump sites may exist for a longer time, thereby extending their negative impact on the environment (like land, water and air pollution)and being breeding places for vectors like mosquitoes, rodents and snails. These dump sites also increase the scavenger populations, which also helps to spread diseases. In Harare, most non-formal dump sites are found in the high-density residential areas predominantly inhabited by low-income groups. According to Mapira (2012:50), the number of non-formal dump sites reflects mainland use as well as types of food mainly consumed across the city. More agricultural-based waste is found in high-density suburbs and informal settlements because these people cannot afford the luxury of processed foods from shops. In the more affluent suburbs, there are fewer and smaller informal dump sites and these are characterised mostly by hedge trimmings. According to Makarati and Chikobvu (2011) the problem of these non-formal dump sites can be reduced by rigorously implementing spot fines; placing billboards on dump sites with information discouraging people from illegal dumping; increasing municipal police visibility; and reaching out to people on the radios and television and in newspapers.

Table 1: Selected areas and number of waste dumps in Harare

AREA	NUMBER OF DUMPS	ESTIMATED VOLUME IN KG	AREA	NUMBER OF DUMPS	ESTIMATED VOLUME IN KG
Glen Norah	39	11 700	Eastlea	31	93 000
Hatfield	6	18 000	Cranborn	32	96 000
Greendale	7	21 000	Mabvuku	35	105 000
Highlands	4	12 000	Avondale	4	11800
Sunningdale	13	39 000	Highfield	156	310 000
Mt Pleasant	18	54 000	Mbare	281	104 300
Radcliffe	17	51 000	Borrowdale	2	6 000

(Source: City of Harare and Field work 2014)

Table 1 shows some selected suburbs in Harare with their number of non-formal dump sites and estimated volumes of waste and loads required to remove the waste**.** The municipality can also provide storage facilities for waste before transportation. Non-formal dump sites must be identified and managed since ignoring them will only worsen the situation. From Table 1, there are more non-formal dump sites in low-density residential areas (as is seen in areas like Glen Norah, Mabvuku, Mbare, Highfield earlier shown in Figure 3 . This can be attributed to high population sizes and informal activities (like backyard industries) that produce a lot of waste.There are fewer illegal dump sites in low-density residential areas (as is seen in places like Borrowdale, Mt Pleasant, Avondale, Highlands, Eastlea and Greendale) (Low density). Low population densities in these areas and better environmental awareness are cited as the main reasons for the fewer number of dump sites. Hatfield and Cranborne are some of the medium residential areas in Harare and also have fewer dumpsites compared to high-density residential areas.

2.5 SOLID WASTE MANAGEMENT

2.5.1 Introduction

This section is presented in terms of content using a funnel design from the general, to global, to Africa and down to conditions in Zimbabwe The general approach covers the field of solid waste management with respect of is conventional about waste generation, transportation, treatment and final disposal. This then provides the background for looking at what research has been carried out on solid waste management in different parts of the world.

2.5.2 Conventional solid waste management

Puorideme (2010) defines integrated solid waste management as a comprehensive model that combines elements of waste prevention, recycling, composting and disposal with active stakeholder participation which ensures efficient and sustainable waste management. The natural objectives of integrated solid waste management are to deal with social acceptability,

environmental sustainability, economic affordability and management effectiveness. The model advocates full stakeholder participation in all the environmental activities that take place in the city. Environmental sustainability is at the core of integrated solid waste management, hence all economic and human activities should be contracted in a way that always leads to environmental sustainability. Effective management means waste should be properly managed during generation, temporary storage and transportation, and should be disposed of in an environmentally-friendly manner that does not pose any danger to human beings and animals. Economic affordability entails that while municipalities strive to achieve a cleaner and safer environment, the economic implications should not be ignored – which means that municipalities should ensure that the management of solid waste is cheap and affordable (Kemal 2007:24).

The major ways of managing solid waste are recycling, re-using, reducing, composting and disposal, and are in interrelated. The benefits that accrue from an integrated management system are immeasurable, ranging from energy recovery, money from selling waste, less health hazards and improved resource conservation to improved public health. In as much as the model tries to meet economic, environmental and managerial obligations, the social aspects also have to be met. This means that it must be accepted by its constituency, which are the stakeholders, and the ultimate goal should be to benefit residents. An integrated waste management system also promotes energy recovery and greater coordination between the stakeholders and processes. Health hazards are reduced, costs are cut and public participation is enhanced, leading to collective responsibility. In an integrated management system, it is very easy to identify areas of weakness and prompt action can be taken, and routine checks and balances can be instituted, since all the stakeholders are aware of their mandate and do not take offence when they are found wanting. Tevera (2013:8)posits that an integrated solid waste management system is the way to go for all modern cities and municipalities, as it is the glue that holds together the various components and ensures sustainability, accountability, financial affordability and social acceptability.

Source reduction is aimed at reducing the quantities of waste at their generation/source. According to Saungweme (2012:63), source reduction is best done through purchasing or using material, for instance using products and packaging in lower quantities and with less toxicity. Better waste segregation in households and communities reduces waste to the landfill. Local authorities and communities should be encouraged to promote the use and return of re-usable and retainable containers. Public awareness on the benefits of waste reduction is also very important as it empowers the community on environmental, economic and social implications. Thus, generators of waste must constantly be reminded of their environmental obligations.

All waste that can be recycled should by law or policy be recycled to reduce waste, costs and environmental pollution. Materials like glass, paper, water, plastic and metals should be recycled to ensure the sustainability of resources. According to UNEP (2000), the USA produced about 231.9 million tonnes of solid waste and 69.9 tonnes were recycled. The concept of waste recycling, especially domestic waste, has not received the attention it deserves (as is clear from Table 6).

Table 2: Recycling in Europe

COUNTRY	**% MUNICIPAL WASTE RECYCLED**	**COUNTRY**	**%MUNICIPAL WASTE RECYCLED**
UK	40%	Denmark	29%
Italy	35%	Austria	50%
Spain	23%	Germany	21%
Netherlands	43%		

(Source: UNEP 2010:59)

The situation shown in Table 2 paints a very bleak picture considering that all the countries belong to the developed world, but their level of commitment to recycling domestic solid waste is far below expectations.

Composting is one of the oldest ways of solid waste management since the establishment of relatively permanent settlements and the advent of crop farming. According to Kutiwa et al

(2010), composting is a method of solid waste management where the biodegradable components of a waste stream are placed in prepared areas so that the waste decomposes and valuable mineral elements are unlocked and returned to the soil to improve its fertility. It can also be used for anaerobic breakdown to generate biogas as a way of energy recovery. Composting is more effective when done with agricultural waste.

The concept of re-use means that materials should be used again and again for as long as they can still serve the purpose for which they were made and do not pose a threat to human health and the environment. Materials recovered from the waste stream can be used in their current form, like bottles and plastic containers that are cleaned after use and then used again. Used water can be used for cleaning cars, gardening and cooling machines in industries. This cuts costs, saves time on manufacturing and reduces volumes of waste to landfills.

In small and isolated communities like farms and in hospital and schools, most of the waste that is generated is destroyed in well-engineered incinerators. This method involves the combustion of solid waste to reduce it to ashes, thereby significantly reducing the volume of the waste. Incineration can also be used to recover energy. If the waste is from plant remains, the ashes can be used as an alkaline fertilizer (Manyuchi and Phiri 2012). However, if incineration is done on a large scale, it can cause air pollution.

Disposal refers to the process of taking waste to dump sites, incinerators and landfills. Sound, healthy and sustainable environmental practices dictate that disposal should be carried out as a last resort because it is the only method of solid waste management that has the greatest environmental impact and therefore it should be avoided at all costs or be minimised as much as possible. The volume of waste should be reduced as much as possible prior to disposal and the residual should be disposed of in an environmentally sound manner, preferably at landfills.

Landfills are scientifically designed and engineered facilities where solid waste is disposed of, compacted and managed. After all the other contemporary methods of solid waste

management have been applied and/or failed, the remaining waste must go to a landfill (Manyuchi and Phiri 2012). The same authors observed that landfills must be located 60m from lakes and streams, 1500 m from human settlements and 2 S000 m from airports. The waste must be compacted on a daily basis and covered with a layer of soil to immobilise the waste and reduce the activities of scavengers. Leachate must be monitor regularly to see if it will affect ground water. Landfills are expensive to build and to operate. In most cases, landfills have a lifespan of about 25 years, which – in terms of financial costs – is a relatively short period of time. Even during closure, landfills still have to be financed. The heavy machinery used in operating a landfill is very expensive to acquire and maintain. The diagram below (Figure 10) shows Pomona Landfill in Harare, which is currently the only functional landfill in Harare and the biggest landfill in the country. According to the Harare City Council's Department of Waste Management (2014), there are 200 registered people who collect waste from the dumpsite to sell to recycling companies like Hunyani Pulp and Paper and individuals for re-use. These people are registered for accountability by the city council because the landfill is a protected area and access to it by persons other than municipal workers has to be sanctioned by the city council's Department of Waste Management.

Figure 7shows how an integrated solid waste model works and the benefits that accrue from it if it is properly implemented. From the model environmental management can be enhanced through an integrated system with a wide view that is aimed at sustainability. Modern solid waste management can be addressed effectively if there is greater integration of the core components of the environmental management cogs, which are social acceptability, environmental sustainability, economic affordability and management effectiveness. It is shown from this diagram that integrated environmental management is the only option for countries to effectively deal with the issue of solid waste management. It promotes public participation, good environmental sustainability, cost effectiveness, better human health and a greater desire for natural resource conservation. Accountability on the side of the generators of waste leads to better co-ordination and performance improvement.

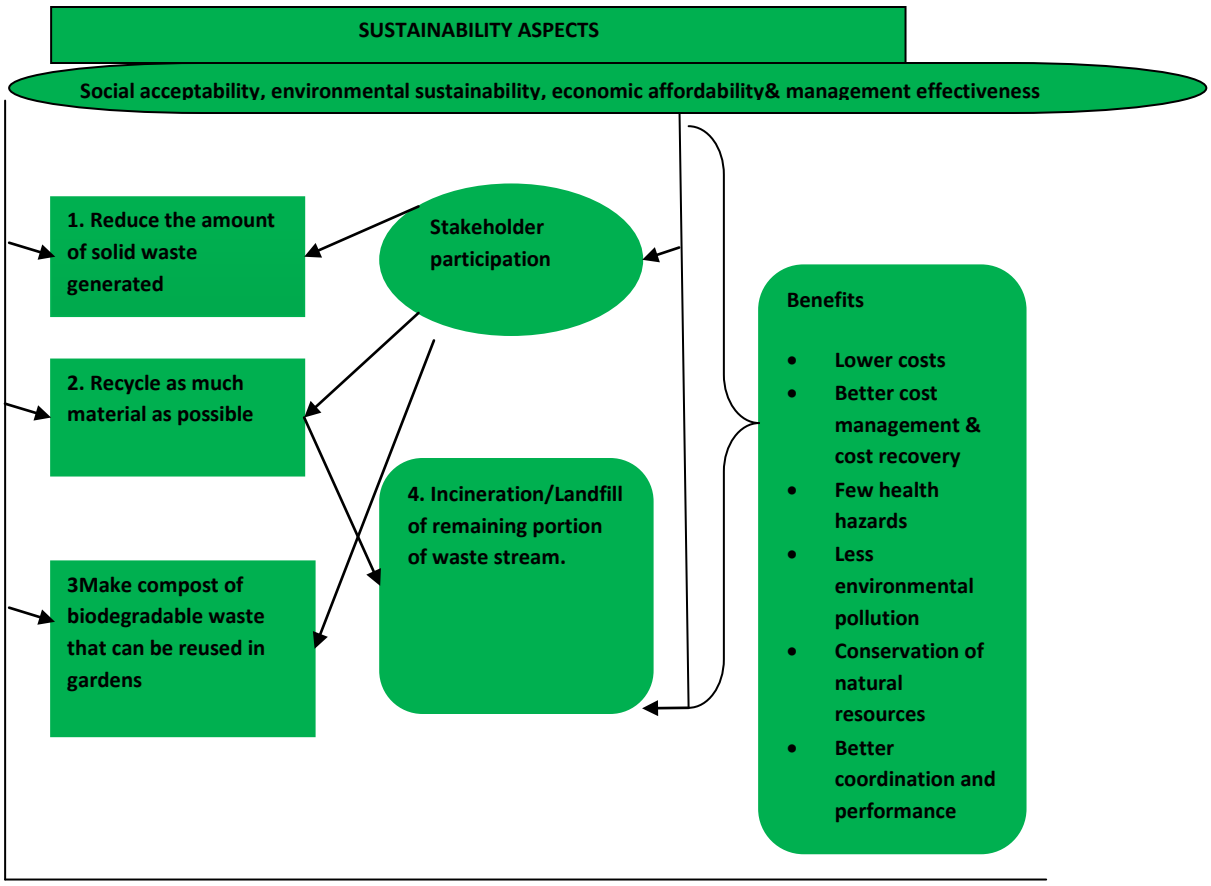


Figure 7: Integrated solid waste management model

(Source: Adapted from Puopiel 2010)

Solid waste impacts heavily on the environment and the effects can be very adverse if the waste is not managed properly Mapira (2012:37). The effects can range from short term to long term, with varying degrees of impact on the environment. The short-term environmental effects to the immediate environment include odours; outbreaks of disease like cholera; air water and land pollution; blocked sewer pipes; and distortion of the aesthetic appeal of the environment. Some waste, like broken bottles, can injure people and animals. According to Waugh (2006:241), the long-term environmental effects on the environment last much longer, cause considerable damage and threaten species with extinction. These include climate change due to the emission of greenhouse gases into the atmosphere, threats to biodiversity, desertification and siltation of water bodies around the city. In order for the city of Harare to

achieve sustainable waste management, there should be rigorous environmental education on the need for the proper disposal of domestic waste.

The municipality must provide adequate handling and disposal facilities. Investors must be encouraged to set up recycling industries to deal with the problem of non-biodegradable materials. Residents must be mobilised to join clean-up campaigns/weeks. Waste production can also be reduced by using strong bags and baskets instead of plastics bags and using both sides of the paper when typing. Materials can be re-used (e.g. glass and plastic bottles with deposits can be returned to shops for re-use) and waste can be recycled (e.g. plastic, rubber, paper and water).

Solid waste management is undertaken to reduce the effect of waste on health and the environment. Tapera (2013) observed that basically, all the waste management methods are aimed at reducing waste at the source.

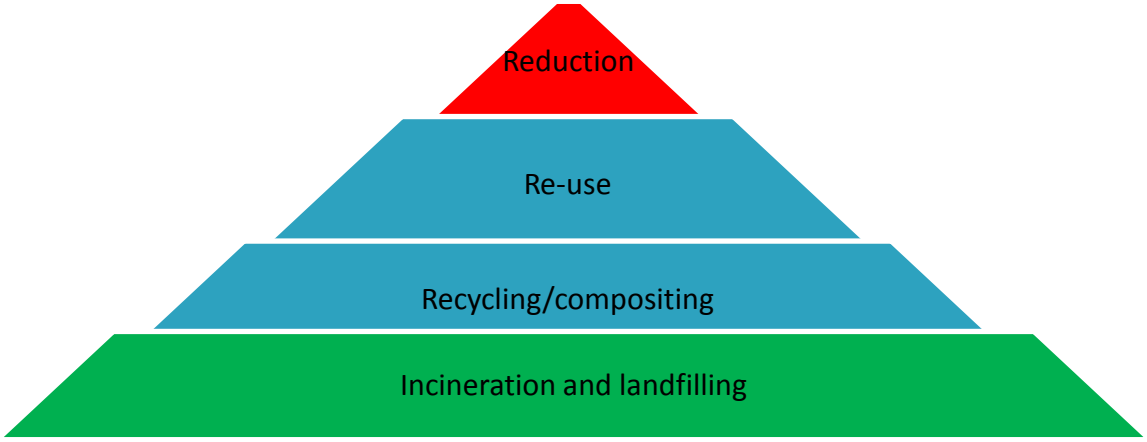


Figure 8: Waste management hierarchy

(Source: UNEP 2005)

This is mainly achieved through waste segregation. Waste segregation is widely used to manage household waste at the source. It involves separating waste by type, for instance biodegradable material, plastics, paper and tins. A waste management hierarchy illustrates the preferences for each method of solid waste management (as shown in Figure 8).

The waste management hierarchy places great emphasis on waste reduction and encourages recycling where reduction has failed. According to UNEP (2005),the waste management hierarchy model encourages the prevention of waste or reduces the amount of waste generated, and reduces toxicity or the negative impacts of waste. According to Saungweme (2012:81), solid waste management has social, environmental and economic benefits, accruing from team work, protection of the environment and saving money by recycling and re-use of solid waste.

Table 3: Waste collection recommendations

GEOGRAPHICAL LOCATION	FREQUENCY OF WASTE COLLECTION
Tropics	Daily
Temperate	Every two days in summer; every three days in winter
Cool climates	Twice a week in summer; once a week in winter

(Source: UNEP 2006:37)

According to UNEP (1996), of necessity, the frequency of waste collection depends on the geological location of the place and the tropical areas are obliged to be more regular in their waste collection given their high temperatures which promote high microbial activity. Medical waste should be collected daily. The situation is best illustrated in Table 3.

2.5.3 The Global Context

In many parts of the world, solid waste management has become a dominant urban environmental issue that continues to attract growing audience that ranges from academics, politicians, economists, the media and civic organisations. In recent years, it has undoubtedly become a big employer and a pursuable discipline of study. In general, West European cities are more advanced than African cities when it comes to solid waste management and can only be compared with cities in the United States of America. According to Halfman (2010), most European companies now focus on avoiding and recovering waste, and view disposal as a last resort when the waste cannot be turned into anything of value. Waste management is also viewed as an industry that generates employment, skills and revenue for municipalities. According to the central intelligence (2010:10), the generators of waste should be responsible for educating consumers about their products and the best way of disposing of the eventual

waste. Consumer information on products is mandatory. According to Seng and Seng (2010), some municipalities in Germany are encouraging turning landfills into recreational parks as a way of reclaiming land.

While the situation of solid waste management in Harare is worrisome, studies carried out in other parts of Africa, Western Europe, the USA and Asia show that the issue of solid waste management is a global problem and that even the developed countries have sad stories to tell. In the USA, Table 4, solid waste disposal is also a problem. According to Cherubini (2010), American citizens produce about 2kg of waste per person per day. Space for waste is also a big problem. According to the US EPA (2010), municipal waste disposal costs the country billions of dollars per year. The most common waste streams in the USA are shown in the Table 4.

Table 4: Municipal waste streams in the United States

WASTE STREAM	PERCENTAGE (%)	WASTE STREAM	PERCENTAGE (%)
Food	12.5	Textiles	7.6
Yard	12.8	Wood	5.6
Paper	37.7	Glass	5.3
Plastic	12.1	Other	3.2
Metals	8.2		
Others	3.2		
Total			**100.0**

(Source: US EPA 2010)

The USA has a higher food waste percentage (12.5 %) compared to most developing countries (8% on average).However, in terms of performance, their systems of solid waste management are very functional and efficient. The main methods of solid waste management disposal in the US include composting, incineration, ocean dumping and recycling. According to Halfman (2010), recycling municipal solid waste in the US only accounts for 40%. This author notes an intensification of source reduction techniques in the country.

In China, municipal solid waste disposal is also a major concern. According to Chung (2010), about 500 million people in China live in urban areas. Most of the solid waste that is generated in the cities is managed by landfills (89.3%) incineration (3.72%) and composting (6.98%). According to Geng, Zhu, Doberstein and Fujita (2009), China has 651 solid waste disposal facilities, which include 528 landfills, 78 composting sites and 45 incineration plants; recycling is currently at 44%, which is quite commendable by world standards. In Italy, land fillings are the most common waste management practice. According to Cherubini (2010), waste is used to generate about 15% of the electricity in Italy (especially in Rome, where more than 15% of the municipal electricity is generated from waste). This is a plausible energy recovery way that reduces waste and protects the environment.

2.5.4 Conditions in Africa

Awoso and Tariwo(2010) note that solid waste management problems (particularly in African cities) are exacerbated by the low levels of environmental literacy and the type of food, which in many cases is unrefined and produces a lot of waste during preparation. They also note that most of the industries are mainly agricultural based and extractive, which means that they produce a lot of waste compared to cities in the developed world where the service industry is high and produces less waste. Ruhiiga(2013) reports that most African cities experience problems with solid waste management because countries are rapidly and massively urbanising while there are no clear budgets for municipalities. He also says that land acquisition is difficult and therefore informal settlements mushroom. He notes that most cities in Africa do snot generate enough money to service their clients. This leads to poor solid waste management. According to Burnley (2007), most African cities fail to manage e-waste because it is a relatively new product and disposal methods for it have not been developed.

In the East African Community (EAC)- made up of Kenya, Tanzania, Uganda, Rwanda and Burundi- the management of solid waste is reportedly a major problem. The wastes generated by the EACs, according to Okot-Okumu and Nyenje(2011), is decomposable matter but e-waste is becoming significant due to the increasing levels of technology. The majority of municipalities therefore need to be educated on how to manage e-waste. Old computers can be broken down for parts to reduce waste since most of the hardware can be re-used. These include keyboards, the outer cover and even the mouse. Kenya is leading other East African countries in as far as e-waste management is concerned (UNEP 2009).

Table 5: Comparison of waste compositions in East African cities

WASTE COMPOSITION (%)	**DAR-ES-SALAAM**	**MOSHI**	**JINJA**	**KAMPALA**	**LIRA**	**NAIROBI**
Bio-waste	71.0	65.0	78.6	77.2	68.7	65.0
Paper	9.0	9.0	8.0	8.3	5.5	6.0
Plastic	9.0	9.0	7.9	9.5	6.8	12.0
Glass	4.0	3.0	0.7	1.3	1.9	2.0
Metal	3.0	2.0	0.5	0.3	2.2	1.0
Others	4.0	12.0	4.3	3.4	14.9	14.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

(Source: UNEP 2011:71)

Table 6: Comparison of solid waste management in selected cities

city	Collection of waste by local authority
Dares Salaam (Tanzania)	More than 63% of solid waste remains uncollected in residential areas.
Kinshasa(Democratic Republic of Congo)	Collection of household waste is undertaken only in residential areas. In the rest of the city, waste is put on the roadside, at illegal dump sites, in open spaces or in storm water drains.
Karachi(Pakistan)	Only 40% of solid waste produced by households is collected.
South Africa	Nearly 42% of all waste is recycled.

(Source: UNEP 2011)

UNEP (2011) provides comparative statistics for several cities in East Africa ib Table 5. Overall, the waste generation rates for urban cities in EACs vary on average from 0.26(low income) to 0.78(high income) kg per capita per day (UNEP 2009).The lack of integrated solid waste management in most EACs means that the collection of solid waste is sporadic and poorly monitored. In Table 6, conditions across two cities and two countries are presented. According to Ruhiiga (2013), in cities like Kampala in Uganda and Nairobi in Kenya, the encroachment of urban agriculture has impacted on urban boundaries – which means that too much waste is left close to cities or actually gets into cities. The availability of rail and road infrastructure has also increased accessibility to urban cities by many volumes of people; hence more waste is produced which the cities (with their meagre budgets) cannot manage properly.

In Southern Africa, most countries will have to contend with the problem for a little longer. According to Bere (2011:11), municipalities in Southern African cities (cities in South Africa excluded) are failing to come up with efficient waste management operations that are sustainable. They continue to base their models and resources on a "collect, transport and throw away" approach. This model of solid waste management has proven to be faulty since it is ineffective, inefficient and unsustainable. Table 2 illustrates the different percentages of waste management for selected cities. According to government of South Africa solid waste management can be defined as a holistic approach including all the activities involved in the handling of waste – from generation, storage, transportation and disposal – in an environmentally-friendly manner. According to Burnely (2010), solid waste management is aimed at maximising energy and material recovery, while minimising the amount of waste delivered to the dump site/landfill, the pollution related to waste and the treatment collection steps.

Compared to the rest of Africa, South Africa has done fairly well in solid waste management. The country has laid down laws on managing solid waste. The National Environmental Management Act 107 of 1998 sets out laws and policies on environmental issues. According to this Act, there should be an emphasis on waste avoidance, reduction, re-use, recycling,

recovery and treatment, with safe disposal as a last resort. According to Matate and Trois (2010), South African cities are moving towards zero waste. They now peg recycling of waste at more than 45%. In major cities like Johannesburg, skip bins are available in most areas; solid waste in residential areas are collected once a week in Ekurhuleni Municipality; and there are marked collecting facilities in central Johannesburg for plastics, glass, paper and food waste. Though Johannesburg has made great strides in solid waste management littering and pollution still remain big challenges. According to the National Waste Management Strategy of 2011, South Africa will achieve 95% waste collection in urban areas and over 80% of the disposal sites will be licensed by 2015.As a fast-growing country, South Africa produces a lot of waste. Mudau, Ruhiiga and Malan (2013), report that South Africa is doing fairly well when it comes to solid waste management, although there are challenges of compliance and environmental literacy.

2.5.5 Waste Management in Zimbabwe

According to Mangizvo(2010:15), an integrated system helps to promote a cleaner and safer neighbourhood, high efficiency and improved resource augmentation. It saves costs due to the reduced levels of final waste for use. There are also better business opportunities and economic growth, and increased local ownership and participation. It can be seen from the that solid waste management is still a serious problem in developing countries due to the fast rate of urbanisation. Harare is hardest hit by this problem. While Harare's solid waste problems seem to be quite insurmountable, some researchers still believe that the situation can be improved with proper planning. According to Makura(2013:18), the municipality of Harare needs proper policing and adequate financial support from all stakeholders in order to improve its waste management system. This author also notes the general unwillingness among residents to participate in waste management issues because most of them are preoccupied with bread and butter issues because of the increased poverty in the country.

The city of Harare is a typical example of a failed city when it comes to waste management. The number of non-formal solid waste dumps has increased to unbearable proportions, as can be seen at bus ranks in Mbare, in Fourth Street, in Rezende Street, at the Charge Office and at Market Square. According to Madebwe and Mudebwe (2010:15), most emerging economies still find it difficult to manage solid waste due to the lack of technical expertise, inadequate funding, and clear government and municipal policies on solid waste management. According to Bere (2013:11, the real problem with solid waste management in Zimbabwe is neither financial nor technical, but strategic and management in nature. This means that lasting solutions can only come from an integrated approach, where the municipality must move away from the current unsustainable "collect, transport and throw away" approach to an integrated solid waste management approach. An integrated solid waste management is currently viewed as the only system that covers the whole spectrum of solid waste management as it covers its generation, storage, treatment, recovery and disposal with an emphasis on maximising the use of resources efficiency. Therefore, contrary to the common belief that most of the problems associated with solid waste disposal in Zimbabwe are a result of the lack of financial, technical and political will, Bere (2013) maintains that the city of Harare must develop strategies that are coherent enough for it to successfully implement a sustainable, integrated solid waste management system.

Mapira(2012) observed that in recent years, in Harare, solid waste management remains the responsibility of the city council and the subject of integrated solid waste management in Zimbabwe is still largely the domain of environmental academics who are mostly outside central and local government, with their theoretical knowledge locked away in their offices and computer software. According to Mangizvo (2010), municipalities in Zimbabwe still view solid waste disposal as a task to be performed or an event to be managed but not as a continuous process. He encourages city councils to come up with routine and continuous cycles to check the efficiencies and effectiveness of their systems. It has also been noted that Zimbabwe municipal by-laws for environmental offences, particularly littering, are not prohibitive. UNEP(2011) states that strategy is weak, particularly in developing countries where the laws

are less strictly and less harshly enforced. There is also a lack of documentation on solid waste quantities, as there are no weighbridge facilities at disposal sites to accurately weigh and document the amounts of solid waste disposed. According to Okot-Okumu (2012), many cities do not have the results of solid waste processing per day and there is no characterisation; instead, all types of waste are mixed and thrown into a community bin and the quantities are determined by the number of truck loads per day. According to Muchadehama(2012:27), the city of Harare has to improve local governance if it is serious about sustainable solid waste management. This author notes that rampant corruption and lack of accountability are some of the factors that have contributed to the collapse of the solid waste management system in Zimbabwe and particularly in Harare. It has also been observed that the current political system in Zimbabwe affects the proper functioning of municipalities.

Magadu(2013) observes that unregulated vending points along the streets of Harare as also responsible for the increasing number of non-formal solid waste disposal sites in the city. The vendors– selling vegetables, fruits, food and drinks – do not have bins to service their customers. He notes that the few public toilets cannot cope with the ever-increasing population and this leads to people relieving themselves on the pavements and at the back of buildings. The few efficient and clean toilets in the city are beyond the reach of many as they charge 50cents, which is equivalent to R5.For many Zimbabweans, this is very prohibitive compared to the charge in other cities in the region. For example, in Johannesburg, most municipal toilet facilities charge R1 and in Gaborone the charge is P1.

It has been observed in history and human sociology that unemployment and poverty change people's bodies and minds; hence, it can be said that the problem of illegally dumping solid waste and littering in Harare is are a reflection of the changed mindset of the general populace who are overwhelmed by economic hardship and have forgotten the culture of cleanliness as they are perennially busy with issues of survival. Makarati and Chikobvu (2011:63) note that the political system in the country interferes with donor and lobby groups who want to help with both financial and technical support to help the council to deal with solid waste management.

The government views these donors and lobby groups as agents of regime change bend on destabilising the country and exposing the government's failures. The populist philosophy of most African governments is also blamed for the problem of illegal dumping because governments do not want to reprimand residents for fear of losing votes in elections, hence the mushrooming of illegal vending stalls and parking lots for commuter buses. The government is aware of the fact that they cannot create employment, so they sometimes allow people to vend in undesignated areas. In Harare, the problem of illegal dumping is also a result of ineffective managerial capabilities of the Department of Waste Management because as one walks around, there is evidence of gross negligence of basic waste management practices like street sweeping and cleaning public toilets (both of which do not require much finance and thinking). Some residents who were interviewed during the fieldwork accused the city council of corrupt tendencies, where municipal police officers take bribes from vendors on a daily basis so that they can continue to conduct their businesses in undesignated areas. The overcrowding of bus termini (like in Mbare, at Market Square and in Fourth Street) adds to the problem. These facilities have not been expanded in many years to accommodate the ever-increasing number of taxis that join the existing traffic everyday. The high rate of unemployment, which is estimated at 80%, has also meant that a lot of the most able-bodied residents have joined the ranks of the vendors – resulting in more waste being generated. According to the Zimbabwe Central Statistical Office (2013), the level of unemployment in the country (and in Harare in particular) is a major driver of waste generation since most of the residents are now engaged in activities that generate a lot of waste (like selling scrap metal, backyard carpentry, selling vegetables and green mealies, shoe repair and flea markets).

According to Mapira (2012:12), solid waste disposal should be viewed in the social context where all citizens are socialised from an early age about the importance of good solid waste disposal. This will help them to become responsible citizens when they are adults. From this, the city of Harare has a lot of challenges when it comes to solid waste disposal. This is also clear from the solid waste littered and heaped around the city. There are many non-formal solid

waste disposal sites in the CBD. This poses a danger to the people and is a public nuisance. The situation is both filthy and unsightly.

Waste management, including refuse collection, in Zimbabwe is governed by environmental laws and council and municipal by-laws. The following are some of the laws that govern solid waste generation and management in Zimbabwe. The Environmental Impact Assessment Policy of 1994is aimed at monitoring and assessing the impacts of all human activities on the environment. It ensures that activities and projects in the country conform to environmental standards. Activities have to be environmentally audited before the commencement of the activity (pre-auditing), on site while the project is going on and after the completion of the project. The National Sustainable Development Strategy of 2004 dictates that all developments should be carried out in a manner that is sustainable and never compromises the environment. It strives to ensure that while current human endeavours seek to satisfy the needs of the present generation, they should not compromise or rob future generations of a livelihood. The Draft Waste Management Strategy of 2006governs the management of waste in Zimbabwe while the Science and Technology Policy of 2002 mandates that all scientific research and new technology must enhance and promote environmental sustainability. The Draft National Environmental Policy of 2003 was crafted to ensure that the environment is protected; it makes it criminal for anyone to act in any manner that will endanger the environment.

In Harare, only the city council and/or its contractors have the responsibility of removing domestic waste from premises (according to a City of Harare by-law of 1979). In principle, domestic waste has to be collected at least once a week, but currently heaps of wastes left for more than five months without being collected and the situation is even worse at non-formal dump sites. Access to waste is restricted once the waste is deposited at disposal sites (City of Harare 1981)The EMA is an arm of government tasked with ensuring that environmental laws are understood, observed and applied. Its powers override those of municipalities, though in a complementary manner. Currently EMA fines for companies and municipalities that do not comply with environmental laws from US$1500 to US$5000 (as gazetted).

Although the law does not give people access to dump sites, economic hardships force many people to scavenge on them in an effort to put their hands on anything sellable. From the evidence from both formal and non-formal dump sites, it can be seen that that very little recycling is taking place. Because of the city of Harare's failure to collect waste on time, most residents have resorted to other alternatives of storing waste while others hopelessly wait for the perennially incompetent council to collect the waste. People have resorted to burning, burying, dumping and composting waste to get rid of it – often with dire consequences. The alternative mechanisms/methods are shown in Figure9.

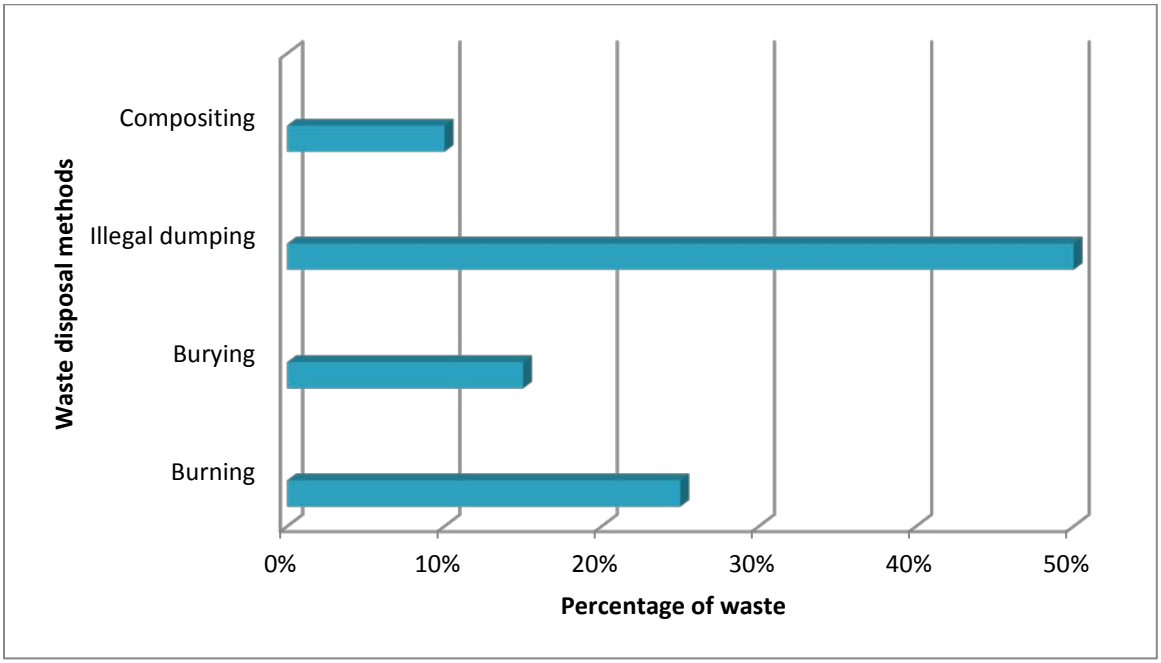


Figure 9: Waste disposal methods in Harare

(Source: City of Harare 2014)

It can be seen from Figure 9that illegal dumping of waste has become so fashionable that people no longer feel bad about dropping waste anyhow which was a taboo not so long ago.

At household level, waste is stored in a variety of receptacles before it is disposed of. These include metal bins supplied by the city council and plastic bags that the residents buy. Some households do not even store the waste in receptacles but put it in the alleys behind their

houses. Figure 9shows that at almost 50% of Harare residents illegally dump their waste. Most residents do not use conventional methods of managing waste, as is seen by the 25% who burn solid waste and 15% who bury waste. While composting is encouraged since it helps in decomposing waste for organic fertilizers that are used in gardens, one can notice that it is not widely practiced (as shown by the 10%). These measures are taken by residents as they try to deal with waste that the municipality is failing to handle. Burning and burying waste are mainly done as a way to deal with waste, but there are far-reaching consequences (like odours, breeding ground for pathogens and vectors, and rodents) and they make the vicinity ugly and unsightly. The situation speaks volumes about the extent to which the city of Harare has failed to deal with the problem of solid waste.

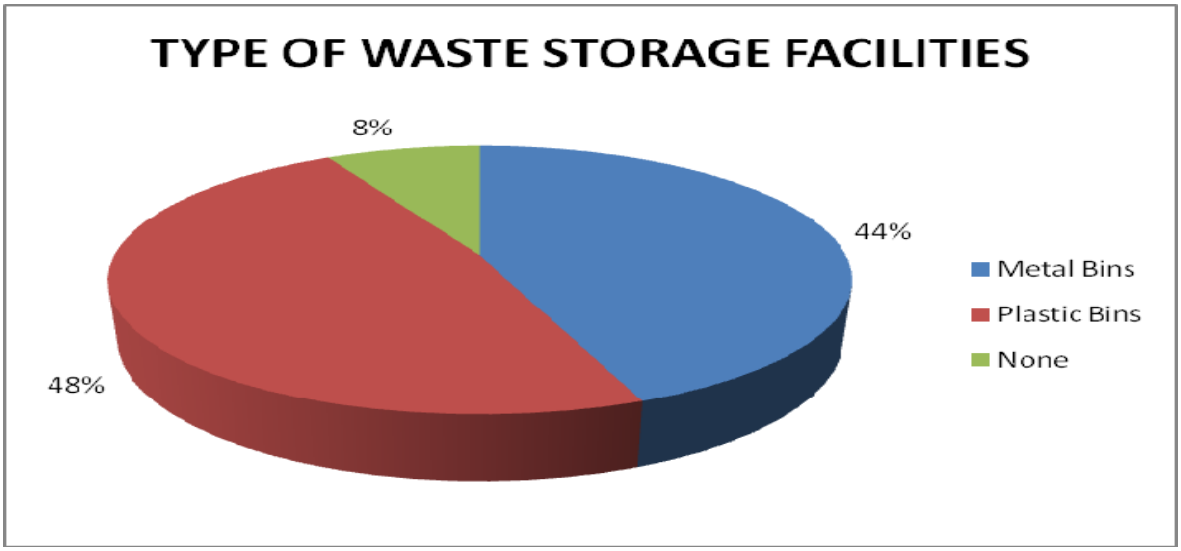


Figure 10: Waste storage facilities

(source: Fieldwork 2014)

Figure 10 shows that the bulk (48%) of solid waste in Harare is temporarily stored in plastic bags at the generation source before it is transferred to dump sites. The inadequate waste storage facilities at household level (as indicated by the 8%) is a great cause for concern since this forces residents to store and dispose of waste in both unhygienic and unsustainable means. While the situation in Harare can be described as dire, all hope is not yet lost because some researchers still feel that their ideas can be used to help contain the situation while long-term

solutions are pursued. According to Beres (2012), the city of Harare should start educating its residents about good solid waste management practices. It is felt that the newly introduced colour-coded bins –see Figure 11-should be locally manufactured to reduce costs and it has been observed that they are only used in the CBD. The city of Harare is encouraged to increase the number of these bins and spread them evenly across the city as this will go a long way in disseminating the information about separating and recycling waste. The fact that the bins are coloured means that they have a natural appeal and are conspicuous enough to attract the public and entice them into depositing waste in these bins. Public places like shopping malls, bus termini and market places are the most ideal for a start.

Figure 11:Colour-coded bins in Harare

(source: City of Harare 2013)

From 2012, the city of Harare has experienced visible developments and actions in solid waste management. Colour-coded bins have been introduced as a way of emphasising the need for solid waste characterisation and recycling. These colour-coded bins can now be seen around the streets, parks and shopping malls in the CBD, but they are still few and the city council

should increase and distribute them evenly across the city if there is to be any meaningful change in the littering levels in the CBD and the rest of the city.

2.6 SUMMARY

The characterisation and management of non-formal solid waste disposal sites remain a challenge in most developing cities and Harare is no exception. In the literature review, it was noted that uncontrolled rural–urban migration, political interference with council business, corruption and technical incompetence are the main causes of poor solid waste management in Harare. Possible solutions to the challenges have been suggested. Contemporary solid waste management strategies have been described with a view to encouraging sustainable solid waste management methods**.**

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

In this chapter the research design and methodology of the study are discussed. Elements such as the following are covered: an overview of methodological approaches, sampling, and data collection instruments and procedures. Issues of validity, reliability and trustworthiness that are relevant to the study are highlighted.

3.2 RESEARCH DESIGN

The research design for the study was quantitative, non-experimental, descriptive and predominantly based on parametric data sets obtained through observation, interviews and existing official statistics of the city of Harare. The research work involved a random selection of study sites corresponding to different land-use types. Primary data sources were generated on the basis of the physical measurement of attributes of non-formal waste dumps and site observations to generate classes of solid waste. A structured interview was then used to solicit information on waste management practices from officials of the City Council of Harare responsible for waste management. The survey design was justified because the objects of investigation, non-formal waste dumps were studied in their natural state without manipulation of the variables. The variables of interest were measured on ratio and interval scales, rendering data sets suitable for quantitative analysis. According to Chikoko and Moyo (2003:27), this design allows for flexibility during the collection of data. The design also allows for the collection of data on the basis of which questions on the who, what, where, when and how phenomena can be addressed. Correlation was used at stage two of the analysis, following the computation of descriptive statistics based on both primary and secondary data sets. The techniques of multiple correlation and regression as well as chi-square formed the basis of for testing statistical relationships. This design was further justified because it allowed for a multiplicity of measurable variables, which in turn allowed for the analysis of internal

relationships between the cluster of independent variables at one level and between the explanatory and dependent variables at another level. The use of statistical analysis made it possible to test hypotheses and draw conclusions.

On the whole, the design incorporated the use of a hybrid of primary and relevant secondary data that was numerical and textual. The researcher had a relative degree of control over the information that was collected and methods of collection. Primary data sources included results of survey measurements on non-formal waste dumps and responses of interviews with eight officials of the City Council of Harare.

3.3 DATA SOURCES

As indicated above, the primary data sources included results of survey measurements on non-formal waste dumps and responses of interviews with officials of the City Council of Harare. Secondary data sources consisted of sets of data on waste from the city of Harare covering the period from 1990 to 2014 that were extracted from the annual reports of the City Council of Harare (budget and waste performance).

3.4 POPULATION

According to Mouton (2001:81), a population can be defined as the total number of elements or cases that one can investigate. Bryman (2007) describes a population as the universe of units from where a sample is drawn in an attempt to statistically represent a population. It is not possible to investigate every member of a given population due to time constrains. According to the Harare City Council's Department of Waste Management (2014) there are approximately 789 non-formal dump sites across the city. In this research, a ground census was carried out after selecting three specific districts for inclusion in the study. The areas that were represented were high-density residential area, a medium-density residential area and low-density residential area.

3.5 DESIGN OF RESEARCH INSTRUMENTS

The researcher designed the research instruments. The interview was mainly structured and a few parts were semi-structured to suit different respondents. The observation schedule was designed to capture data on dump sites according to classes of waste, the physical properties of waste, locational attributes and the main land-uses that generated the waste.

3.6 DATA MANAGEMENT AND PRESENTATION

For each of the objectives specified earlier, the sources of data are indicated and the method of collection, method of analysis, specification of analytical techniques and their justification are provided. The results of each objective are initially represented graphically by using Excel spreadsheet software (Gwimbi & Dirwai 2003:84). The individual graphs are at the level of frequency distributions, following the screening of data sets and removal of outliers. Hypothesis tests were performed to check the accuracy of the hypotheses. The actual data analysis was presented using the SAS JMP (Microsoft 2012).

The objectives were matched with a relevant statistical technique and reasons for the choice are advanced as follows:

- *Objective 1*.Measure the locational attributes of non-formal solid waste dumps (size of dumps, type of waste, generation sources, quantities of waste and size of land covered by waste); statistical technique – descriptive statistics.
- *Objective 2*.Analyse internal linkages between locational attributes of waste; statistical technique – correlation, SAS JMP. This was chosen because it describes the relationships between known variables of solid waste.

- *Objective 3*. Classify waste by type in the study area. No statistical technique was used; instead, the classification was based solely on direct visual observation at the dump sites.
- *Objective 4*.Analyse the variations in the profile of waste in the study area; used descriptive statistics based on observations.
- *Objective 5*.Describe current waste management approaches; used descriptive statistics: correlation. This was chosen because it describes relationships between solid waste and their variations.
- *Objective 6*. Generate advice on sustainable waste management approaches; used an efficiency index. This enabled the researcher to measure the performance standards of the existing strategies and then compare them with the suggested strategies.

3.7 CHOICE OF INSTRUMENTS

Only interviews and observations were used to gather primary data. The researcher chose these instruments over others because they were more appropriate for the study and easy to administer. Since the research dealt with physical and locational attributes and types of solid waste, the observation method was found to be very fitting. The structured interview was also chosen because it enabled the researcher to get primary data from city council officials and because of the adaptability of interviews.

Table 7: Instruments and variables measured.

INSTRUMENT	VARIABLES	DESCRIPTION OF MEASURE	TYPE OF SCALE
Interview	Distance of dump site from main land-use	Distance of dump site from main land-use measured in metres	Ratio
	Size of dump site	Volume of waste for each dump site measured in kilograms	Ratio
	Number of dump sites	Total number of dump sites measured in figures	Ratio
Observation	Number of dump sites	Total number of dump sites counted across study area in figures	Ratio
	Distance of dump site from main land-use	Distance of dump site from market, shops or railway line measured in metres	Ratio
	Size of dump site	Volume of waste for dump site measured in kilograms	Ratio
	Type of waste	Waste classified into categories (e.g. food, wood and plastic)	Ratio

(Source: Author)

Interviews were administered to 8 officials in the directorate of waste management of the city of Harare. The interviews were meant to solicit information on the distance of dump sites from the main land-use zones and this was measured in metres, the sizes of the dump sites were determined and expressed in kilograms while the number of dump sites in the city was counted and the total was given in figures. Table 7 shows the variables which were observed. Firstly the number of dump sites was established, the distances of dump sites from main land-use zones were established and given in kilometers. The sizes of dump sites were also estimated in kilograms. The type of waste was estimated visually by using surface area expressed as a % of

the entire area covered by the site and then translated into kilogram equivalents. The inherent limitations in this technique are acknowledged but it was not possible to physically sort waste at each of the fifty sites.

3.8 PILOT STUDY

A pilot Study was conducted on five non-formal solid waste disposal sites in the study area in order to test the validity and reliability of the research instruments. From the feedback, the researcher was able to establish the correctness of individual questions in the interviews and individual items in the observation schedules were found suitable for generating responses in agreement with specific variables. Both the questions and the instructions on the interview grid were pre-tested for errors and clarity. Reliability was tested by assessing the level of precession achieved in the design measures for capturing data. According to Kitchin and Tate (2000), the instruments should be revised to eliminate ambiguities and clarify some questions. On the whole, the pilot study was done to check the viability of the research instruments.

3.9: DATA COLLECTION

The data was collected through observations and interviews.

3.9.1 Observations

Before the actual data collection procedures were carried out, a pilot study was conducted to check the accuracy of the research instruments and refine questions that were thought to be unclear or ambiguous. The primary data was gathered through observations, which were carried out to establish the sizes, number and distribution of non-formal dump sites in the Harare. Records were kept on the amount of land covered by these dump sites and the types of waste on these dumps were classified. the impact of the waste on the immediate environment was investigated. According Makarati and Chikobvu (2011:12), observations have the advantage of giving the researcher the opportunity to interact with the subjects of the investigation and all field measurements are done on the spot.

3.9.2 Interviews

The interviews were carried out to collect information on issues that could not be observed in the field. Waste management officials were interviewed to get information about the calibre of

personnel in the Department of Waste Management, the budget allocated for waste management, the number of solid waste collection vehicles, future plans and targets. According to Chifamba (2010:37), interviews are very effective as a method of gathering data because they are flexible and adaptable. Managers from the Department of Waste Management, the city's Health Department and ordinary residents were interviewed during face-to-face interviews where the researcher had the luxury to modifying various lines of inquiry. Non-verbal responses during the interview enhanced a greater understanding of and helped in bringing out possible changes in the meaning of some aspects of the issues that were probed. However, the interviews were time consuming and required adequate and through preparation. Taylor and Proctor (2001) assert that interviews can develop interpersonal trust, leading to the respondent revealing more information.

3.10 SAMPLING TECHNIQUE

A sample can be viewed as a part or segment of the population that is selected for the study. The researcher used purposive and non-probability sampling where, according to Bell and Bryman (2007), some units have an unknown chance of being selected. The city of Harare has 46 municipal wards which are serviced by the city council. These wards are demarcated according to population size and are mapped for election purposes; hence, one residential area may have more wards than others. The Zimbabwe CSO (2013) puts the population of Harare (urban) at 1 485 231 people, with 372 862 households that each has an average of four persons. According to the ground survey carried out and records from the Harare City Council's Department of Waste Management (2014), there are 789 non-formal solid waste dumps across the city. A ground census was carried out in the field to identify, map and code each of these sites. From the 789 waste dumps, 50 sites were sampled randomly (which translated to 6.33% of all the dumps). A sample size of 50 was deemed appropriate for this study. All the dump sites were mapped and using a table of random digits against the total population earlier coded. The locational attributes that were measured included the number of dump sites, the size of the dump sites and the distance of a dump site from a significant landmark like a shopping mall, a bus terminus and/or a market place. These attributes were measured to ascertain whether the

land use, its intensity and the distance influenced the location of the waste dumps. The population of the dump sites was 789. This figure was derived from a ground enumeration exercise that was carried out in June 2014. Each of the 789 dump sites was allocated a three-digit number (code): 001, 002, and 003, et cetera to789. Random sampling was used to identify the population of the study. The sample was obtained from the three main land-uses: high-density residential areas, medium-density residential and low-density residential areas. 50 dump sites were chosen to represent the sample because it was large enough to provide conclusive facts. The distribution of coded dump sites is shown in Figure 12.

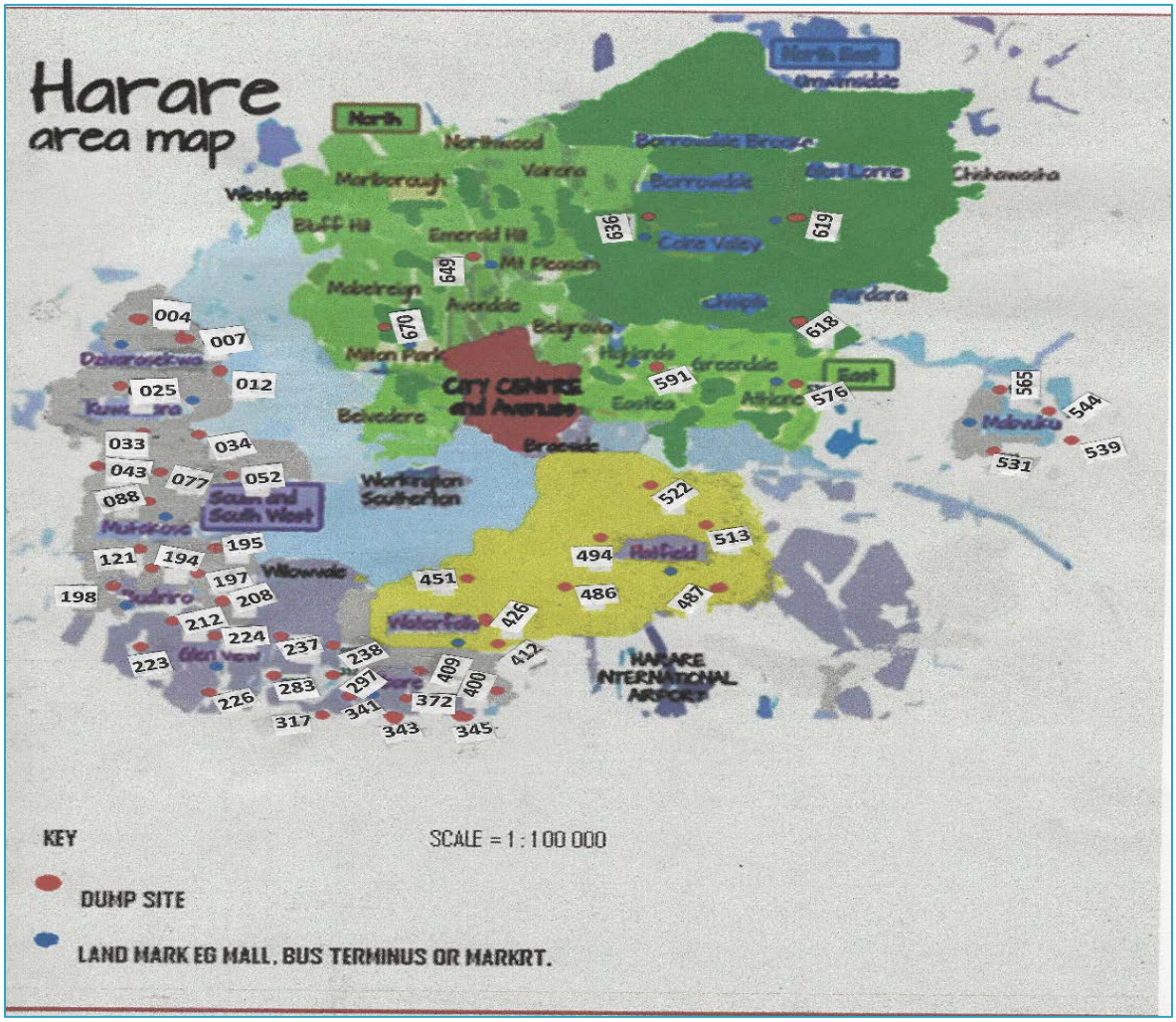


Figure 12: Distribution of illegal dump sites in Harare (Source: City of Harare and Field work 2014)

The samples were counted in an anti-clockwise direction from Divarasekwa, starting with dump site004 and ending in Malborough with dump site 670. A distribution table –see Table 8-was generated to show how the dump sites were grouped according to size.

Table 8: Size of dump site in relation to land use

Dump site code	Volume of waste in kg	Small - less than 1000kg	Medium – less than 2000 kg	Large more than 2000 kg	Land use
004	2100			✓	High density
007	1500		✓		High density
012	1300		✓		High density
025	2000			✓	High density
033	1100		✓		High density
034	2300			✓	High density
O43	1300		✓		High density
052	2800			✓	High density
077	1500		✓		High density
083	2100			✓	High density
121	2700			✓	High density
194	3 000			✓	High density
195	2 000			✓	High density
197	18 00		✓		High density
198	13 00		✓		High density
202	20 00			✓	High density
212	26 00			✓	High density
223	30 00			✓	High density
224	27 00			✓	High density
227	21 00			✓	High density
237	23 00			✓	High density
238	33 00			✓	High density
283	1700		✓		High density
297	3100			✓	High density
317	2900			✓	High density
341	2200			✓	High density
343	1900		✓		High density
345	2800			✓	High density
368	1900		✓		High density
372	2300			✓	High density
400	1800		✓		High density
409	3000			✓	High density
412	2700			✓	High density
426	3100			✓	High density
451	1100		✓		Medium
486	0800	✓			Medium
487	1000		✓		Medium
494	7 00	✓			Medium
513	1100		✓		Medium
522	800	✓			Medium
531	2800			✓	High density
544	2 00			✓	High density
565	2100			✓	High density
576	600	✓			Low density
591	5 00	✓			Low density
618	8 00	✓			Low density
619	1000		✓		Low density
326	500	✓			Low density
649	400	✓			Low density
670	500	✓			Low density

Source: (Fieldwork and records from city of Harare: 2014).

The dumps were grouped according to volume size, with those less than 2000 kg defined as small, less than 2000 kg as medium and those with more than 3000 kg as large. The dump sites were also identified according to land use or where they were located: high-density, medium-density and low-density residential areas.

3.11 SUMMARY

In this chapter, the research design, data collection procedures, data collection instruments the sampling technique were discussed. The research findings are presented in the next chapter.

CHAPTER 4: PRESENTATION OF THE DATA

4.1 INTRODUCTION

Chapter 2 gave a panoramic view of solid waste and its management at a global, regional and local level. An in-depth study of non-formal solid waste disposal sites was carried out, with the emphasis on their management and characterisation in Harare in particular. Chapter 3 dealt mainly with issues of data collection. In this chapter the research findings and their analysis are presented on the basis of the empirical evidence on the state of solid waste management in the city of Harare. To enhance an understanding and the visual impact of the presentation, percentages, tables, graphs and photographs are used. These findings are from the interviews conducted with employees of the Department of Waste Management and the residents of Harare. Further data was gathered through field observations.

4.2 LOCATIONAL ATTRIBUTES OF WASTE DUMPS

The locational attributes that were measured included the number of dump sites, the size of the dump sites and the distance of a dump site from a significant landmark like a shopping mall, a bus terminus and/or a market place. These attributes were measured to ascertain whether the land use, its intensity and the distance influenced the location of the waste dumps. No illegal dump sites were observed in the CBD and industrial areas; there was only littering and the reasons for this were not difficult to understand. Firstly, the municipality gave preference to the CBD when it came to waste collection because it is where that the cleanliness of the city is easily noticed and where most visitors to the city go; hence, the face of the city has to be protected at all costs. At the time of the research, there was widespread closure of many business outlets in the city due to the economic recession which led to a reduction in the amount of waste that was generated and some companies were permitted to transport their waste to the municipal landfill. All the illegal dump sites that were studied were therefore in

the residential areas and were grouped under high-density, medium-density and low-density residential areas.

Figure 13 shows people at Pomona Landfill in Harare picking up solid waste for resale, recycling and re-use. Currently, it is the only functional landfill in Harare. If properly managed, landfills can generate bio-fertilizers, electricity and heat from methane gas, and employment. They reduce the impact of solid waste on the environment. Figure 13 shows how dire the problem of illegal dumping has become in Harare, especially in the high-density residential areas where there seem to be total disregard for the need to dispose of waste properly.

Figure 13: Solid waste dump in Mbare

(Source: Fieldwork 2014)

Figure 13shows that the highest number of illegal dump sites was in the high-density residential areas and this can be attributed mainly to the high populations in these areas. The lower number of illegal dump sites in both medium-density and low-density residential areas can be attributed to low populations, better environmental awareness and a better waste collection service by the municipality. The number of dump sites varied from one land use to another.

There were 37 dump sites in the high-density residential areas, seven dump sites in the medium-density residential areas and only six dump sites in the low-density residential areas. The distribution of dump sites in Figure 14 shows that the high-density residential areas had more illegal dump sites owing to their large population sizes and low environmental awareness. It is also clear from the figure that most of the high-density suburbs in Harare were located in the western and south-western parts of the city, with a few in the eastern part. The leafy and affluent suburbs were in the northern part of the city. The sizes of the dump sites were estimated and a table (Table 8) was created which shows the volume of waste for each of the 50 dump sites in the various land uses.

Table 8 shows that the dump sites in the high-density residential areas were generally bigger compared to the dump sites in the low-density and medium-density residential areas. The reasons for this are that there was a greater generation of waste in the high-density residential areas compared to the medium-density and low-density residential areas. The population sizes may also have contributed to the amount of waste. Although the average household size in Harare was four persons per household, it can still be observed that the average for most high-density residential areas was greater than four persons per household and the average for most low-density residential areas was lower than four persons per household. This explains why there were more and bigger dump sites in high-density residential areas than in medium-density and low-density residential areas. Most of the informal industries were found in the high-density residential areas, which was a contributing factor.

Table 9:Distance of dump site from main land-use

High density	3	19	9	4	2	3
Medium	0	2	2	1	1	6
Low density	2	4	0	1	0	7
Total	**5**	**25**	**11**	**6**	**3**	**50**

(Source: Fieldwork 2014)

Table 9 shows the frequency distribution and mean distance of dump sites from the main land-use zone in the city. From the table, that most dump sites were located between 50 mand 100 m from the land use. Of the 50 dump sites surveyed, 41 were within a 100 m radius, while only six were within a 150 m radius and only three dump sites were outside the 200 m radius. This suggests that people were not prepared to walk long distances to dump waste and this was evident across all the land-use zones. The mean distance was calculated to establish the average distance that residents were prepared to walk to dump waste.

Overall mean distance = $\frac{25\times5+75\times25+125\times11+175\times6+225\times3}{50}$

$= \frac{5100}{50}$

= 102 m

From table 9, the average distance that residents were prepared to walk to dump waste was 102 m, beyond which the number of dump sites decreases since people did not want to walk such distances for a mere household chore.

4.3 ANALYSIS OF INTERNAL LINKAGES OF LOCATIONAL ATTRIBUTES

The internal linkages were regarded as a means to establish relationships between the variables, like distance of dump site from main land-use, volume of waste and land use as well as the number of dump sites and the main land-use. The size of the dump site in relation to the distance to the main land-use- see Figure 14 and Table 10- was established by means of the SAS JMP. The results show a very limited relationship between the size of the dump site and the distance from the main land-use. A reason for this could be that the size of a dump site was mainly a product of land use and not distance. The SAS JMP printout below illustrates this relationship.

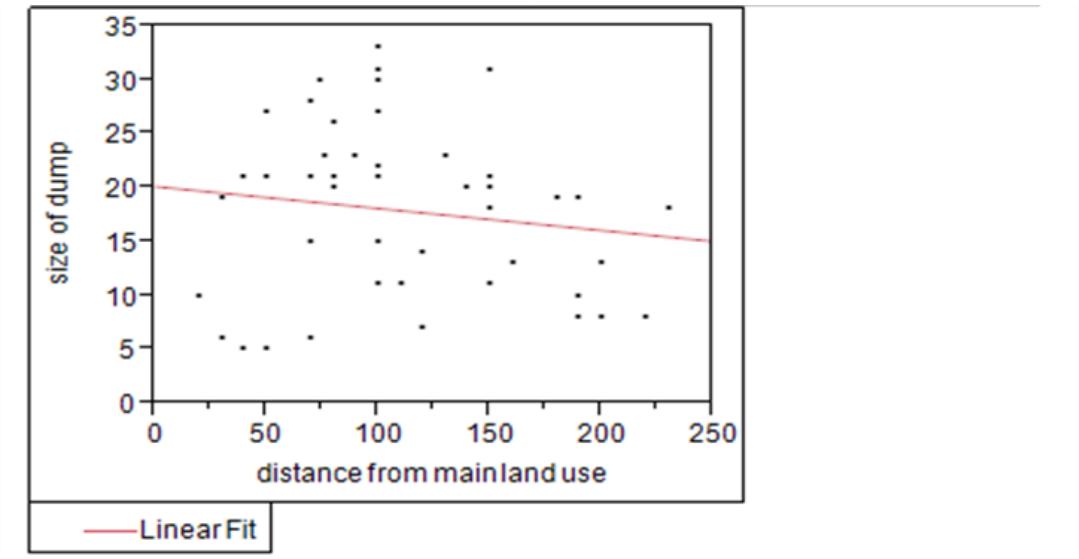


Figure 14: Size of site and distance from land-use

Table 10: SAS output

Linear Fit				
Size of site=20.1584-0.0203827 * distance from the main land-use				
Summary of Fit				
R Square	**0.019121**			
Adjusted R Square	**-0.00131**			
Root Mean Square Error	**8.175122**			
Mean of Response	**17.9**			
Observations	**50**			
Lack of Fit				
Source	**DF**	**Sum of squares**	**Mean Square**	**F-Ratio**
Lack of Fit	**19**	**1527.7326**	**80.4070**	**1.3878**
Pure Error	**29**	**1680.2333**	**57.9391**	**P > F**
Total Error	**48**	**3207.5000**		**0.2081**
				Max R square 0.4862

Analysis of Variance				
Source	**DF**	**Sum of Squares**	**Mean Square**	**F-Ratio**
Model	**1**	**62.5340**	**62.5340**	**0.9357**
Error	**48**	**3207.9660**	**66.8326**	**P > F**
C. Total	**49**	**3270.5000**		**0.3382**

Parameter Estimates				
Term	**Estimate**	**Std Error**	**t-ratio**	**P>[t]**
Intercept	**20.1584**	**2.605307**	**7.74**	**<.0001***
Distance from main land-use	**-0.020383**	**0.021072**	**-0.97**	**0.3382**

From the SAS JMP output, it can be seen that there is an extremely weak correlation between the distance from the main land-use and the size of the dump – as shown by the value of R^2 = 0.019121, which tells us that only 2% of the variability in the size of the dump is explained by the distance from the main land-use. The points are scattered all over, which confirms that the size of the dump and the distance from the main land-use were not correlated.

Table 11 was created to explain both expected frequency and observed frequency. Expected frequency refers to the results and figures that the researcher would expect to get in a normal situation when all other variables are silent. It is calculated as follows:

Expected frequency $\boldsymbol{e_i} = \frac{\boldsymbol{Row\ total \times Column\ total}}{\boldsymbol{Grand\ total}}$

The observed frequency refers to the results that the researcher obtained from the fieldwork. These results are compared with those from the expected frequency so that conclusions maybe generated. For better results, the number of dump sites for both low-density and medium-density residential areas were combined. This was done to avoid situations where some cells had very few elements or no elements because this would have compromised the results. The

data for the two types of areas were also combined because they share a lot of similarities in terms of population sizes, economic activities and consumption behaviour

Table 11: Distance between dump site and main land-use

	DISTANCE					
LAND USE	**≤50**	**50< X≤100**	**100< X ≤150**	**150< X ≤200**	**>200**	**TOTAL**
Observed frequency	3.00	19.00	9.00	4.00	2.00	37.00
High density						
Expected frequency	3.70	18.50	8.14	4.44	2.22	37.00
Medium density						
Observed frequency	0.00	2.00	2.00	1.00	1.00	6.00
Expected frequency	0.60	3.00	1.32	0.72	0.36	6.00
Low density						
Expected frequency	0.7	3.5	1.54	0.84	0.42	7
Total	**5**	**25**	**11**	**6**	**3**	**50**

(Source: Fieldwork 2014)

Medium and low density were jointly evaluated for they both had only 13 dump sites which did not warrant separate analysis compared to high density residential areas which over half of the total number of dump sites (37).From Table 12, it is evident that for the high-density residential areas, there were three dump sites within 50 m radius; there were only two dump sites for both the low-density and medium-density residential areas, suggesting that people would not normally dump waste very close to their homes. In a 50 m to 100 m radius, there were 25 dump sites (19 for high-density and six for medium-density residential areas respectively). This again shows that more than half the dump sites (30 dump sites) were in a 50 m to 100 m radius,

which is indicative that people were reluctant to walk long distances to dump waste. From 100 to 150 m, there were 17 dump sites (13 for high-density and four for low-density and medium-density areas).

Table 12: Combined data for low-density and medium-density areas

	DISTANCE					
LAND USE	**≤50**	**50< X≤100**	**100 X≤150**	**150<X ≤200**	**>200**	**TOTAL**
High density						
Observed frequency	3.00	19.00	9.00	4.00	2.00	37.00
SExpected frequency	3.70	18.50	8.14	4.44	2.22	37.00
Medium and low density						
Observed frequency	2.00	6.00	2.00	2.00	1.00	13.00
Expected frequency	1.30	6.50	2.86	1.56	0.78	13.00
Total	**5.00**	**25.00**	**11.00**	**6.00**	**3.00**	**50.00**

(Source: Fieldwork 2014)

The reasons for this sizeable number of dump sites were that the waste type included bulk waste like old furniture, electric goods like fridges and old vehicles that require more space. Beyond 200 m, there were only three dump sites – suggesting that beyond 150 m, people would not travel to dump waste unless there was a special reason (like the unavailability of dumping space close by or the presence of an environmental management enforcement agency).

A chi-square test for independence was used. The test was found suitable since categorical data was used. According to John and Sall (2011) the test helps to establish the 'the goodness of fit' of a theoretical distribution to an observed distribution and in testing independence of attributes in a contingency table. The test was used to prove that the location of a dump site was closely related to the dominant land-use type, for instance there were more dump sites in high-density residential areas than in low-density residential areas. Thus:

$\boldsymbol{\chi^2_{(r-1)(c-1)=}\chi^2_{4.005=9.488}}$·

$\boldsymbol{\chi^2_{Cal=}\sum_{c-i}^{n}\frac{(Oi-Ei)^2}{Ei}=1.16235.}$

Reject if $\boldsymbol{H_o\chi^2_{Cal}>\chi^2_{tab}}$

Since 1.16235<9.488,the $\boldsymbol{H_o}$ was not rejected and the conclusion was that there was a relationship between the location of a dump site and the dominant land-use type. There is a statically significant relationship between the location of dump sites and the proximity of the dominant land use as postulated by hypothesis 1. As can be seen, over half of the dump sites were located within a 50 m to 100 m radius, suggesting that people were not ready to move long distances to dispose of waste regardless of where they were implying that people will naturally dump waste within the shortest distance possible– be it high-density, medium-density or low-density residential areas.

$\boldsymbol{H_o}$: Distance and land use are independent of each other.

$\boldsymbol{H_1}$: The location of a dump site is closely related to a dominant land use.

Table 13 shows that the number of dump sites with less than 1000 kg were very few for all land uses, with three and five for high-density residential areas and the combined total for both low-density and medium-density residential areas respectively. Nine dump sites for high-density residential areas had between 1000 and 2000 kg and 25 dump sites had more than 2000 kg, all translating to 37 dump sites in the high-density residential areas. There were only 13 dump sites for both low-density and medium-density residential areas. From the table, it can be

deduced that the size of a dump site was closely related to the dominant land-use type. The figures show that there were nine dumpsites with more than 1000 kg in the high-density areas compared to six in both low-density and medium-density areas.

Table 13: Land use and size of dump sites

	SIZE OF DUMP SITE IN KG			
LAND USE	**≤ 1000 KG**	**1000< X ≤2000 KG**	**>2000 KG**	**TOTAL**
High density				
Observed frequency	3.00	9.00	25.00	37.00
Expected frequency	5.92	11.1	19.98	37.00
Low and High density				
Observed frequency	5.00	6.00	2.00	13.00
Expected frequency	2.08	3.90	7.02	13.00
Total	**8.00**	**15.00**	**27.00**	**50.00**

(Source: Fieldwork 2014)

The scenario shows that there were bigger dump sites in high-density residential areas than in both low-density and medium-density residential areas. This can be attributed mainly to high population sizes and bigger household sizes in the high-density residential areas. According to the Central Statistical Office's (2013) annual mid-year reports, the average number of people in Harare was 4.2 for high-density residential areas, 3.9 for medium-density residential areas, 3.7 for low-density residential areas and 4.0 for the city. This explains why there were more and bigger dump sites in high-density residential areas compared to both low-density and medium-density residential areas. To this effect, a test was carried out to check the correctness of the postulation that the actual size of a dump site was related to the land-use type. The chi-square

test for independence was used since categorical data was used. A contingency table was also used to display the data for analysis. Thus:

$$\chi^2_{0.005=5.991}$$

$\chi^2_{cal} = \sum_{i-1}^{n} \frac{(Oi-Ei)^2}{Ei}$ = 11.9186

RejectH_o if $\chi^2_{Cal} > \chi^2_{tab}$

s

Since $\chi^2_{Cal=11.9186} > 5.991$, H_o is rejected and it is concluded that the size of a dump site was closely related to the land-use type (as is shown by the distribution of waste dumps of varying tonnage across the different land-use types with more and bigger dump sites located in the high-density residential areas).

4.4 CLASSIFICATION OF WASTE BY TYPE

According to Mondal (2010), the classification of waste refers to the systematic method to group waste streams according to their physical, chemical and biological composition in order to easily separate, transport and recover waste for both re-use and recycling. The waste types for the 50 dump sites of the sample were also looked at as individual entities in order to ascertain the amount of each type of waste that constituted the dump site. Three dump sites were selected from each of the three main land-uses to compare the waste streams found on the chosen dump sites. The dump sites were (4), from the high-density residential areas, (565) from the medium-density residential areas and (670) from the low-density residential areas. From the three dump sites that represented the three main land-uses, there were variations in the percentages of waste profiles even though the types of waste were homogeneous all the dump sites.

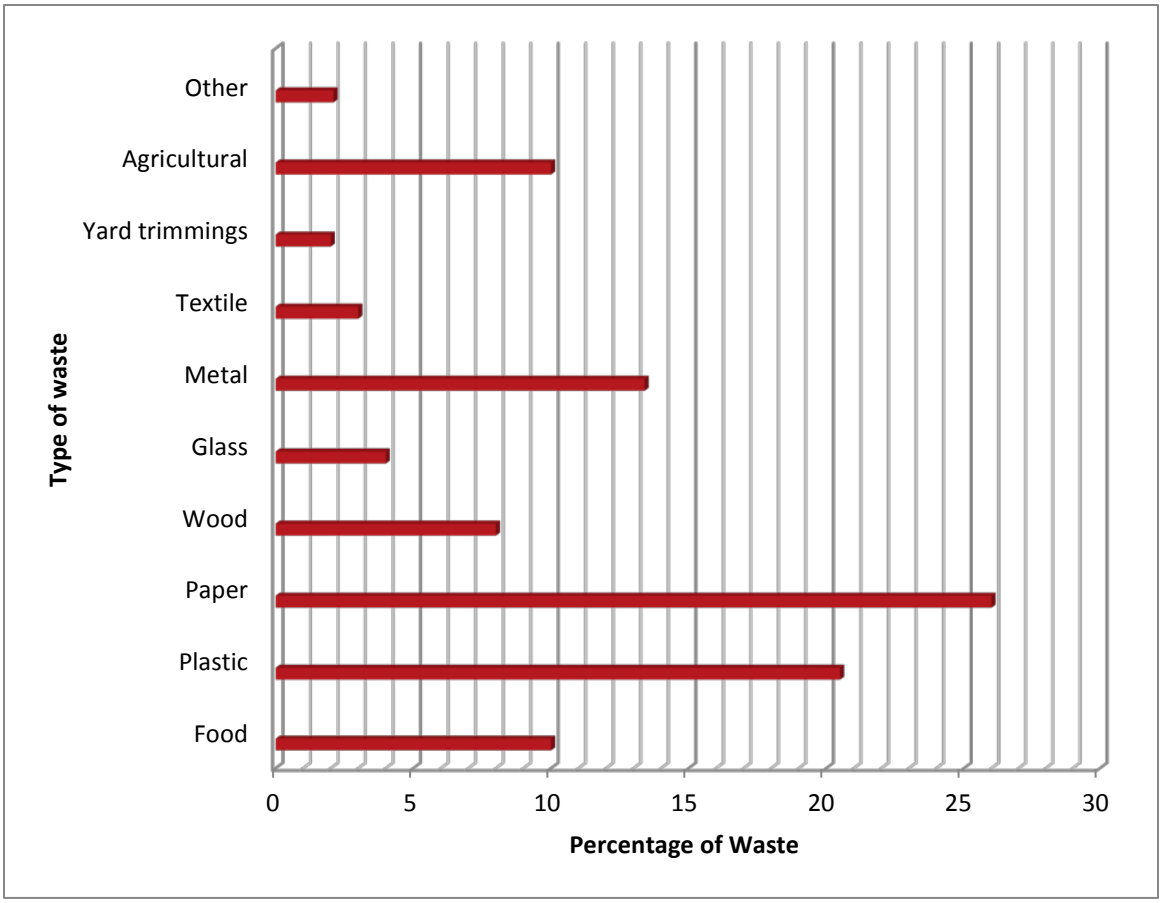


Figure 15: Waste profiles of high-density residential areas
(Source: Fieldwork 2014)

Figure 15 shows that there was more agricultural (10 %) and wood (8 %) waste in low-income residential areas. The reason which emerged from the interviews was that the general populace in these areas were engaged in urban agriculture to supplement their incomes, while the wood was used as fuel. Food waste in low-income residential areas was low(at an average of 10%) and this can be attributed to low food levels in these areas, hence the low level of food waste.

Figure 16 shows a different scenario in medium-density areas, with higher food waste since these residents are middle-income earners who can afford to buy substantial amounts of food. The average food wastage in this category was 20%, which was twice than that in low-income residential areas and only 4% less than that of low-density residential areas. Figure 16 shows that the percentage of food waste was higher (20%) in medium-density residential areas

compared to high-density residential areas, which was half (10%). Other wastes constituted the lowest percentage at 3%.

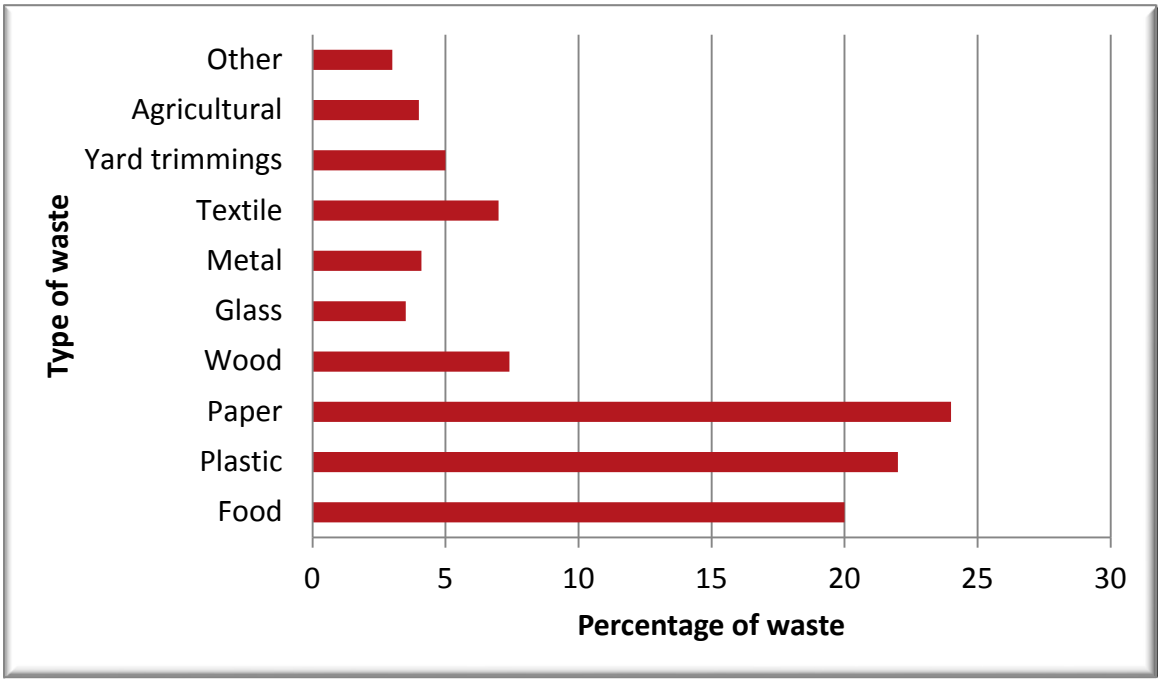


Figure 16: Waste profiles of medium-density residential areas

(source: Fieldwork 2014)

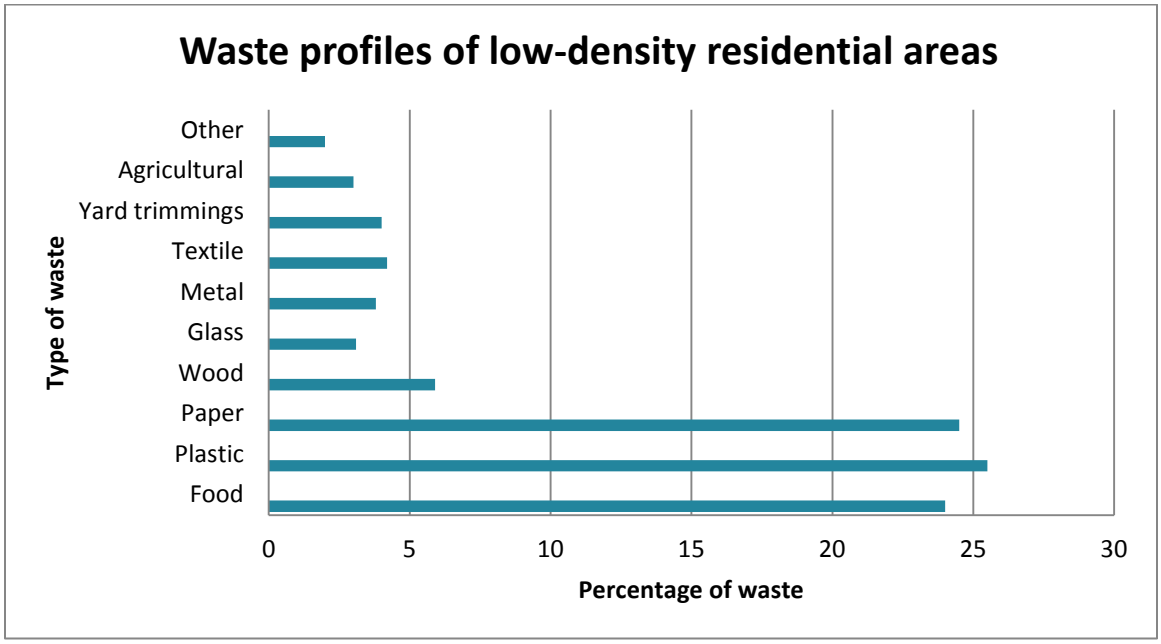


Figure 17: Waste profiles of low-density residential areas (Source: Fieldwork 2014)

Figure 17shows that low-density residential areas generated more food (24%) compared to medium-density and high-density residential areas (which had 20% and 10% respectively). A reason could be that the low-density residential areas housed wealthy people who could afford to buy food in bulk and have the luxury to throw away leftover food, which is unheard of in the high-density residential areas and is a not-so-common practice in the medium-density residential areas. Plastic and paper waste is also high in this income group.

4.5 ANALYSIS OF VARIATIONS IN WASTE PROFILES

The survey revealed variations in the waste profiles for the residential areas. The profiles varied from area to area, depending on whether the area was a low-income residential area, a medium-income residential area or a high-income residential area. According to the Harare City Council's Department of Waste Management (2014),in December 2013 waste generation per capita stood at 0.9 kg per day per person in Harare. Collection efficiency is currently was pegged at 50% according to official records, although the information that was gathered from residents showed a much lower efficiency. The city of Harare computed its waste collection as follows: once a week = 100%, hence once in a fortnight translated to 50%.The level of waste collection efficiency for a country emerging from an economic and political quagmire was fairly plausible.

Figure 18 shows the waste profile variations in Harare per land use. There were great variations in the waste profiles of Harare's main land-use zones. Although there were great variations in the percentages, there was general uniformity in the type of waste commonly found in Harare. However, the bulk of waste in Harare (a city in a country experiencing economic hardships) is predominantly agricultural waste as a result of urban agriculture.

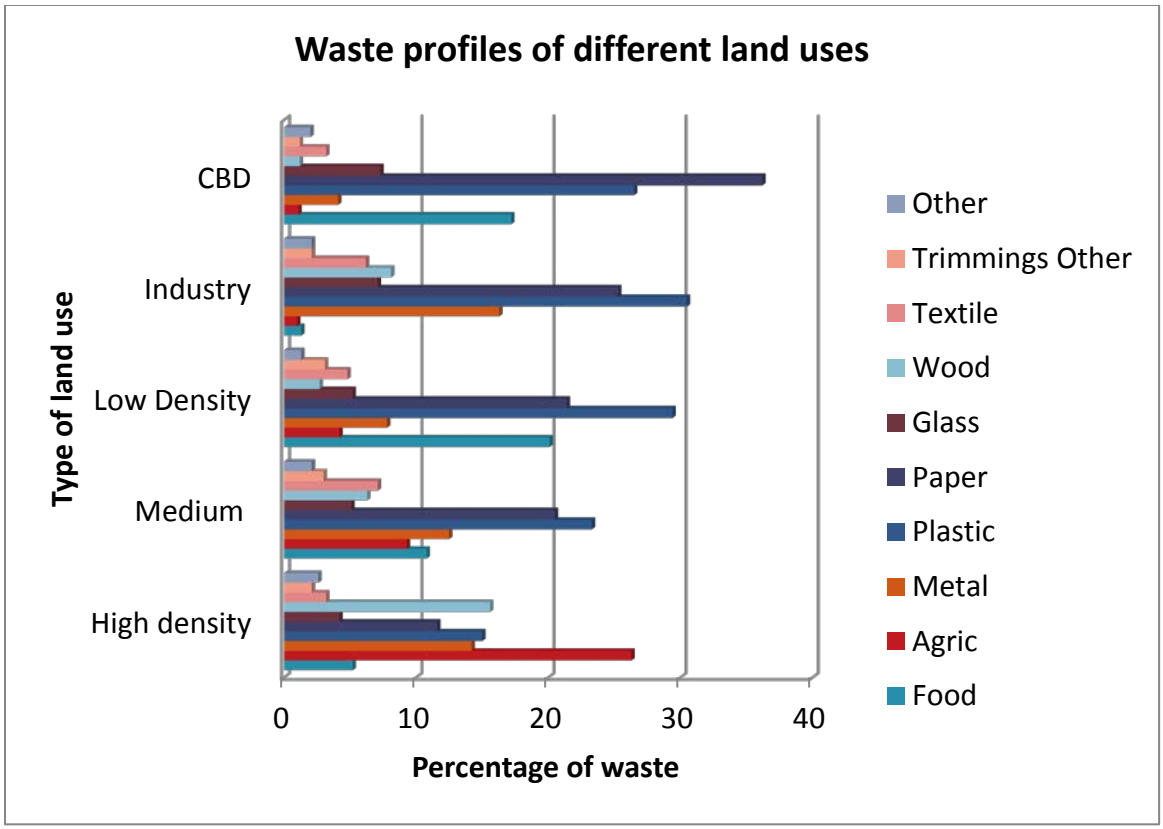


Figure 18: Waste profiles of different land uses (source: Fieldwork 2014)

Figure 18 shows that there was more agricultural waste (26.3%) in the high-density residential areas than in other areas. As earlier indicated, this can be attributed to increased participation in urban agriculture. The high-density residential areas also had the least amount of food waste (5.2%), showing a low mean per capita income and constrained consumption. There was a high percentage of wood waste since wood was used mainly as fuel due to power cuts and because most residents could not afford paraffin or generators. The low-density residential areas had the highest level of food waste (20.1%) and the least agricultural waste compared to other residential areas. These areas were where the rich people of the city stayed; they had high incomes and could afford to buy a lot of food and throw away leftovers. The only agricultural waste that they had was from garden vegetables. They had 29.4% plastic waste, which was the highest for residential areas because of their heavy dependency on buying packed, wrapped products and carrier bags from shops and their high use of stationery. Industry had the highest percentage of plastic waste. Plastic was used mainly for packaging and wrapping goods in

factories. The CBD had the highest percentage of paper waste (36.2%), which generally came from offices, retail shops, banks and food outlets. Plastic waste was also high at 26.5%. In general, there was low textile waste and other waste across the areas, with an average of 2%.

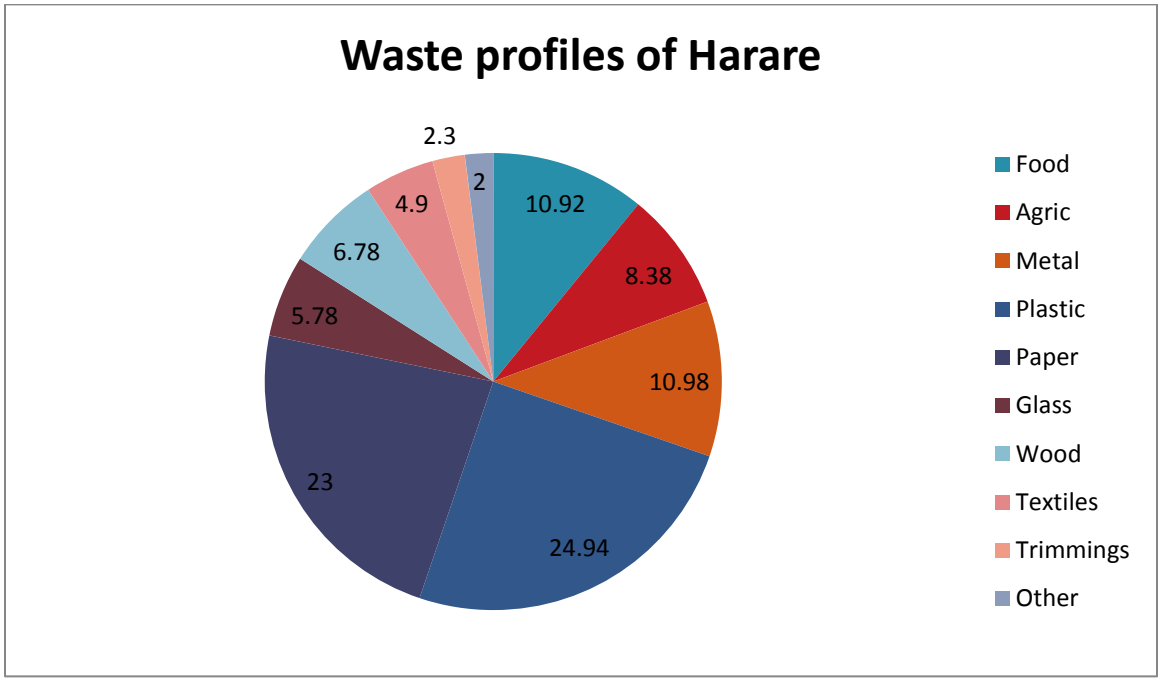


Figure 19:Waste profiles of Harare

(Sources: Fieldwork 2014)

Figure 19 shows that Harare had more plastic and paper waste. These were the most widely used materials for packaging, wrapping and carrying goods. Food waste was at 10.92%, which was about 3.5% below the world average and compared fairly well with regional standards (Practical ActionZimbabwe2010:27).There was very little construction activity in the city. Plastic and paper were mainly from shops, offices, institutions like schools and packaging industries. Rubbish waste was at 15.5%, which was quite a high percentage. This was attributed to the presence of informal industries which operated mainly in the backyards of homes and at roadsides.

4.6 CURRENT WASTE MANAGEMENT APPROACHES

As already established in chapter 2 of this dissertation, the city of Harare has two parallel forms of dump sites: legal and the illegal dump sites. The legal dump sites are monitored and regularly serviced, and the waste is transported to landfills. There is also participation by lobby groups and pro-waste groups that are sanctioned by the city council. These include clean-up campaigns by non-governmental organisations, volunteers and private companies that do not recycle waste. While the formal dump sites receive regular servicing, it is usually not the case with non-formal dump sites. These illegal dump sites are not serviced regularly and are more prevalent in low-income residential areas. They are symptomatic of the inability of the municipality to manage waste. All the waste collected is disposed of at Pomona Landfill, which is in the northern part of the city. According to the Harare City Council's Department of Waste Management (2014), the other landfill at Golden Quarry (which is located to the western side of the city) has been closed due to viability problems. At the landfill, the waste is spread and then compacted. Official records of the Harare City Council (2014) show that there are 200 registered vendors who collect waste from the landfill to sell to recycling companies or their agents. Only 20% of the solid waste generated in Harare is recycled.

According to the city's Health Department (2014), all hospitals and other generators of pathological waste operate under a permitting system whereby they are licensed to manage their waste. This means that hospitals and pharmaceutical companies can incinerate their waste, while the rest of the companies that produce chemical waste are permitted to transport their waste to the landfill site. Some of the companies that produce chemical waste and have been permitted to manage their waste include Turnal Asbestos, Hunyani Pulp and Paper, Zimbabwe Fertilizer Company (ZFC) and all the tanneries.

4.6.1 Inventory of the Department of Waste Management

The Harare City Council's Department of Waste Management was understaffed at the time of the research, with 1020 staff members instead of 1227. Despite the shortage, the department was considering a further staff cuts due to insufficient funds to pay the workers. The results of the interviews were documented as follows:

Table 14: Level of education of personnel in the Department of Waste Management

HIGHEST EDUCATIONAL QUALIFICATION	NUMBER	%
Primary	408	40
Secondary	510	50
Tertiary	102	10

(Source: City of Harare 2014)

Table 14 shows that most of the waste management personnel had a secondary (50%) education, with only 102 of them having a tertiary education. The reason for this was explain as follows: most of the work was manual and did not require special skills.

Table 15: Equipment used for managing waste

EQUIPMENT	TOTAL AVAILABLE	OLD	NEW	DESIRED NUMBER OF EQUIPMENT
Skip bins	121	80	41	200
Refuse trucks	47	27	20	60
Skip trucks	6	–	6	15
Tractors	10	7	3	15
Tippers	6	2	4	12

(Source: Harare City Council's Department of Waste Management 2014)

Table 15 shows that the Harare City Council was inadequately equipped to deal with solid waste since the equipment they used was far less than what was required. Thiswas an obvious indication why the municipality failed to manage waste. The desired number of equipment is based on the volumes of waste generated in the city and sizes of the municipal wards in terms of households.

According to the Department of Waste Management (2014), waste was supposed to be collected once per week (with the hope of increasing the frequency to twice a week) but at the time of the study, most wards were serviced once every fortnight. The municipality supplied plastic bags free of charge to residents for the temporary storage of waste at three-month intervals. Skip bins were placed at public places like markets, shopping malls and bus termini. To ensure compliance with municipal by-laws on the generation, storage and disposal of waste, the city council issued fines to offenders as follows:US$50 for the illegal dumping of domestic waste, US$250 for a truckload of waste and US$20 for littering. For non-payment of rates, the municipality disconnected the water supply.

4.6.2 Waste handling methods

The responses from the household interviews indicate how waste was handled. These appear in Figure21.

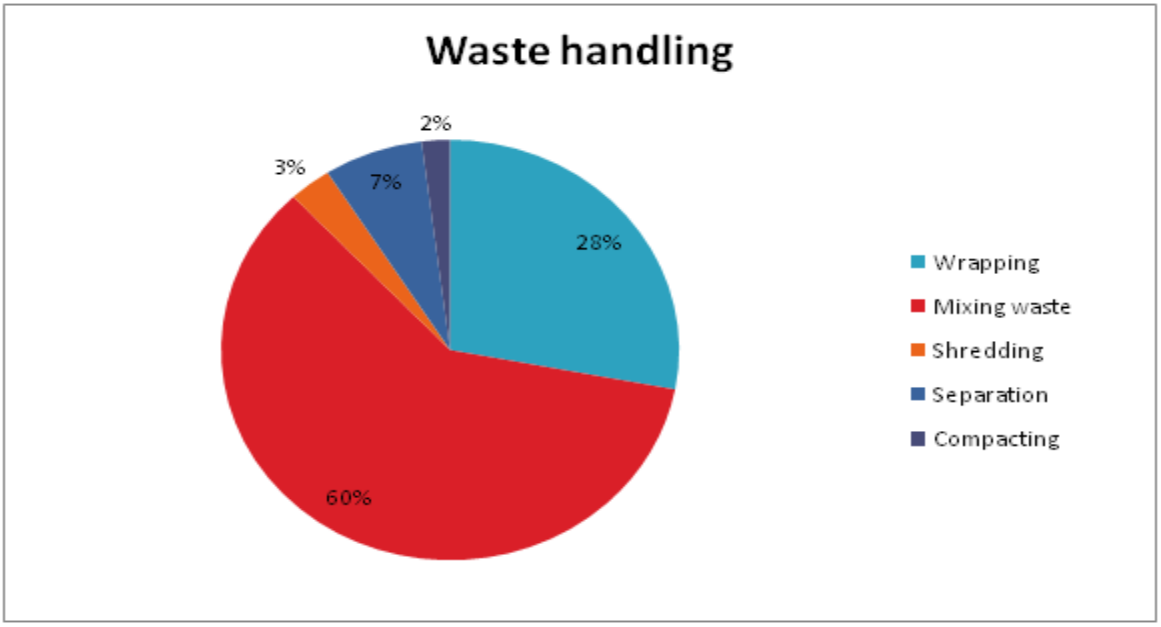


Figure 20: Waste handling methods

(Source: Fieldwork 2014)

Figure20shows that most residents of Harare mixed their waste. Most residents did not separate their waste, as shown by the 60% for the mixing of waste. This is mainly due to the lack of handling facilities.

4.6.3 Receptacles used

Harare residents used a number of receptacles for the temporary storage of waste before it was transported to the landfill (as shown by Figure 22).

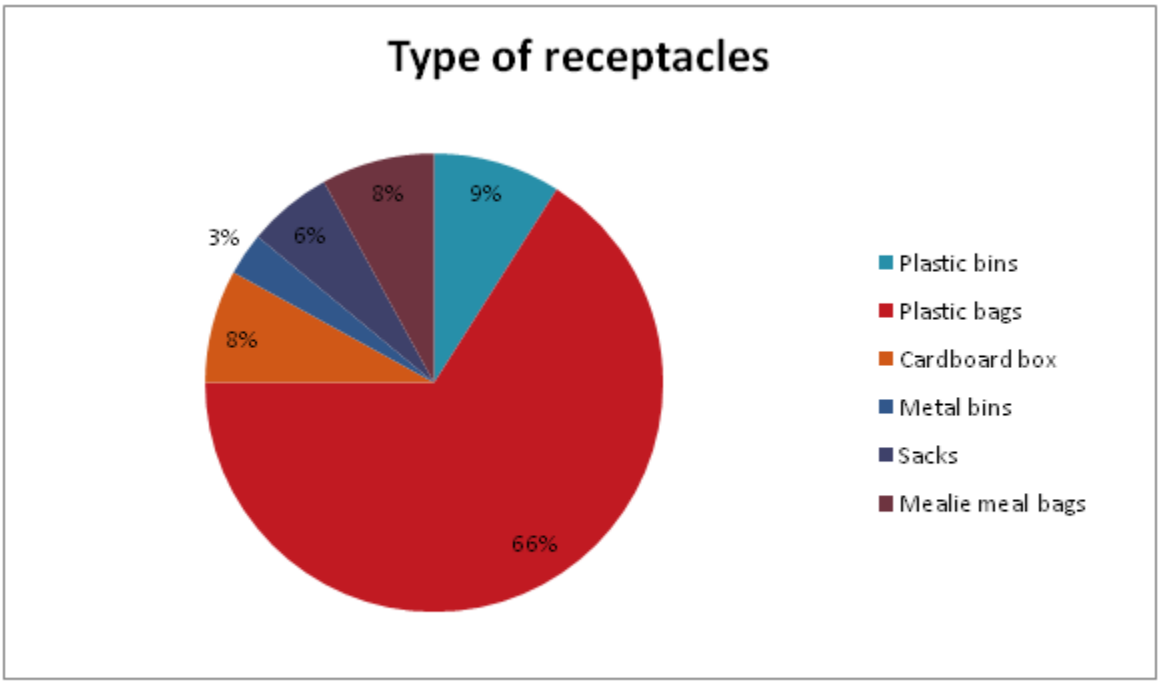


Figure 21: Types of receptacles used and their percentages

(Source: Fieldwork2014)

Figure 21 shows that the largest percentage of residents used plastic bags for the temporary storage of waste. This confirms what the waste management employees indicated during the interview. However, the prevalence of non-conventional receptacles (like mealie-meal bags and sacks) is evidence that the city council failed to manage the waste.

4.6.4 Waste disposal

The results of the survey show that a number of waste disposal methods were used across the city of Harare with varying degrees of intensity depending mostly on the type of land use. It was also clear from the field survey that there a number of unauthorised and unhygienic methods of waste disposal was used (see Figure 22).

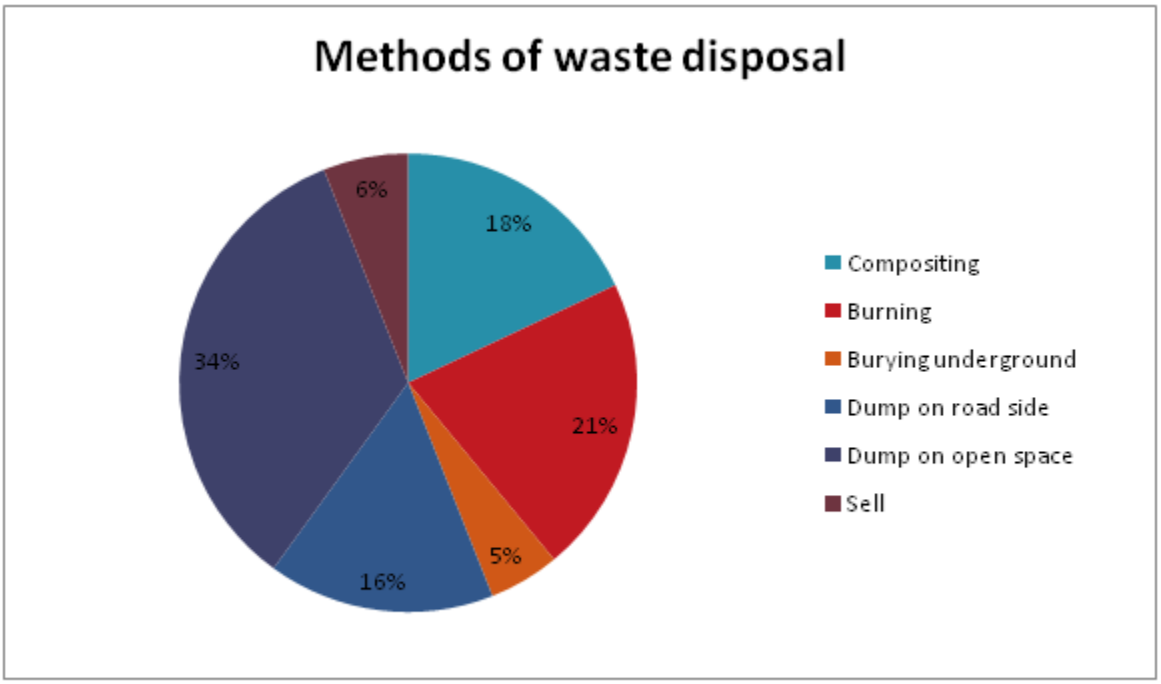


Figure 22: Methods of waste disposal and their percentages (Source: Survey2014)

The above pie chart shows that there were six common ways to dispose of waste in Harare. It can also be seen that dumping waste in undesignated areas was rampant. This explains why the city was battling with problems of non-formal dump sites. In urban areas, burning waste is strongly discouraged as it causes air pollution. Composting accounted for 18% of the waste disposal, which is quite significant as this method generates odours and greenhouse gases like methane. Although the resultant manure can be used, the negatives far outweigh the positives. Selling waste was still very unpopular but if publicised, it could be a cleaner way of managing waste in the city. There was both material and financial recovery. Burying waste underground, just like composting, can contaminate ground water; exude odours; and be a breeding ground for rats, mosquitoes and other disease-causing organisms**.**

4.7 SUMMARY

In this chapter, the locational attributes of non-formal solid waste dumps were discussed and measured, and some internal linkages within the locational attributes were established. Solid

waste was classified according to type while the variations in the waste profiles of the areas in the study were studied and analysed. Various waste management approaches that were used in Harare were also discussed.

CHAPTER 5: DISCUSSION OF THE RESEARCH RESULTS

5.1 INTRODUCTION

The research results were presented and analysed in the preceding chapter. In this chapter, the research findings are discussed with a view to establishing relationships between them, accepting or rejecting the hypotheses where possible, and articulating pertinent issues about the characterisation and management of non-formal solid waste disposal sites in Harare.

5.2 LOCATIONAL ATTRIBUTESOF NON-FORMAL SOLID WASTE DUMPS

The following locational attributes were measured: distance of dump site from main land-use, size of dump site and number of dump sites in a given land-use zone. The research showed that from the 50 dump sites that were studied, five were located within a 50 m and 25 were located within a 50 to 100 m radius. This shows that 60% of the dump sites were located in a 50 to 100 m radius and six dump sites were located in a 150 to 200 m radius; only three dump sites were found beyond a 200 m radius. It can therefore be said that more than half of the dump sites were located in a 100 m radius, which suggests that the residents were not prepared to walk a long distance to dump waste unless if there was virtually no space for dumping or some environmental enforcement agency was visible. The distribution of the dump sites varied across the various land-use zones, with all the land-use zones (low-density, medium-density and high-density residential areas) registering more than half of their dump sites within less than 150 m radius. It was also established that there were more dump sites in high-density residential areas (37) – 48% more than the combined number of medium-density and low-density residential areas (which were six and seven respectively). The reasons for this included that there were higher population sizes in high-density residential areas. According to the Zimbabwe Central Statistical Office (2014), the average population for high-density residential areas was 31 431 people, 20 241 for medium-density residential areas and about 14 593 for low-density residential areas. It had already been established that the generation of waste per capita in

Harare was 0,900 kg per day, which meant on average one high-density residential area produced about 28 287.9 kg of waste while a low-density residential area produced about 13 133.7 kg of waste per day. The study also showed that due to the high rate of unemployment, a lot of informal industries operated in the backyards of homes. This was more evident in the low-income residential areas, where waste generation had increased and accounted for the higher number of dump sites in these areas. The sizes of the dump sites were measured and the results did not show any pattern in the distribution of the dump sites across the areas that were studied. Of the 37 dump sites in high-density residential areas, three were less than 1000 kg, nine were between 1000 and 2000 kg, and 25 were more than 2000 kg. The situation was different for low-density and medium-density residential areas, where only two dumpsites were bigger than 2000 kg. The distribution did not show any distributional matrix, suggesting that no factors influenced it. For the low-density and medium-density residential areas combined, more than half the number of dump sites was less than 2000 kg25 dump sites in the high-density residential areas were more than 2000 kg.

5.3 INTERNAL LINKAGES OF LOCATIONAL ATTRIBUTES

The internal linkages of the locational attributes of dump sites were analysed across the areas that were studied. This included the distance of a dump site from the main land-use, the number of dump sites in a given land-use area and the sizes of the dump site in relation to the dominant land-use type. Of the 50 dump sites studied, it was observed that most were located within a 100 m radius. For the high-density residential areas, three were within a 50 m radius; there were no dump sites for medium-density residential areas and two dump sites for low-density residential areas in the same radius. In a 50 to 100 m radius, there were 19 dump sites in high-density residential areas, two dump sites in medium-density residential areas and four dump sites in low-density residential areas.

The above distribution shows that 30 dump sites were located within a distance of 50 to 100 m, representing 74% of the total. From this, it can be deduced that people usually dump waste

close to where they stay and are not prepared to walk long distances to dump waste. Within a 150 to 200 m radius, there were only six dump sites for all the residential areas (accounting for only 12% of the total). Beyond 200 m, the dump sites were distributed in the following order: two in high-density residential areas, zero in medium-density residential areas and one in low-density residential areas – translating to 6% of the total number of dump sites. It is therefore clear from the above distribution of dump sites across the various land-use types that there was a statistically significant relationship between the location of a dump site and the dominant land use. There were more dump sites close to the dominant land-use type than there were away from the dominant land-use type.

The sizes of the dumpsites were also measured to establish whether there was a link between the size of the dump site and the land use. The dump sizes were measured in kilograms, the smallest being less than 1000 kg and the biggest more than 2000 kg. Out of the 50 dump sites that were studied, six dump sites were located in medium-density residential areas and seven in low-density residential areas. The total number of dump sites that were less than 1000 kg was only eight for all the land uses, representing 16% of the total number of dump sites. In the high-density residential areas, there were nine dumpsites between 10 000 and 2000 kg, and three dumpsites each in the medium-density and low-density residential areas. There were 25 dump sites above 2000 kg in the high-density residential areas and one each above 2000 kg in the medium-density and low-density residential areas.

There did not seem to be a definite pattern in the way that the sizes of the dump sites were distributed across the dominant land uses. This was especially true for both medium-density and low-density residential areas, where the distribution was haphazard – suggesting that there was no relationship between the size of a dump site and the land use, but rather that the size of the dump site depended on the type of waste and the availability of dumping space. The numbers of dump sites per land use were enumerated and the figures were used to determine if there were any linkages between the land use type and the number of dump sites. From the research, it emerged that out of the 50 dump sites that were studied, 37 were located in high-

density residential areas and six and seven were located in medium-density and low-density residential areas respectively. It can therefore be said that the number of dump sites was closely related to the dominant use type. The fact that most of the dump sites were located in the high-density residential areas (accounting for 74% of the total number of dump sites that were studied) could be attributed to the high population sizes in these areas compared to the other areas.

5.4 CLASSIFICATION OF WASTE BY TYPE

The waste was classified according to type so that the researcher could ascertain the main types of waste in the various land-use types and Harare in general. According to Mensah and Larbi (2005), classification is done so that the materials that make up the bulk of the waste are known. The waste must also be categorised because this will help to determine the biodegradability of the toxicity and the ease with which the waste can be handled.

The types of waste found at each dump site were classified to generate primary data about the source, transporting equipment and risks involved in handling the waste. It was not an objective of the study to come up with a new way to classify solid waste but rather to classify the waste by using traditional methods to determine the types of waste in Harare. The main waste types were food and garbage which result from the preparation, cooking and serving of food. Other waste types came from green markets: the handling, storage and sale of meat and vegetables. These wastes are mainly generated by households, institutions and commercial entities such as hotels, shops and restaurants. There were also rubbish waste, including combustibles (primarily organic), paper, cardboard, wood, plastics, yard trimmings, cloth, leather and rubber. In this group (rubbish), there were also non-combustible (inorganic) metals, tin cans, ceramics, glass and crockery. Some of the most common wastes in the study areas were bulk wastes which included large auto parts, tyres, discarded furniture, stoves, refrigerators, tree branches and other large appliances. Street waste was a common sight during the investigation. These included street sweepings, dirt, leaves, animal droppings and

the contents of litter receptacles. This type of waste mainly comes from streets, sidewalks, alleys, vacant lots and parks. Some wastes were classified under construction and demolition waste. These wastes were sporadically spread across the study areas as very little construction activity took place in the city due to the economic challenges in the country. They were seen mainly in residential areas where people from the Diaspora were building houses. Other construction wastes that were seen in Harare were the remnants of the notorious Murambatsvina (Operation Restore Order) of May 2005, when the government went on a demolition spree pulled down all the structures which did not meet municipal standards. Nine years down the line, at the time when the research was conducted, the heaps of waste still haunted the city, which did not have the capacity to dispose of the waste. Although some wastes were classified under dead animals for the sake of convenience, this type of waste was not common (here and there a dead rat, bird or dog could be seen but that did not warrant much debate).

5.5 WASTE PROFILES IN HARARE

UNEP (2010:53) defines a waste profile as a description of the material characteristics (chemical, physical and biological composition) of waste, together with information about the waste from when it is generated to when it is disposed of. Simply put, a waste profile refers to the materials that make up the waste. The waste profile is important because it helps in determining the processing unit, transportation, destruction and reduction of the waste.

For this study, the waste profiles were first looked at in terms of land use and for the city of Harare in general. The main profiles that were considered were food, paper, plastic, glass, textile, agricultural waste, yard trimmings, metal, wood and others. Of the land-use types studied, the high-density residential areas had the least amount of food waste and this was mainly due to low levels of income. According to the Word Food Programme (WFP) (2013) the income of more than half the population of Harare stands at US$300 per month and this is far below the PDL, which (according to the Zimbabwe Central Statistical Office(2014)was pegged at

US$550 (a pie in the sky for most of the residents of Harare). For this reason, therefore, there was very little food waste in the high-density areas, which accounted for only 5.2% (less than half the average for the city, which stood at 10.92%). There was also more wood waste in the high-density residential areas compared to the other land-use zones – a situation that was explained by the prevalent use of firewood for cooking since ZESA struggled to supply enough power and residents had to resort to wood as an alternative source of energy. The CBD had the highest percentage of waste (17.2%) and this was explained as being due to the high number of food outlets and vendors selling food from every available space in the city. There was more agricultural waste in the high-density residential areas than in the other land-use zones. The reasons for this distribution were that most of the residents in these areas supplemented their disappointing salaries by growing their own food, especially maize (which is the staple crop). The emergence of urban agriculture (which was the brain child of the agrarian reform accelerated by the government after the controversial land redistribution)led to many residents engaging in some form of agriculture or the other, leading to an increase in agricultural waste (26.3% compared to 13.6% for medium-density and low-density residential areas, industry and the CBD combined). What was interesting was that for metal waste, industry had a slightly higher percentage and this was attributed to the increase of informal industries in residential areas, mainly due to the closure of companies and the resultant high levels of unemployment.

Compared to the other residential areas, the low-density residential areas had the highest percentage of food (20.1%), plastic (29.4%) and paper (21.4%)waste. The reasons for this were that these were high-income residential areas; hence the people could afford plenty of food and threw away leftovers. Plastic waste was mainly generated from the packaging of food and goods, while paper waste came from stationery, packaging and wrapping goods, food and parcels. For glass, textiles, yard trimmings and other wastes, the differences between the land-use zones were not much (±1%).The main reason for this was because these wastes did not accrue from regular activities and did not normally have much to do with land use but were rather a result of occasional and/or activity-based efforts. Although textiles can be explained in a slightly different manner (like durability and that it requires a decision for one to throw away

old clothes or linen), it was not instantaneous as with other types of waste which could be irritating or offensive.

On average, the waste profiles in Harare compared fairly well with those of other cities in developing countries – in some streams even with developing countries, though food waste was well below the level for most cities (which was ±15% of all waste). The waste profiles in Harare were dominated by plastic and paper, accounting for 48.94% (almost half of all the waste generated in the city). This emanated from low levels of recycling which, according to the Harare City Council's Department of Waste Management (2014),was 20% less than half of South Africa's– which was 42% (Makarati & Chikobvu 2011:15). It is ironic that in a city where poverty is common, the concept "recycle, re-use and reduce" was still in its infancy – contradicting the commonly held view that there is more sustainability in poverty than in affluence.

5.6 CURRENT WASTE MANAGEMENT STRATEGIES IN HARARE

Although the research findings revealed that most of the waste management strategies in use in Harare conformed to international standards, the level of compliance to even very basic norms like recycle and re-use still differed greatly from regional and international standards. Waste management in Harare (and in Zimbabwe as a whole) is mainly monitored by the EMA, which is an arm of the government, but city councils have their own by-laws on waste management. It has been observed that the inability of the city council to effectively manage waste is mainly due to inadequate personnel. The Department of Waste Management (2014) indicated that from the required 1 227 personnel member, the department had only 1020 (which was 16.87% less than the required personnel). The problem was compounded by inadequate and/or obsolete equipment.

A number of waste handling methods were used in Harare, especially at household level, and this was a reflection of the city council's commitment to waste management. Most generators

mixed their waste (60%, as shown in Figure 21), which shows that waste was not separated at the source. It is disappointing to note that only a paltry 7% separated waste at the source, which made the characterisation and management of non-formal solid dump sites difficult. This shows that the culture of separating waste was still in its infancy in Harare (and the whole country in genera). 28% of the waste generated in Harare was handled by wrapping, indicating that quite a great deal of the waste was managed by using very rudimentary methods not befitting a city in the 21st century. Wrapping waste also shows a lack of handling facilities. Only 3% of the solid waste generated was shredded, which is quite a small percentage compared to other cities in the region. It shows that the bulk of the waste was disposed of in their raw and bulk state, which made it expensive to transport since it was voluminous and required more space for disposal. In addition, very little compacting took place (as is shown by a mere 2%), mainly due to lack of equipment. The waste handling mechanisms that were used in Harare were still very traditional and did not reflect any efforts by the city council to modernise the mechanisms. This has also attributed to the problem of non-formal solid waste dumps which are now engulfing the city.

The city of Harare battled to provide its residents with enough and reliable waste receptacles on time. According to the Harare City Council's Department of Waste Management (2014), the city provided plastic bags to residents once every three months. This is both insignificant and unsustainable, given the volumes of waste generated per day (let alone per month). Metal and plastic bins were mainly given to business entities and institutions like schools and hospitals. Plastic bags constituted 66% of the receptacles used to temporarily store waste before disposal, which is a substantial percentage. From the research, it emerged that the plastic bags had shortcomings – like aiding in the rotting of waste generating offensive odours, especially in summer given that Zimbabwe is a tropical country where the temperatures are always high – and black plastic bags were least preferred to metal bins. Plastic bins accounted for only 9% of all the receptacles used in Harare and were only given to businesses and institutions. Increasing the number of these plastic bins and giving them to households could be a good move that will go a long way in solving the problem of using non-conventional receptacles since they are both

durable and user friendly and can accommodate more waste, even though the city council alleged that they could not afford the costs of these plastic bins (as indicated in the research). From Figure 22, it can be seen that only 3% of all the receptacles used in Harare were metal bins and these were only accessed by businesses and institutions. These metal bins were big and durable but still user friendly since they had handles for convenience and hygienic reasons. However, the issue of affordability was again raised by the city council, which always complained of working on a strict budget due to economic hardships and the non-payment of rates by nearly 40% of the residents. Some residents resorted to using sacks for the temporary storage of waste (6%).This is usually the norm when residents have to wait for the next issue of plastic bags from the city council, which only lasts a week. Some households used cardboard boxes to store waste before disposal and this accounted for 8% of the receptacles used in Harare. These cardboard boxes are not ideal for storing waste since they leak if the waste produces fluids; they become wet, produce odours and are difficult to handle. Mealie-meal bags were also used (8%) and this indicated desperate situation, where residents could not afford to buy the recommended plastic bags while they waited for the allocation from the municipality (which was only four times per year). Considering their poor durability and that waste was collected weekly – combined with the fact that these plastic bags were carried off with the waste – it meant that for the other 48 weeks of the year, the residents had to make do with whatever they could lay their hands on since they could not afford to buy the black plastic bags.

It is evident from the above scenario that the inability of the city of Harare to supply residents with proper and conventional receptacles for the storage of waste could be blamed for poor waste handling at a household level that led to the unprecedented and unacceptable levels of using non-formal receptacles. This caused health problems like the cholera and dysentery outbreaks in the suburbs of Budiriro, Glenview, Mbare, Kuwadzana and Mufakose which brought untold levels of human suffering and loss of life. A number of waste disposal methods were used in Harare, many of which were outdated and had been cited as the chief causes of the environmental woes in the city. 21% of the waste was disposed of by burning, which

(according to the city council) caused air pollution, urban heat islands and in some instances fires. Burning waste also causes soot, which eventually lands on buildings and distorts the visual beauty of buildings. Burning (especially the burning of tyres, polyvinylchloride [PVC] products and rubber) has also been linked to chemical pollution. Composting accounted for 18% of the methods used. When left unchecked, organic manure can be a haven for rodents and other vectors; hence, it is not ideal for urban waste disposal due to lack of space. Compost also generates odours, which leads to air pollution. Burying waste is also a common practice in Harare (5% according to the data in Figure23). This is a very poor method of waste disposal, especially when done in residential areas.

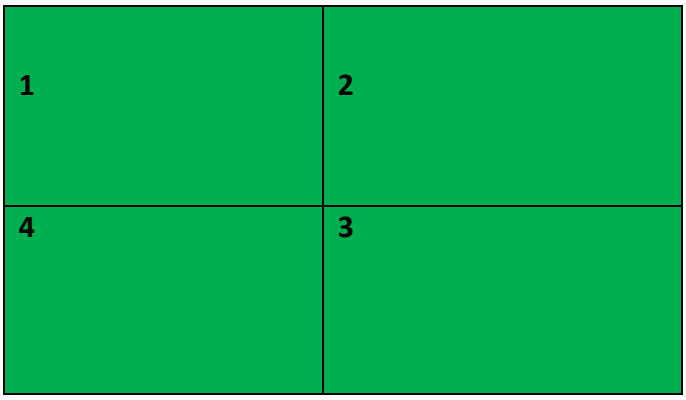
5.7 ADVICE ON SUSTAINABLE WASTE MANAGEMENT STRATEGIES

The city of Harare was found wanting in many aspects of its waste management, especially with respect to the characterisation and management of non-formal solid waste disposal sites, handling waste, the provision of waste handling facilities at household level and the involvement of key stakeholders.

5.7.1 Integrated environmental management system

Puorideme (2010) defines an integrated environmental management system as a comprehensive solid waste model that combines elements of waste prevention, recycling, composting and disposal with active stakeholder participation that ensures efficient and sustainable waste management. The definition gives a clear guideline on how municipalities should manage waste. From the research, it was found that there was very little stakeholder participation in waste management in Harare and this is a major shortcoming that residents capitalise on when not complying with city by-laws. The residents should be empowered and must be made to feel that they own the city. Environmental lobby groups, the government and the corporate world must all be embraced because they are all very important cogs in the environmental management wheel. Natural and obvious efforts must be directed towards reducing waste by innovatively designing and manufacturing products with less materials and materials that are less toxic or non-toxic, recyclable and biodegradable. An integrated

environmental system is therefore suggested,-in Figure 23-where all stakeholders are involved, their responsibilities are outlined and they are made aware of the responsibilities of their counterparts. To this effect, an environmental management window of responsibilities model is suggested for the city of Harare. The municipality is mainly mandated to provide infrastructure like landfills, waste management equipment like skip bins, waste collection trucks, bins and enforcement of by-laws. The main roles of the residents are to make sure that waste is disposed of at designated areas, pay waste collection fees to the municipality, report illegal dumping and also help with ideas that enhance good waste management practices. Industry naturally helps with relevant technology and trends in waste management so as to reduce costs as well as improving efficiency. Government ensures that national environmental laws are adhered to by both the municipality and the residents, help with technical and financial assistance. The legislature help with interpretation of the laws and by-laws pertaining to environmental management and waste management while lobby groups are charged with information dissemination as well as environmental awareness campaigns.



1= Municipality

2= Residents

3= Industry

4= Legislature/lobby groups/government

Figure 23: Environmental management window of responsibilities (EMWR) model

(Source Author: 2014)

The four panes represent the four natural stakeholders: the municipality, residents, industry and legislature. The outer frame of the window represents a common goal, thus embracing everyone; the dividing lines assign responsibilities to each pane while every pane is a group of stakeholders with distinct responsibilities. The window panes are of the same size, meaning that all the stakeholders have equal responsibilities. Each pane is self-contained (which means its roles are clear and peculiar to that pane) and is attached to the others (which show integration, interdependence and indispensability). It is evident that members of each pane are aware of what members of the other panes are doing and what they are supposed to be doing. Increasing the size of one pane reduces the size of another pane, leading to more responsibilities on one part while responsibilities are diminished on the other part.

The model is a window because it means that everything is clear for everyone. Thus, from the model, one can surmise that in order for effective waste management to be realised, all stakeholders must participate fully according to their areas of responsibility. Though responsibilities may overlap as a way of helping struggling members the sole responsibility remains with the stakeholders in that pane and this must not result in pushing other stakeholders into obscurity which lead to disintegration, despondency and non-compliance.

5.7.2 Contracting system

From the information obtained, it is noted that the Harare City Council failed to collect waste on time and that insufficient waste-collecting trucks is one of the reasons for this. This has led to an ever-increasing number of illegal dump sites in the city. It is therefore proposed that a contracting system be introduced whereby private companies are contracted to collect and transport waste to landfills. This should be done through a tender system in order to minimise incidences of corruption and at the same time secure the best service provider. The contract should be reviewed after a stipulated period in order to curb complacency and incompetence.

5.7.3 Environmental awareness

The Harare City Council is advised to embark on massive environmental awareness campaigns to make residents aware of the need for a cleaner and safe environment that can only be realised through good solid waste management, shared responsibilities and a sense of ownership. This can be achieved through clean-up campaigns and promotions like cleanest suburb of the year, cleanest home of the suburb and cleanest school/hospital of the city. This will encourage residents and institutions to compete for recognition. Cleaner institutions, homes and suburbs can be rewarded with certificates and monetary prizes. Promotions on the use and return of waste should be encouraged since this will lead to more waste being reused and/or recycled. Better separation at the source is another way to reduce waste as the separated waste will be easy to recycle. The city council can extend theuse colour-coded bins to other areas to encourage residents and make it easy for them to recognise which type of waste to put in which bin. This will also automatically promote the idea of recycling.

5.7.4 Human resources development

In recent years, it has become quite natural and obvious that human capital supersedes all forms of capital, including land, money, and even gold and diamonds. Therefore, the city of Harare is advised to invest in human development. The research data revealed that 90% of the employees in the Department of Waste Management had only primary and secondary education and many did not have any form of training. This is seen as militating against service delivery. Residents complained about council workers being very discourteous, and this can only be attributed to a lack of public relations and customer care training. This was also cited as the reason why most residents did not comply with the city's by-laws, did not attend council meetings and did not pay their rates (and those who did pay did not do so on time).

The research survey revealed that the council operated with a skeletal workforce of 1020 employees instead of 1227. It has already been indicated that Harare had an urban population

of 1 485231 at the time of the research and that the Department of Waste Management's staff compliment of 1020 translated to one worker servicing about 1456 people. This is disproportional and was one of the reasons why waste was not collected on time. The researcher therefore advises that more workers be hired to relieve the already strained human resources of the city council. This will help to increase the frequency of waste collection and will improve waste management in the city.

5.7.5 Legislation

Legislation on waste management should be reviewed often, as some pieces of legislation are outdated. For instance, the Domestic Waste Collection Act of 1981a states that domestic waste shall be collected once a week but it is silent on what should happen in a week where there are public holidays. The growth of the city was also not considered. It appears that most of the by-laws have been overtaken by events and are no longer relevant to modern city standards. The Waste Disposal Act of 1979 states that council may demand that the owner of a premise and generator of waste remove all domestic waste and deposit it at a disposal site. This is tantamount to saying that the city has no obligation to remove waste from private premises. The Act further suggests that residents may not complain to the city council for the non-collection of waste. While the current fines for dumping waste in undesignated places (US$250 for trucks dumping waste, US$50 for dumping domestic waste and US$20 for littering) are plausible, it is felt that enforcement should be strengthened and should be applied unilaterally. While the disconnection of water due to non-payment of rates is seen as more radical, in some quarters it is regarded as primitive and insensitive and could be replaced by more proactive and non-humiliating punishments like instituting legal action and community services in council facilities like parks, schools, farms and stadiums. The council is also advised aggressively promote the increasingly popular concept of the 3Rs (recycle, re-use and reduce) at household level.

5.8 SUMMARY

In this chapter, the locational attributes of non-formal solid waste disposal dumping sites were explored and measured and some internal linkages within the locational attributes were established. Solid waste was classified according to type for the study, while variations in waste profiles were studied and analysed. Various waste management strategies used in Harare were discussed. Lastly, some advice on sustainable waste management was offered.

CHAPTER 6: CONCLUSION AND RECOMMENTATIONS

6.1 SUMMARY

In chapter one, an introduction to the research is provided. The context of non-formal waste dumps in Harare, Zimbabwe is placed in the wider context of contemporary urban problems. The research problem is identified, the purpose of the research specified together with the key objectives of the study. The chapter is rounded up with a definition of key concepts. In chapter two, presented a survey of the state of contemporary literature on the management of solid waste in urban environments. It was established that there existed widespread challenges in the way municipal solid waste was managed. It was noted that developing countries faced severe challenges which called for country specific solutions. Chapter three looked at the way the research was carried out. Built on a descriptive, non-experimental research design, instruments were designed and piloted before application in data collection. Field sampling was carried out to isolate a sample of sites for observation in Harare City. Field observation was the main instrument for primary data on the characterisation of waste dumps while secondary data was retrieved from Harare City Council. This second set of data provided information on current waste management approaches. The data so collected was analysed using SAS JMP. The results of the research were presented in chapter four. Applicable Excel generated graphics that capture the characteristics of non-formal waste dumps were presented and described with respect to the key objectives of the study. The testing of the hypotheses was carried out using. The results show a great deal of gaps in available knowledge and techniques in the current practices in solid waste management in Harare. Chapter five presented the discussion of the findings. These were bench marked against similar findings in the literature. Possible interventions to improve the performance of waste management are indicated. Chapter six having, recognised the importance of the research findings this chapter therefore presents the conclusion and recommendations for improving the management of solid waste with special emphasis on non-formal disposal sites. The recommendations call for a more integrated approach which enhances greater environmental, economic, social and political sustainability.

6.2 CONCLUSION

The problem of illegal waste dumps in Harare has attracted considerable attention from the civics, academics, environmental lobby groups, the government and the general public. This has led to a barrage of criticism against the municipality, especially the Department of Waste Management. Although the problem of non-formal solid waste disposal sites in Harare may mainly be linked to population growth, urbanisation and the general poor performance of the economy (as the municipality wants people to believe), these are not reasons enough to exonerate the municipality which – in every sane person's view – is characterised by incompetence, corruption and political interference. The practical solutions that have been advanced in this research may still come to nought if they are not implemented from an integrated solid waste management perspective. Although funding is key to the success of all the recommendations that are made, stakeholder involvement, transparency and efficiency on the part of the municipality are paramount.

6.3 RECOMMENDATIONS

After the field survey and the interactions with residents, organisations, the city council, government and environmental advocacy groups, and captains of industry, it became mandatory for the researcher to present a number of recommendations to the mentioned stakeholders. These recommendations have been structured to suit the various stakeholder groups for ease of understanding and possible implementation.

6.3.1 Recommendations to the Department of Waste Management

The following recommendations are made to the department:

- *Implement an integrated environmental management system*. The city of Harare should embrace the now internationally acclaimed approach to waste management which co-operates all the functional units of waste management and all the stakeholders for the speedy and efficient collection of waste in the city.
- *Colour coded bins* provide colour coded bins to residents so that they can segregate waste at household level.
- *Use durable waste/garbage bins*. It is recommended that the city council supply residents with more durable waste bins (e.g. the metal ones or the plastic ones with handles and wheels for easy handling of waste). Although these bins may initially be expensive, the long-term advantages far outweigh the disadvantages. The number of bins supplied must be based on the size of the household (unlike the present situation where there is only one bin per household in three months).
- *Involve stakeholders.* From the research, it emerged that there was minimal stakeholder participation in most of the issues pertaining to waste management in Harare. It is suggested that the Harare City Council involve all the stakeholders in waste management if its ambitions to be a world-class city by 2025 are to be realised.
- *Provide open places to make compost from biodegradable waste*. Increase the number of colour-coded bins in public places. This encourages waste separation, which will eventually promote recycling and re-use. At the time of the research, these bins were only seen in the CBD.
- *Review city by-laws governing the management of waste*. The research unearthed a number of archaic laws that were crafted more than thirty 30 years ago and are no longer relevant to modern methods of waste management. Here reference is made to the 1979 Policy on Waste Management, which states that only the city of Harare has the responsibility for the removal of all domestic waste from premises. This is only possible in a functional municipality with the capacity to manage waste.

- *Conduct a waste audit*. An audit should be carried out at six-month intervals in order to establish the nature and amount of the waste generated, with a view to putting in place a collection frequency that meets the generation rate.
- *Provide greater autonomy.* The Department of Waste Management should be given greater autonomy for effective performance. They should always have contingency measures to deal with the increasing volumes of solid waste, especially in summer when there is increased agricultural waste.
- *Develop a cost recovery scheme*. This can be achieved by imposing a levy on the residents, shops and market vendors as a way of financing the collection of waste.
- *Educate the public.* Posters with environmental information should be regularly made available to the public to educate them about good environmental management and the importance of public participation in environmental issues, and current trends and developments in waste management.
- *Offer rewards/incentives*. The Harare City Council should consider awarding trophies or price money for, say, the cleanest suburb of the month, the cleanest market of the city or even the most improved suburb of the city.The maximum number of persons per household should be fixed and be accompanied by the appropriate infrastructure to avoid overcrowding, which ultimately leads to more waste being generated per household.
- *Invest in waste management* much effort and resources should be channelled to skilling of waste management personnel.

6.3.2 Recommendations to the residents of Harare

The following recommendations are made:

- Start segregation of waste at household level so as to promote recycling and re-use.
- Inculcate in children waste management skills so that they will grow up as responsible citizens.

- For the purpose of composting, organic waste should be separated from other waste at the source.
- All types of waste that are recyclable should be segregated at the source and put in separate facilities for recycling.
- Littering should be avoided by putting rubbish in bins or holding on to it until a bin is accessed. For instance, if someone has generated waste (e.g. fruit peels, cans, food wrappers or newspapers) in areas where bins are not readily available.
- Residents should be encouraged by the city council and environmental groups to attend and participate in community and municipal environmental meetings, campaigns and programmes.
- The Harare City Council should provide vendors with proper structures that have waste disposal facilities so that they can conduct their business and store their wares at night for a nominal fee.
- Residents should have a sense of ownership and respect for the city. This will lead to more responsibility and accountability, thereby reducing littering and the illegal dumping of waste.

6.3.3 Recommendations to the government

The following recommendations are offered:

- Environmental laws should be reviewed regularly to keep pace with the latest trends in waste management. Since the country has adopted a multi-currency system and abandoned the Zimbabwe Dollar, all fines and levies must be quoted in US$ to avoid confusion and prejudice.
- Public and private partnerships in small-scale recycling enterprises that handle some of the waste components should be established.
- The Ministry of Education, Sports and Culture should include environmental education in the curriculum, with the aim of making it an examinable subject at both ordinary and

advanced level in future. This will automatically emphasise the importance of managing the environment. Students may also be entered in competitions where they design projects and models on environmental management.

6.3.4 Recommendations to the industry

The following recommendations are made:

- Packaging material should be made from biodegradable material and using plastic packaging should be avoided as much as possible.
- Manufacturing companies must come up with designs for products that produce less waste.
- Wherever possible, industry should strive to use recyclable resources such as raw material, since this will reduce the eventual waste that finds its way to the landfill.
- Encourage consumers of their products to sell back or return all recycle able products after use.

The chapter availed some recommendations to the main stakeholders involved in managing waste in Harare. All the recommendations were tailor made to meet each individual group's mandate and abilities with the view of wanting to mainly achieve an integrated solid waste management system in a more sustainable way while encouraging a culture of responsibility and accountability

LIST OFREFERENCES

Awoso, JA & Tariwo, AM. 2010. Waste disposal and pollution in urban areas. A workable remedy for the environment in developing countries. *Journal of Environmental Science*6(1):26–32.

Bere, S. 2011. Waste management issues in Zimbabwe. *Journal of Sustainable Development in Africa* 21(6):1120–1128.

Bere, S. 2013. Waste management challenges and solutions in Zimbabwe. *Journal of Sustainable Development in Africa* 13:120–129.

Bryman,A.2007.*Social research methods*. New York: Oxford University Press.

Burnley, SJ. 2010. A review of municipal solid waste composition in the United Kingdom. *Waste Management* 27:1274–1285.

Central Intelligence. 2010. The State of Health and Safety in Zimbabwe. *Proceedings from An Urban waste management work shop:* Harare 13 July 2010.

City of Harare. 2013*Waste Management By-laws Statutory Instrument 477 0f 2006*. Harare: Harare.

City of Harare.2014. *Draft National Environmental Management.Waste Management Bill*. Harare: Government Printers.

Cherubini, F. 2010. Life cyclesassessment of urban waste management. *Journal of Waste Management* 10:1016–1023.

Chifamba, P. 2010. Trace metal contamination of water at solid waste disposal in Kariba, Zimbabwe. *African Journal of Aquatic Sciences*32(1):7178.

Chigwinya, A & Mudzengerere, F. 2012. Waste management in Bulawayo City Council in Zimbabwe: In search of sustainable waste management in the city. *Journal of Sustainable Development in Africa*14(1):228–243.

Chikoko, V & Moyo, S. 2003.*Dissertation guidelines for the Master of Education in Educational Administration*. Harare: Zimbabwe Open University.

Chung, S. 2010. Local waste management constraints and waste administration in China. *Journal of Waste Management* 28:272–278.

Faccia, D. 2011. Municipal solid waste in the United States of America. *Journalof Environmental Science* 27:720–733.

Fuggle, FL & Rubie, MA.2006.*Environmentalmanagement in South Africa.* Pretoria: McMillan.

Geng, Y, Zhu, Q, Doberstein, B & Fujita, T. 2009. Implementing China's circular economy concept at the regional level: A review of progress in Dalian, China.*Journal of Waste Management* 29:996–1002.

Government of the Republic of South Africa. 2006. *Draft National Environmental Management: Waste Management Bill.* Pretoria: Government Printer.

Government of Zimbabwe. 2002.*Environmental Management Act (Chapter 20:27)*. Harare: Government Printers.

Government of Zimbabwe. 2013.*Environmental management policies and strategies for environmental impact assessment*. Harare: Government Printers.

Gwimbi, P& Dirwai, C. 2003.*Research methods in Geography and Environmental Studies.* Harare: Zimbabwe Open University.

Halfman, DA. 2010. Solid waste management. *Journal of Environmental Science* 2(11):1023–1027.

Jambwa, D. 2011. Municipal solid waste disposal challenges in the city of Chinhoyi, Zimbabwe. *Journal of Sustainable Development in Africa* 13(2):615–621.26.

Johns, B and Sall, J. 2011. JMP statistical discovery software. *Wiley international planning review.* Computational statistics 3(3): 188;194.

Kemal,SA2007: Solid Waste Management. *European Journal of Sustainable Development,*2(2)452-500.

Kutiwa, S, Boon, E and Devuyst, D 2010: Urban Agriculture in Low income households of Harare: an adaptive response to economic crisis. *Journal of Human Ecology,*32(2)85-96.

Mader. J E. 2011. *Applying the Integrated Solid waste Management Frame work to the waste collection System*. Aguascalientes. AGS : Mexico.

Madebwe, V & Mudebwe, C.2010. Demolition waste management in the aftermath of Zimbabwe's Operation Restore Order(Murambatsvina). The Case of Gweru, Zimbabwe.*JournalofAppliedSciencesResearch*2(4):217–221.

Magadu, S. 2013. Urban solid waste management. *European Journal of Sustainable Development* 2(1):68–98.

Makarati, F & Chikobvu, D.2011. Solid waste management in Zimbabwe. *Journal of Sustainable Development in Africa* 13(7):184–199.

Mangizvo, RV. 2010. Challenges of solid waste management in the central business district of the city of Gweru in Zimbabwe. *Journal of Sustainable Development in Africa* 9(3):134–145.

Manyanhaire, IO & Munasirei, D. 2010. Analysis of a domestic solid waste management system: A case study of Sakubva high-density suburb in Mutare, Zimbabwe. *Journal of Sustainable Development in Africa* 11(2):127–140.

Manyuchi, M & Phiri, D. 2012.*Waste management in Zimbabwe*. *Landfill design and management.* Harare: Harare institute of technology.

Mapira, J. 2012. Challenges of solid waste disposal and management in the city of Masvingo, Zimbabwe. *Journal of Social Development in Africa* 26(2):26–34. Matate, N & Trois, L. 2010. Towards zero waste in emerging countries – A South African experience. *Journal of Waste Management* 28:1480–1490.

Mawire, W. 2010. Waste management. *The Zimbabwean*, 19 November.

Mbanga, W. 2011. Editorial comment. *The Zimbabwean,* 24 August.Momoh, A & Oladebeye, DH. 2010. Waste management. *Journal of Human Sciences*4(2):201–216.

Momoh, J J and Oladebeye, D H.2010. Assessment of awareness of attitude and willingness of people to participate in household solid recycling programmes in Odo-Eketi, Nigeria. Journal of Applied Sciences in Environmental Sanitation: (2) 231-253.

Mensah, A and Labi, E 2005. Solid waste disposal in Ghana. www. Trend wastenet{ Accessed 20 September 2014}.

Mondal, P. 2010, Major classification of waste. *Journal of Waste Management:* 22(2):78–89.

Mouton, J. 2001.*How to succeed in your master's and doctoral studies:SA South African guide and resource book.* Pretoria: Van Schaik.

Muchadehama, D. 2012. Improved local governance, answer to service delivery. *Daily News on Sunday, Zimbabwe,* 12 August:1.

Mudau, VN, Ruhiiga, TM & Malan, PW. 2013. A review of efficiency parameters in South Africa's municipal solid waste management. *Asia Life Science*, supplement 9:157–172.

Musademba, D, Musiyandaka, S,Muzinda, A, Nhemachena, B & Jambwa, D. 2011. Municipality solid waste (MSW) managementchallenges of Chinhoyi Town in Zimbabwe: Opportunities of waste reduction and recycling. *Journal of Sustainable Development in Africa* 13(2):148–153.

Munzwa, L 2010. Urban Development In Zimbabwe: *A Human Settlement Perspective Number 5(14) February 2010.*

Nyakudya, IW& Stroosnijder, L. 2011. Water management options based on rainfall analysis of rain fed maize (ZEA mays L>) production in Rushinga district, Zimbabwe. *Agricultural Water Management*98:1649–1660.

Okot-Okumu, J. 2012. Waste management – An integrated version. *International Journal of Urban and Regional Research* 28(4):874–894.

Okot-Okumu, J & Nyenje, R. 2011. Solid waste management in African cities. *International Journal of Urban and Regional Research* 28:728–752.

Practical Action Zimbabwe. 2010. Proceedings of emerging issues in urban waste management workshop, Harare, 10 February.

Puopiel, F. 2010. Solid waste management in Ghana. The case study of Tamale Metropolitan Area. Thesis in Development Policy and Planning, Kwame Kuruma University, Kumali.

Puorideme, D. 2010. Solid waste management in Ghana. Master of Science thesis in Development Policy and Planning, Kwame Kuruma University, Kumali.

Ruhiiga, TM. 2013a. Managing explosive urbanisation in Africa. *Journal of Human Ecology*42(1):43–52.

Ruhiiga, TM. 2013b.Growth of urban agglomeration nodes in Eastern Africa. *Journal of Human Ecology* 41(3):237–246.

Seng, B & Seng, H. 2010. Municipal solid waste in Cambodia. *Journal of Waste Management and Research* 29:491–500.

Taylor, D& Proctor, M. 2001.Literature review: A few tips for conducting it. http://www.utoronto.ca/writing/litrev.html (accessed 27 September).

Tapera, R.. The 2013importance of integrated solid ate management in independent Zimbabwe: The case study of Glenview Area 8, Harare. *Global Journal of Biology, Agriculture and Health Sciences. 33: 68-72.*

Tevera, DS . 1991 Solid waste disposal in Harare and it's effects on the environment: Some Preliminary Observation: *The Zimbabwe Science News.* 25(1): 32-34.

United NationsEnvironmental Programme. 1996. Solid waste management. *Journal of Sustainable Development in Africa 2(2)78-92.*

United Nations Environmental Programme. 2000. Solid waste management. *Journal of Sustainable Development in Africa*18:323-361.

United Nations Environmental Programme.2002. Environmental management in Zimbabwe. *A Geographical Journal in Zimbabwe*27:43-47.

United Nations Environmental Programme. 2005. Environmental management in Zimbabwe. *A Journal of Sustainable Development in Africa 19: 173-177.*

United Nations Environmental management Proramme.2006. Environmental management in Zimbabwe. *A Journal of Sustainable Development in Africa* 22:46-69.

United Nations Environmental management Proramme.2007. Environmental management in Zimbabwe. *A Journal of Sustainable Development in Africa* 25: 55-73.

United Nations Environmental Programme. 2010. Environmental management in Zimbabwe. *Journal of Sustainable Development in Africa*14:201-253.

United Nations Environmental management Programme. 2011. Hazardous substances. *Geographical in Zimbabwe.*17(2):53-70.

United States Environmental Protection Agency. 2010.*Policies for waste management*. Washington: Public Health Services.

Zimbabwe Central Statistical Office. 2013. *Census 2012 Report*. Harare: Government Printers.

Zimbabwe Central Statistical Office. 2014. *Consumer Report . 15 October 2014.*

Waugh, D. 2006.*Geography: An integrated approach.*Cape Town: McMillan.

World Food Programme. 2013 Food Security in Zimbabwe. *Report on state of food security in Zimbabwe by WFO 18 September 2013.*

APPENDICES

APPENDIX 1: INTERVIEW SCHEDULE FOR THE DEPARTMENT OF WASTE MANAGEMENT

My name is CastonMahamba. I am a student for the MSc degree in Environmental Management the University of South Africa. I am conducting research on the characterisation and management of non-formal solid waste disposal sites in Harare, Zimbabwe.
Could you kindly assist me in gathering information by completing the attached questionnaire? Information generated will only be for academic purposes and will be treated with a high sense of confidentiality. Your co-operation will be highly appreciated.

A set of objectives are advanced for this study as follows:

- Measure the locational attributes of non-formal solid waste dumps.
- Analyse the internal linkages of the locational attributes.
- Classify waste by type across the study area.
- Analyse the variations in profiles of waste in the study area.
- Describe current waste management approaches used in Harare.
- Generate advice on sustainable waste management strategies.

SECTION A: MUNICIPAL CAPACITY TO DEAL WITH SOLID WASTE

LEVEL OF EDUCATION OF WASTE MANAGEMENT PERSONNEL

Primary	
Secondary	
Tertiary	

SECTION B: INVENTORY OF EQUIPMENT

Skip bins				
Refuse trucks				
Skip trucks				
Tractors				

SECTION C: DEPARTMENT OF WASTE MANAGEMENT

(1) How big is the workforce in your department?

(2) How many skip bins do you have and how big are they?

(3) How many waste collection vehicles are servicing the city, for example trucks and tractors.

(4) How do you ensure that the public refrains from illegal dumping?

(5) What problems do you encounter as a city in handling solid waste?

(6) What plans do you have to improve your performance?

SECTION D: MUNICIPAL CAPACITY TO DEAL WITH WASTE

FREQUENCY OF GARBAGE COLLECTION BY THE DEPARTMENT OF WASTE MANAGEMENT

Twice a week	
Once a week	
Fortnightly	
Monthly	
Rarely	

APPENDIX 2:OBSERVATIONPARAMETERS

Observation will be mainly carried out on disposal sites to check the following:

(1) Location of dump sites
(2) Number of dump sites
(3) Types of waste
(4) Composition of solid waste
(5) Size of waste dump
(6) Physical properties of solid waste
(7) Presence of municipal posters discouraging and warning residents about the negative effects of littering

APPENDIX 3: VOLUMES OF WASTE FOR SAMPLED DUMP SITES

DUMP SITE CODE	VOLUME OF WASTE IN KG	SMALL (LESS THAN 1000KG)	MEDIUM (LESS THAN 2000 KG)	LARGE (MORE THAN 2000 KG)	LAND USE
004	2100				High density
034	2300				High density
O43	1300				High density
052	2800				High density
077	1500				High density
083	2100				High density
121	2700				High density
194	3000				High density
195	2000				High density
197	1800				High density
198	1300				High density
202	2000				High density
212	2600				High density
223	3000				High density
224	2700				High density
227	2100				High density
237	2300				High density
238	3300				High density
283	1700				High density
297	3100				High density
317	2900				High density
341	2200				High density
343	1900				High density
345	2800				High density

368	1900				High density
372	2300				High density
400	1800				High density
409	3000				High density
412	2700				High density
426	3100				High density
451	1100				Medium
486	800				Medium
487	1000				Medium
494	700				Medium
513	1100				Medium
522	800				Medium
531	2800				High density
544	200				High density
565	2100				High density
576	600				Low density
591	500				Low density
618	800				Low density
619	1000				Low density
326	500				Low density
649	400				Low density
670	500				Low density

APPENDIX 4: TYPES OF WASTE FOR SELECTED DUMP SITES

	TYPES OF WASTE										%
Dump code	**Food**	**Plastic**	**Paper**	**Wood**	**Glass**	**Metals**	**Textile**	**Yard trimmings**	**Agricultural**	**Other**	
004	10.0	20.5	26.0	7.4	8.4	13.4	3.3	1.4	10.0	2.1	100
007	8.2	24.0	27.0	7.0	6.0	14.0	2.8	1.0	8.0	2.0	100
012	9.0	15.0	16.5	12.5	5.5	13.0	3.0	3.0	18.5	4.0	100
025	11.0	13.1	15.0	15.9	5.0	12.0	4.6	4.4	16.0	3.0	100
033	8.8	11.1	16.1	14.0	7.0	17.0	3.5	3.5	17.0	2.0	100
034	9.9	13.0	13.1	11.0	5.0	14.3	4.3	4.4	19.0	6.0	100
043	10.0	10.7	9.1	13.0	4.8	12.1	8.0	8.5	13.5	4.0	100
052	10.0	20.0	26.5	7.0	5.0	12.5	3.0	3.0	10.0	3.0	100
077	8.7	13.2	17.0	12.1	4.9	14.1	4.0	3.9	18.1	4.0	100
083	12.0	21.0	13.4	15.6	5.0	14.7	4.3	3.0	12.0	2.0	100
121	9.9	20.1	15.0	13.5	8.0	12.5	5.0	2.9	11.0	2.1	100
193	11.0	15.7	21.0	11.0	6.3	13.0	4.0	6.2	9.8	3.0	100
194	10.0	20.0	17.0	12.0	7.0	11.0	3.2	4.4	11.4	3.0	100
195	12.0	9.9	17.0	11.1	6.0	15.6	4.0	6.4	12.0	6.0	100
197	10.0	21.0	11.0	15.0	3.8	11.2	6.2	4.8	15.0	2.0	100
202	13.9	14.2	12.7	20.0	5.0	9.9	4.4	0.9	16.0	3.0	100
212	15.0	13.0	11.6	15.4	5.7	12.0	5.7	5.0	12.6	4.0	100
223	11.0	17.0	13.9	13.0	6.1	14.0	3.8	4.0	14.2	3.0	100
234	12.0	11.0	13.0	12.8	5.2	16.0	5.0	2.0	20.0	3.0	100
237	11.0	12.0	18.0	13.0	6.0	13.2	5.8	3.0	14.0	4.0	100
283	13.0	9.5	13.5	10.1	6.6	14.3	5.0	2.0	14.0	3.0	100
297	11.0	21.0	17.2	8.8	5.5	13.5	4.0	3.0	12.0	4.0	100
317	10.0	13.0	21.0	12.4	4.8	12.2	4.7	3.9	15.0	3.0	100
341	13.0	16.0	14.0	11.9	5.8	13.0	4.5	4.5	13.0	4.3	100
343	11.0	1.07	14.0	9.9	4.9	14.1	5.1	4.0	17.0	3.0	100
345	10.0	12.0	15.0	11.3	4.7	16.0	4.9	4.1	20.0	3.0	100
368	9.9	17.0	13.0	11.9	5.0	16.0	4.0	4.2	16.1	2.9	100

372	11.8	12.0	18.2	10.8	4.2	13.0	6.0	4.4	13.6	6.0	100
400	14.0	1.2	17.0	11.9	5.1	12.0	6.0	5.0	13.0	4.0	100
409	9.0	16.0	12.6	12.4	5.0	16.0	5.2	4.2	17.6	2.0	100
412	11.4	14.6	11.9	16.0	4.1	12.0	3.3	4.7	18.0	4.0	100
426	10.0	16.0	14.0	12.3	6.2	15.5	3.0	5.0	15.0	3.0	100
451	15.0	11.0	17.6	10.1	5.3	17.0	5.0	2.9	12.1	4.0	100
486	14.9	12.0	16.0	13.1	7.0	13.9	4.1	3.0	12.9	3.1	100
487	12.0	11.9	15.1	14.8	3.2	11.9	5.1	4.2	17.8	4.0	100
494	16.9	13.0	18.0	14.3	3.7	7.0	4.4	5.1	14.6	4.0	100
513	13.0	13.0	17.0	13.1	6.9	12.0	4.2	5.0	12.2	4.6	100
522	14.5	10.0	10.0	14.5	7.2	16.8	7.0	6.0	12.0	2.0	100
531	11.0	15.0	19.0	7.3	5.0	10.3	6.4	5.0	18.0	3.0	100
539	12.0	12.0	16.0	11.2	4.8	11.0	7.0	4.0	17.9	4.1	100
544	23.0	17.0	31.0	6.0	6.3	5.4	6.3	4.3	5.2	3.0	100
565	20.0	22.0	24.0	7.4	3.5	4.1	7.0	5.0	4.0	3.0	100
576	22.0	23.0	21.0	8.0	4.0	5.9	5.1	4.0	5.0	2.0	100
591	25.0	17.0	25.0	7.9	5.1	6.0	4.0	3.1	6.9	4.0	100
613	23.0	26.0	22.0	5.0	4.0	4.8	3.2	4.0	5.0	3.0	100
619	22.0	24.0	26.0	4.2	3.4	5.0	4.0	3.2	6.2	2.0	100
632	20.0	27.0	22.0	5.0	3.9	6.1	6.0	2.0	6.4	1.6	100
647	19.0	26.0	23.8	5.8	4.4	7.0	3.9	3.0	4.1	3.0	100
670	24.0	25.5	24.5	5.9	3.1	3.8	4.2	4.0	3.0	2.0	100

APPENDIX 5: ETHICAL APPROVAVAL FROM UNISA

UNISA university of south africa

2014-04-14

Ref. Nr.: 2014/CAES/103

To:
Student: C Mahamba **Student nr: 47279664**
Supervisor: Prof T Ruhiiga
Department of Environmental Sciences
College of Agriculture and Environmental Sciences

Dear Prof Ruhiiga and Mr Mahamba

Request for Ethical approval for the following research project:

Characterisation and management of non-formal solid waste disposal sites in Harare, Zimbabwe

The application for ethical clearance in respect of the above mentioned research has been reviewed by the Research Ethics Review Committee of the College of Agriculture and Environmental Sciences, Unisa. Ethics clearance for the above mentioned project (Ref. Nr.: 2014/CAES/103) **is given** for the duration of the study.

Please be advised that should any part of the research methodology change in any way as outlined in the Ethics application (Ref. Nr.: 2014/CAES/103), it is the responsibility of the researcher to inform the CAES Ethics committee. In this instance a memo should be submitted to the Ethics Committee in which the changes are identified and fully explained.

The Ethics Committee wishes you all the best with this research undertaking.

Kind regards,

Prof E Kempen,
CAES Ethics Review Committee Chair

Good luck

Prof MJ Linington
Executive Dean: College of Agriculture and Environmental Sciences

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 429 12 429 4150
www.unisa.ac.za

APPENDIX 6: AUTHORISATION LETTER FROM THE CITY OF HARARE

CITY OF HARARE

HUMAN CAPITAL DEPARTMENT
TOWN HOUSE, HARARE, ZIMBABWE
POST OFFICE BOX 990
TELEPHONE 752979 / 753000

EMAIL: hrd@hararecity.co.zw
ADDRESS ALL CORRESPONDENCE TO THE HUMAN CAPITAL DIRECTOR

18 March, 2014

C. Mahamba
C/O Dr. M. Sandada
Graduate School of Management
University of Zimbabwe
P.O. Box MP 167
Mount Pleasant
HARARE

Dear Madam

RE: AUTHORITY TO UNDERTAKE RESEARCH : C. MAHAMBA

This letter serves as authority for Caston Mahamba to undertake his research project on the topic : **"CHARACTERIZATION AND MANAGEMENT OF NON-FORMAL SOLID WASTE DISPOSAL SITE IN HARARE" : A CASE STUDY OF HARARE CITY COUNCIL.**

This is in partial fulfilment of the Msc Degree programme in Environmental Management with the University of South Africa.

The City of Harare has no financial obligation and neither shall it render any further assistance in the conduct of the research. The researcher is however requested to avail a copy of the research to the undersigned so that residents of Harare can benefit out of it. The research should not be used for any other purpose other than for the study purpose specified.

Yours sincerely

DR. C. CHINGOMBE
HUMAN CAPITAL DIRECTOR
RMR/rz

"HARARE TO ACHIEVE A WORLD CLASS CITY STATUS BY 2025"

APPENDIX 7:LETTER OF INTRODUCTION FROM THE UNIVERSITY OF SOUTH AFRICA

UNISA university of south africa

25 June 2014

TO WHOM IT MAY CONCERN

Dear Sir/Madam

LETTER OF INTRODUCTION

This is to confirm that Mr Mahamba, C (student number: 47279664) is a registered student in the Department of Environmental Science, College of Agriculture and Environmental Sciences of the University of South Africa.

He is studying towards a Masters degree in Environmental Management with the research title **"Characterisation and management of non-formal solid waste disposal sites in Harare, Zimbabwe"**. He has four years to complete his qualification.

Will you kindly recognize him in this regard.

If you have any queries or reservations, please do not hesitate to contact the undersigned people:

- Student: cmahamba69@yahoo.com
- Supervisor: Prof T Ruhiiga, Tabukeli.Ruhiiga@nwu.ac.za

Thank you very much in advance for your assistance.

Sincerely Yours

Prof WAJ Nel
COD: Environmental Sciences

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 429 12 429 4150
www.unisa.ac.za