ZERO PLASTIC WASTE FOR A HEALTHIER ECOSYSTEM: AN ASSESSMENT OF SUSTAINABLE WASTE MANAGEMENT IN RUNDA ESTATE, NAIROBI

By

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DECLARATION

I declare and affirm to the best of my knowledge that this Thesis is my original work and has not been presented for a degree or any other award in this or any other college.

Signed: _____ (author)   Date: _____

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I confirm that the work reported in this Thesis was carried out by the candidate under my supervision.

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DEDICATION

This work is dedicated to my baby brother Michael. The stars have become your home, but in our hearts and our memories you will be, always. To Dennis Mbau and his friend Walter who is doing a feasibility study for a start-up waste management company. Walter being the good friend that he is, always talks it (business) out with Dennis almost as if he sought approval.

I also want to dedicate this to my other brother Donald Mbau. He reminds me of the struggle I had trying to study the Brunelleschi approach. Brunelleschi (1377–1446), was an Italian architect whose desire to accurately draw what he saw, led him to explore the principles of linear perspective, a technique for depicting volumes and spatial relationships on flat surfaces. You tell yourself you are capable of grasping the concept but then it does not happen in a thirty minute window as you think it should. I think Donald should be given a chance to make his own mistakes.

INSPIRATION

Albert Einstein once said, "The environment is everything that isn't me." I feel strongly, that the plastic waste situation globally is a threat to this, our environment, and its capacity to support life. But a recent discovery by Yale students, which I thought was righteous, will reportedly be of great contribution towards the fight against plastics. This group of Yale students ventured into the jungles of Ecuador and brought back a fungus, Pestalotiopsis microspora, which is new to science and has voracious appetite for polyurethane. The Yale team published their findings in the journal Applied and Environmental Microbiology, 2014.

Michael Bloomberg, Mayor of New York, has religiously spoken out about the need to take the necessary precautions to protect nature, without which there is great risk to human existence. He has been quoted saying, "we are on a collision course with nature today and we have to change; emissions don't recognize borders," amongst other things that 'add wood to my fire.'

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ABSTRACT

The human anatomy is a practical route to bring the issue of waste to better understanding. A comparison between buildings and the human body shows similarities therein, mechanisms for air to flow in and out, pipe-work for various functions, walls protecting entities within from dangers without, amongst other matching features seeing as buildings are an extension of ourselves. A major difference would be that we are in charge of our own grooming whilst buildings are not. This is the essence of waste management plans. They are important tools that help us keep the environment within and without the building from the 'harms' of waste.

An increasing population leads to a growing demand in plastic goods and generation of plastic waste. Nairobi's population has been growing consistently. This has led to a comparable increase in plastics consumption and consequently an increase in plastic waste generation and pollution. The informal sector is however seen to engage actively in the resource recovery of plastic waste in both of these neighbourhoods. Studies done on plastic waste pollution in ocean waters give ground for constructive brainstorming of possible solutions to the grave problem that threatens human existence. Plastics are consumed by wild life and organisms in the ecosystem and end up traveling through the food chain. Human beings consume (from abattoirs, through hunting and fishing etc.,) foods that contain the same plastics alongside micro-organisms and toxins that may have accumulated in the same.

The purpose of this study is to assess the effects of plastics on the environment and the need for integration amongst stakeholders. This research takes to task segregation as a

much required human behavior for plastic waste management. It however begs the question, are residents motivated to participate in this impactful activity? With constantly changing innovations to meet our constantly changing needs and solving the world's problems through practical solutions, the end of plastics is not in sight.

The design proposed for this study is hypothesis testing because it explains the nature of the relationships between the variables. Questionnaires and interviews are used to collect primary data while secondary data is gathered from perusing books, journals, working papers amongst other research documents. The area of study is Runda Estate in Nairobi. It is served by a private waste management company called Taka Taka Solutions (TTS) who offer sustainable services. This study focuses on Runda Estate because it is an affluent estate where the researcher studies the important consumer habits emanating from their status. The relevant samples for this study are selected through area sampling method and a formula relevant for sample sizes for small populations.

The researcher arrived at the conclusion that reduction, reuse and recycling highly involve and depend on changes in human attitudes, behaviours and patterns. Runda residents were found knowledgeable of the problem of plastics and the existing linkages with the variables aforementioned. However, they have not shown their application of this knowledge in practical terms despite having access to resources. The analysis of the research questions shows that these residents are indifferent to the way and/or manner their behaviours impact plastic waste management. Recommendations and areas of further study to improve efficiency and effectiveness of waste management point to the need for structures that enable a circular economy.

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LIST OF ACRONYMS AND ABBREVIATIONS

5Rs- Reduce, Reuse, Recycle, Recover, Redesign

BBC- British Broadcasting Corporation

BC- Before Christ

CBO- Community Based Organization

CO_2- Carbon Dioxide

CO- Carbon Monoxide

ELCI- Environment Liaison Centre International

EMCA- Environmental Management and Coordination Act

FFBD- Functional Flow Block Diagram

GDP- Gross Domestic Product

HDPE- High Density Poly Ethylene

IFC- International Finance Corporation

IIED- International Institute for Environment and Development

ISO- International Organization For Standards

ISWM- Integrated Solid Waste Management

JICA- Japan International Co-operation Agency

KAM- Kenya Association of Manufacturers

KEBS- Kenya Bureau of Standards

KES- Kenyan Shilling (1 US dollar = 101.99 Ksh; 1 Euro = 101.07 Ksh)

Kg- Kilogram

KGBS- Kenya Green Building Society

KIPPRA- Kenya Institute for Public Policy Research and Analysis

KIRDI- Kenya Industrial Research and Development Institute

KNCPC- Kenya National Cleaner Production Centre

KS - Kenyan Standard

KRA- Kenya Revenue Authority

LDPE- Low Density Poly Ethylene

LEED- Leadership in Energy and Environmental design

μm- micron thickness

MDGs- Millennium Development Goals

MNN- Mother Nature Network

MSW- Municipal Solid Waste

MSWM- Municipal Solid Waste Management

NCC- Nairobi City Council (currently Nairobi County Council)

NEMA- National Environmental Management Authority

NEAP- National Environmental Agency Plan

NGO- Non-governmental Organizations

OECD- Organization for Economic Cooperation and Development

PE- Polyethylene

PET- Polyethylene Terephthalate (used for soft drinks)

PMF- Plastics Management Fund

PP- Polypropylene

PPP- Public Private Partnerships

PS- Polystyrene

PVC- Polyvinyl Chloride

RWL- Runda Water Limited

SCC- Sunshine Coast Council

SPi- Society of the Plastics Industry

SW- Solid Waste

SMW- Solid Waste Management

Tons- Tonnes

TPY- Tonnes Per Year

TTS- Taka Taka solutions

UK- United Kingdom

UKGBC- UK Green Building Council

UMP- Urban Management Programme

UN- United Nations

UNAM- Universidad Nacional Autonoma De Mexico

UNEP- United Nations Environmental Programme

UN-Habitat- United Nations Human Settlements Programme

UNIDO- United Nations Industrial Development Organization

UNON- United Nations Office Nairobi

US- United States

USAID- United States Agency For International Development

TTS- Taka Taka Solutions

WIDER- World Income Inequality Database

WGBC- World Green Building Council

WIEGO- Women In Informal Employment: Globalizing And Organizing

WRAP- Waste And Resource Action Programme

WWF- World Wildlife Fund

YFP- Year Framework Programme

KEYWORDS

Consumption: the use of products, for purposes of this study, plastic products

Ecosystem: an interconnected and symbiotic grouping of organisms that sustains life through biological, geological and chemical activity

Informal sector: scavengers, waste collectors. Neither taxed nor monitored by the government

Legislation: law

Municipal solid waste: waste generated from household, commercial and industrial sources

Municipal solid waste management: managing solid waste is waste collected and treated by or for municipalities.

Plastic: derived from the Greek word plasticos which means having the capacity to be shaped or moulded by heat

Plastic waste/plastic pollution: The accumulation of plastic waste in the environment that affects the ecosystem

Recyclable: the ability of a product or material to be recovered from the solid waste stream for the purposes of recycling

Recycling: a process by which materials that would otherwise become waste are collected, separated or processed and returned to the economic mainstream for reuse

Reduce: convert to a simpler form to reduce waste lower down the chain of supply

Resource recovery: a general term referring to any productive use of what would otherwise be a waste material requiring disposal

Reuse: the use of a product more than once in its original form

Segregation: the process by which waste is separated into different elements

Separation at source: separation of waste commodities at the place where the waste is generated, such as within households or industries

Solid wastes: waste type consisting of everyday items that are discarded after use

Stakeholders: the individuals, organizations and groups that have an interest in the action of an organization and the ability to influence it

Sustainable Development: an approach to development that meets the needs of the present without compromising the ability of future generations to meet their needs

Waste generation: quantity of materials or products that enter the waste stream being recovered

Waste management/Solid waste management: the generation, prevention, characterization, monitoring, treatment, handling, reuse and residual disposition of solid waste

Zero waste: a philosophy that encourages the redesign of resource life cycles so that all products are reused

CHAPTER ONE

INTRODUCTION

1.1 Overview

High consuming cities like San Francisco, Copenhagen and Stockholm have implemented different policies to collect 100 per cent of waste from sources of generation and to manage it properly. In low consuming countries like India and China, the growth in population entails a comparable increase in the volume of waste. Therefore, taking consideration of low consuming city contexts, waste becomes very difficult to manage in a sustainable way. This was reported by Dr. Bindu and Lohani (1982) who were discussing the relationship between the income of countries, the rate of their population growths and capabilities to handle waste which holds true till today. This is further illustrated by Imam et al. (2008) who cite that waste management systems in developing countries are oftentimes multi-dimensional with unfavorable economic, institutional, legislative, technical and operational constraints as a case they studied in Abuja.

For sustainability in waste management systems, an effective waste management strategy must be developed that suits the needs of the demographics in consideration. For example Runda Estate, in Nairobi, is serviced by a sustainable solid waste management company that has been revising its service delivery methods over the months to fit the population, rate of waste generations and volumes thereof. One day a week would not be practical

because of the wastes that would accumulate within households. They initially tried two days per week, but this was a small step that led them to collect waste three times a week, the more efficient option. Nilanthi et al. (2007) continues to note that improved average mean living standards have seen the increase in consumption of materials, which are either synthetic or not common in the ecosystem and are thus potentially hazardous when released from consumers to the environment (e.g., plastics). Thence, some developing countries are left in a dilemma on how to handle the increasing waste. Due to rapid urbanization, Kenya's major agglomerations have been growing quickly but have lacked a concurrent expansion in service provision to match. Much hope lies in the implementation of the Constitution of Kenya (2010) that provides for a greater devolution of resources as stated by Mitullah (2012) who attempts to exhibit governance as a solution to much of the problems faced by developing countries.

In a sustainable waste management system, the waste generated should be recovered. In developing countries this is largely the role of the informal sector. With the focus of the Millennium Development Goals (MDGs) on poverty reduction and of waste strategies on improving recycling rates, one of the major challenges in solid waste management (SMW) for developing countries is how best to integrate with the informal sector, who are a major entity in the recovery of waste. Experience shows that it can be highly counterproductive to establish new formal waste recycling systems without taking into account informal systems that already exist (David et al. 2006).

While the outlook for our ecosystems is bleak, the issues they face are a consequence of human behavior (motivation and participation of residents to segregate being the highlight of this study). This means that, by changing our behaviour, we can change their future (and ours) for the better. The buildings sector is known to be a driver of GDP and green building offers an opportunity for increased output with decreased impact. Global construction output is predicted to grow significantly by 2020 and with markets moving towards greater resource efficiency, policy makers have a central role to play in ensuring that construction is at the forefront of the global green agenda (World Green Building Council, 2013).

1.2   Background to the Problem

Nairobi's basic public services have been a recurring concern of the public authorities since the foundation of the city in 1899. They benefited from major investments by the colonial authorities from the beginning of the 20th century. By 1910, the town authorities had adequate staff to ensure regular cleaning and maintenance of public areas, as well as the collection and disposal of garbage. As portrayed by Tibaijuka (2007), waste management worked relatively well until the mid-1970s, when there came changes in the local government following independence in 1963. The rapid growth of urbanization in Kenya since the 1960s profoundly modified the urban landscape. Today, local authorities in Nairobi seem overwhelmed both with regard to their capacity to manage the various urban services and the provision of infrastructure to its residents. The capital is no longer a portrait of the Green city in the sun.

According to WIEGO (2012), Nairobi generates 876,000 tons of waste per year (or 219 kg per capita per year). The city reports 60 to 70 per cent collection coverage rates; of this 100 per cent is collected from the business district. Waste collection in Nairobi is conducted mostly by the private sector consisting of companies (micro and small enterprises) and community based organizations (CBOs). By focusing on the recycling and re-selling of materials, informal waste management groups would not only reduce the amount of residual waste in the communities, but would also secure additional revenue. These groups would however be more successful by improving their waste management practices. Noteworthy is that a positive relationship with the public authorities is of fundamental importance for these collectors.

Of the municipal solid wastes collected, plastics waste has gained popularity because plastic is functional, lightweight, strong, cheap and a hygienic way of transporting food and goods. It has also been gaining increasing popularity for its grave impacts to the ecosystem. Stewart (2004) reports that it is estimated that between 500 billion and 1 trillion plastic bags are used globally each year. Much of this waste ends up in the waste stream without being recovered.

The mounting concerns about 'environmental degradation and resource scarcity' are trends that have become a manifestation of linear production and consumption models of take, make and dispose. Strong focus has been placed worldwide on the environmental implications of plastic bags.

Solid waste management studies are an important contribution that links the built environment to the natural environment. Studies have been carried out that address plastic waste management and the need to integrate innovation into existing systems for a better relationships for example in Oyake, (2012). However, there is little mention of the influence that human behavior has on plastic management. Others for example Diana, (2008) in her work, a world current of plastic waste, highlights the many studies that have been done on marine plastic pollution but no information or figures of plastic pollution on land. This study hopes to bridge the knowledge gap therein, because the plastic waste pollution we experience on terrestrial habitats cannot be wished away, there needs to be a formula to combat the much unwanted evil and the only way to do that is to give the problem the attention it deserves.

1.3   Problem Statement

Nairobi is a major commercial, financial, manufacturing and tourist centre, reportedly the largest city in Sub-Sahara Africa. However, at the moment the city faces acute problems in the areas of garbage collection and disposal system. It is estimated that over 70 per cent of the Municipal Solid Waste (MSW) generated in the city remains uncollected as reported by Kim Peters (1998). It is only the affluent neighbourhoods which are serviced while informal neighbourhoods and slums which form the bulk of the settlements are neglected (Girum, 2005). Kim Peters (1998) continues, the Nairobi City Council (NCC) also lacks a policy on waste reduction at the source and on involving community groups in waste management, though it does participate in several notable efforts. Officials recognize the need to reduce waste at its source, to conduct mass media campaigns and to

develop clear and enforceable policies and bylaws promoting waste reduction, recycling and community participation, but there is a lack of political will to do so.

Trillions of plastic bags have been produced since their introduction. This depletes our earth's non-renewable resources, such as chemicals, energy and petroleum-based products. The United States alone uses over 100 billion bags annually which is equivalent to throwing away over 12 million barrels of oil per year as narrated by Bashir (2013). Marine debris, about 8 million tons (Amos, 2015) of plastic wastes, finds its way into the worlds' oceans each year. Successful management of the problem requires a comprehensive understanding of both marine debris and human behavior (Amos, 2015).

The plastic bag waste concern has been expressed by many stakeholders including the former president Hon. Mwai Kibaki, the late Professor Wangari Mathaai (the 2004 Nobel Peace Laureate), various government organizations, environmental Non-Governmental Organizations (NGOs) and the public at large. Additionally, Prince Charles during a visit to the US told leading delegates to an environmental conference that the solution to problems caused by a throw-away 'society' was to move towards a circular economy, where materials are recovered, recycled and reused instead of created, used and then thrown away, as recorded on BBC UK (2015).

The study area, Runda Estate, is an affluent neighbourhood where a lot of plastic waste is generated and is hoped to exhibit the problems of a throw-away society as mentioned. This is a result of their high incomes and consequent consumption patterns. Adjacent to

Runda Estate is a slum called Githogoro. On waste collection days, Taka Taka Solutions (the sustainable waste management company in the estate) grumbles that many scavengers from the nearby slum, (attracted by the amount of plastic waste generated), retrieve more plastics than they do and thereafter leave a mess that forces the company to clean up after them. The company also laments that despite providing separate garbage collection bags, some residents still do not segregate their waste. This to the company, does not make economic sense because the two bags are expensive as compared to the one garbage bag provided earlier by garbage.co, the solid waste management company that previously provided services in the estate. Due to a lot of plastics being generated, the low grade plastics (e.g., LDPE) collected therein are many without a means of recycling. These, together with other types of waste that cannot be recycled like diapers and hairs are compressed, and thrown away in the Dandora landfill which is against their mission as a company; to divert 100 per cent waste from landfills.

1.4   Justification of the Study

The greatest challenge to our near-future cities is in how we can grasp the full potential within our buildings to create a new relationship with the natural world, so we are not merely depleting and polluting our environment with toxic waste, but purifying and enriching it (Armstrong, 2013). Notions of 'environmental justice' are now a prominent part of contemporary discussions of the meaning and practice of sustainable development and take the moral concerns further (Elliott, 2006).

We derive plastics from crude oil and we are consuming these natural resources at a rate 50 per cent faster than the earth can produce them. Electricity and transport are still based mainly on the burning of fossil fuels, a process that is emitting carbon dioxide that is contributing to climate change. These observations indicate that our current use of plastics is not sustainable (Hopewell et al. 2009).

Sometimes referred to as the 'North Pacific Garbage Patch', this vortex is the epicenter of a system of currents and winds covering most of the North Pacific. This trash vortex is one of the most studied areas of plastic accumulation in our oceans (Halliday, 2008). According to a claim by the UN, tests of ocean water have found in some areas, the ratio is a ten to one ratio (10:1) of plastic to plankton (Rachelle Foss, 2013). The researcher continues to explain that by nature, plastic attracts oily pollutants and nertles, which resemble fish eggs, a common food for a lot of marine life. Many ocean fish consume nertles coated in toxic pollutants and humans then consume the toxins (which are potentially harmful to their health) when they eat the fish.

Plastic waste heading for oceans quantified (Amos, 2015), is a study done on plastic waste explains that if left unchecked, 17.5 million tons a year could be entering the oceans by 2025. Cumulatively, that is 155 million tons between now (8 million tons of plastic waste per year) and then. There is a lack of data on the accumulation of plastic debris in natural terrestrial and freshwater habitats; however, it seems that the quantity of debris in the environment will continue to increase unless we all change our practices (Thompson et al. 2009).

Globally, the problem of plastic waste pollution is even more pervasive and it is not just a problem that exists in developed countries. The landscape in Nairobi is described as having filmy bags float through the air, swathe the natural foliage, fill ditches and hang from branches (Rachelle Foss, 2013).

An increasing population and growing demand for consumer goods (Table 1.1) increase the per capita rate of waste generation in the cities (Dr. Bindu and Lohani, 1982). The UN's projection is for world urban population to become majority, 66 per cent, in 2050. Case in point, the proportion of Kenyans living in towns rose from 5 per cent in the 1950s to 34.8 per cent in 2000. In the 2009 population census the population density rose to 3 million with 985,000 households (Tibaijuka, 2007). This population is estimated to be at 3.5 to 4 million currently and is expected to grow to 5 million by 2025.

Table 1.1: Waste generation projections for 2025 by Income

Region	Current Available Data			Projections for 2025 (from Annex J)			
	Total Urban Population (millions)	Urban Waste Generation		Projected Population		Projected Urban Waste	
		Per Capita (kg/capita/day)	Total (tons/day)	Total Population (millions)	Urban Population (millions)	Per Capita (kg/capita/day)	Total (tons/day)
Lower Income	343	0.60	204,802	1,637	676	0.86	584,272
Lower Middle Income	1,293	0.78	1,012,321	4,010	2,080	1.3	2,618,804
Upper Middle Income	572	1.16	665,586	888	619	1.6	987,039
High Income	774	2.13	1,649,547	1,112	912	2.1	1,879,590
Total	2,982	1.19	3,532,256	7,647	4,287	1.4	6,069,705

Source: Daniel Hoornweg and Perinaz Bhada-Tata, (2012).

The area of study for this research, Runda Estate found in the western part of Nairobi, is known to house key government representatives, diplomats and international organizations. The estate is served by a private sustainable waste management company

called Taka Taka Solutions who ensure most waste is diverted from Dandora, that is, little or zero waste collected ends up in the landfill. This study is focusing on Runda Estate because it is an affluent estate, with residents who are assumed to have a high disposable income and thus more likely to go shopping more often, to order take-away food, to replace and supplement goods more often than is necessary amongst other consumer habits emanating from their status. With most of the literature on accumulation of plastic in the environment coming from marine habitats, the need for further studies in the built environment is justified.

1.5   Purpose of the Study

The purpose of this study is to assess the effects of plastics on the environment and the need for partnership amongst stakeholders in dealing with the problem. Dumping our waste instead of reusing or recycling it means that we are not using our natural resources efficiently. Instead, we are putting pressure on ecosystems to deliver new natural resources at a rate beyond their ability to rejuvenate (Braungart M. and Mc Donough W., 2008). Without this information, there is a direct threat to the environment and natural resources that continues to go unaddressed. There needs to be a remedy to the problem of plastic waste and alternatives to humanity's plastic addiction (Halliday, 2008). It is emphasized that well managed plastic waste should be explored as a resource in order to reduce dependence on virgin materials.

1.6   Research Objectives

The researcher aims to explore variables in plastic waste management through hypothesis development and the following objectives:

1. To establish the nature of plastic (material and product) consumption patterns in Runda Estate.
2. To find out the extent to which Runda residents are aware of the need for appropriate waste management plans in their homes.
3. To establish the scale to which residents are informed of the relationship between plastic consumption patterns and their effect on the environment.

1.7   Hypothesis

This research takes to task motivation and participation of residents in segregation, a much required human behaviour. The researcher is keen on the role human behavior plays on plastic waste management and consequently develops the hypothesis stated below:

H1: Runda residents are indifferent to the way and/or manner their behaviours impact plastic waste management.

H0: Runda residents are not indifferent to the way and/or manner their behaviours impact plastic waste management.

1.8   Research Questions

1. What is the nature of plastic (material and product) consumption patterns in Runda Estate?

2. To what extent are Runda residents aware of the need for appropriate waste management plans in their homes?

3. To what scale are Runda residents informed of the relationship between plastic consumption patterns and their effect on the environment?

1.9   Scope of the Study

The researcher intends to study the area of Runda Estate in Nairobi, Kenya. The target population is solid waste generators that reside in the estate and are served by Taka Taka Solutions. The study targets these waste generators believed to have an exorbitant lifestyle and consequently generate more plastic waste from their homes. They have resources to manage their solid waste or employ people to do it on their behalf. They have more sustainable options to choose from with regards to goods and services and it is thus easier for them to change their habits. The study aims to research the role of waste management, the impact of human behavior on plastic waste management and the environment. Human behavior, preferences and attitudes, is a broad problem but for purposes of this research, the study focuses on segregation which is a role of the waste generators and whether they are motivated to participate in the activity. It explores literature on how Nairobi, Kenya and other countries are dealing with the problem that worsens as economies grow.

1.10   Assumptions and Limitations

The sampling design for this research study is assumed to represent the Runda Estate population in entirety and eventually exhibit the patterns of consumption and generation of the same. A major limitation is that the residents limit themselves to interactions. This consequently has bearing on the sampling design and more specifically, on the sample size as discussed further in chapter three.

1.11 Organization of the Study

This study is organized into five chapters, beginning with the introductory chapter. It introduces the problem of plastic pollution, makes known the need for information in the research area and proposes a testable hypothesis. Chapter two provides literature review on plastics, municipal solid waste, its management and relation to plastic waste, the informal sector amongst other stakeholders in waste management in Kenya and examples from other disclosed countries around the world. The chapter explains how plastics have evolved with the urbanization of cities and emphasizes the need for public participation in management of the effects of plastics on the environment. Plastic waste is a constituent of municipal solid waste and policies have been highlighted that need to be adhered to. These are all related to the objectives stated in chapter one. A conceptual framework that displays the relationships among the variables and a conclusion to the literature are also offered in this chapter.

Chapter three describes an introduction to research and comprises a series of steps designed and executed, with the goal of finding answers to the problem. The research

project is designed to test the hypothesis developed in chapter one. It is set up to explain, among other issues, collection, analysis and interpretation of further data and finally, to provide an answer to the problem. A sufficient number of homes and authorities were selected for the study so that an examination of the sample characteristics would make it possible for the researcher to generalize such properties or characteristics to the population elements (Sekaran, 2006).

Chapter four provides an analysis of various factors pertinent to the problem being researched. The analysis is guided by the research questionnaires administered with the aim of understanding consumption patterns, household waste management plans or lack thereof and the interface between behavioural and environmental impacts. These results are discussed and put in the context of the literature review and linked back to the objectives. Finally, in chapter five the data gathered are statistically analyzed to check if the hypothesis formulated is supported and to report implications of the results attained in chapter four. Areas of further studies are also proposed for exploration.

CHAPTER TWO

LITERATURE REVIEW

2.1 Plastics

2.1.1 Introduction and History of Plastics

The term plastic is derived from the Greek word 'plasticos' which means having the capacity of being shaped or moulded by heat (Mattia, 2010). Humans have benefited from the use of natural plastic materials since approximately 1600 BC when ancient Mesoamericans, the pre-Columbian civilizations of the Americas, are reported to have processed natural rubber into balls, figurines and bands. In 1839, there came vulcanite and later in 1862, the metallurgist Alexander Parkes created Parkesine. Bakelite, the first truly synthetic plastic, was patented in 1907 by the Belgian chemist Leo Baekeland. Bakelite was first used as electrical insulation in cars and other industrial products. Thanks to its easy manufacture and relative low price, the material was soon applied for the production of other consumer items (Arnold and Inge, 1995).

The growth of the polymer industry was restricted by the considerable lack of understanding of the nature of polymers. After the invention of Bakelite, many other types of plastics were subsequently developed in 1912 and in 1913. The period between the two world wars is frequently called the 'poly era' as some of the most important plastics were invented in those years. In the 1920s plastic designed radios and telephones

were generated and during the 1930s mass production of plastic items was initiated. World War Two turned plastics into a very important military material.

After the war, the plastics industry went back to peacetime production and boomed, satisfying the needs of the large masses. It was only from the late 1950s that plastics raised again the designer's interest and gave expression to the idea of a modern world (Mattia, 2010).

Current levels of their usage and disposal generate several environmental problems. Around 4 per cent of world oil and gas production, a non-renewable resource, is used as feedstock for plastics and a further 3 to 4 per cent (Hopewell et al. 2009) is expended to provide energy for their manufacture. A major portion of plastic produced each year is used to make disposable items of packaging or other short-lived products that are discarded within a year of manufacture.

In Europe alone the plastics industry has a turnover in excess of 300 million Euros and employs 1.6 million people (Plastics Europe, 2008). Almost all aspects of daily life involve plastics and there is considerable potential for new applications of plastics that will bring benefits in the future. It can also be argued that use of lightweight plastics can reduce usage of fossil fuels, for example in transport applications when plastics replace heavier conventional materials such as steel (Andrady and Neal, 2009).

2.1.2 Types of Plastics

In industrialized countries, hundreds of types of plastic materials are available commercially. In less developed countries, fewer types of plastics tend to be used in comparison. The four types of plastics that are most commonly reprocessed in both less developed and industrialized countries, are polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC). Arnold and Inge (1995) continue to explain, that the two main types of polyethylene (PE) are low-density polyethylene (LDPE) and high density polyethylene (HDPE). LDPE is soft, flexible and easy to cut, with the feel of candle wax. When very thin it is transparent; when thick it is milky white, unless a pigment is added. Polypropylene (PP) is more rigid than PE but can be bent sharply without breaking. It is used for stools and chairs, high-quality home ware, strong mouldings such as car battery housings and domestic appliances and so on. Polystyrene (PS) is brittle and usually transparent. It is often blended (copolymerized) with other materials to obtain the desired properties. PS is used for cheap, transparent kitchen ware, light fittings, bottles, toys, food containers, amongst others. Polyvinyl chloride (PVC) is a hard rigid material, unless plasticizers are added. Common applications for PVC include bottles, thin sheeting, transparent packaging materials, water and irrigation pipes, gutters, window frames, building panels, etc.

Primary waste plastics are generated within the plastics producing and manufacturing industries themselves. The waste is pure and suitable for reprocessing. The term 'secondary waste' refers to waste plastics from sources other than the industrial ones. Under the influence of light, heat or mechanical pressure plastics can decompose and

release hazardous substances. Most types of plastics are not biodegradable and the majority of polymers manufactured today will persist for at least decades and probably for centuries if not millennia (Barnes et al. 2009). Open burning of plastic waste releases considerable quantities of polluting substances such as carbon monoxide, a major contributor to the global warming problem, dioxins and furans which are released into the air (Wienaah, 2007). Whilst carbon monoxide is widely known, dioxins and furans are not and yet they are linked to respiratory diseases and cancer. They can also cause asthma and a myriad of allergies.

2.1.3 Plastic Consumption

Use of plastics in the developing world is increasing as the lower unit cost and improvements in performance specifications for example air and water tightness, continually promote its substitution for materials such as paper, metals, wood and glass. Plastics constitute an important component of a range of materials and because of this versatility, it is important to establish the characteristics of consumption patterns of the study area. For example, transportation vehicles can now contain up to 20 per cent plastics typically as parcel shelves, door liners, steering wheels, electrics and electronics, and recent aircraft such as the Boeing Dream liner is designed from up to 50 per cent plastics. Plastics can also be used to improve the performance and reduce the costs of building materials. Examples of this include lightweight fixings, window and door frames, fixtures and insulation materials (PlasticsEurope, 2008).

2.1.4 Plastic Litter

Littering is a behavioural issue that needs to be addressed primarily through education (Andrady, 2003). The growth in the amount of plastics in municipal solid waste is a basis for concern by solid waste managers and policy makers. One theory is to use taxes to shift the relative cost of plastics packaging to direct consumers' choices to other materials. Cairncross (1991) reported this in his book 'costing the earth' where the different uses of 'cost' state a problem and form basis for its solution, portraying a scenario still relevant today. More attention and resources need to be devoted to increasing the participation and awareness of consumers about the environmental consequences of litter. In Singapore for example, a government scheme with large fines and corrective work orders has proved to be a very effective anti-littering measure, Barnes et al. (2009) cite.

2.1.4.1 Accumulation of Plastic Waste in the Natural Environment

There are accounts of inadvertent contamination of soils with small plastic fragments as a consequence of spreading sewage sludge, fragments of plastic and glass contaminating compost prepared from municipal solid waste and of plastic being carried into streams, rivers and ultimately the sea with rain water and flood events (Zubris and Richards, 2005). Here, the limited data there is suggest that storm water pulses provide a major pathway for debris from the land to the sea (Ryan et al. 2009). Work in Japan has shown that plastics can accumulate and concentrate persistent organic pollutants that have arisen in the environment from other sources (Mato et al., 2001).

2.1.4.2 Plastic Waste and Human Health

Most plastics are relatively inert biologically, and problems with their use largely result from the presence of trace amounts of non-plastic components e.g., monomers and plasticizers. This has led to restrictions on the use of some plastics for food applications. For example, the use of polyacrylonitrile for beverage bottles was banned because the traces of its monomer, acrylonitrile, were a possible carcinogen. There has been concern about endocrine disruption from phthalate-containing plasticizers used for plastics (e.g., PVC). Safer plastics include PET usually for soft drinks, water bottles, ketchup and salad dressing. Plastics to avoid include PVC used to make toys, especially because children put everything in their mouths (Bashir, 2013). They leach as they age (mostly into fatty foods). It is a public health hazard because it contains dioxin and other persistent organic pollutants that can leach into the surrounding environment over time (Halliday, 2008). There is also a link between phthalates and early onset of puberty. There is also suggestion that phthalates are suspect as human cancer-causing agents, could damage the liver and kidneys, and might damage the development of reproductive organs (Bashir, 2013).

2.2 Solid Waste Management

2.2.1 Effects of Urbanization on Waste Management and the Environment

In pursuit of the Millennium Development Goals (MDGs) a global consensus was successfully forged in September (2000) around the importance of poverty reduction and human development. Urbanization provides new jobs and new opportunities for millions of people but at the same time, adding pressure to the resource base by increasing

demand for energy, water and sanitation, as well as for public services, education and health care (World Economic and Social Survey, 2013).

Forecasts for future urban growth inevitably conclude that the major waste management challenges facing many cities in developing countries will continue to be among basic priorities. These issues are pertinent as pointed out by (Wilson, Velis and Rodic, 2013) and include, to protect public health and the environment by extending waste collection to all the citizens and to eliminate uncontrolled disposal.

2.2.2 Nature of Solid Waste in Nairobi County

In a research funded by JICA in 1998, it was estimated that a total 1530 tons of waste per day was generated, of which more than 60 per cent (JICA, 1998) was from domestic waste and from road side traders and entrepreneurs which is usually organic. Given that the population at that time was just over 2 million they gave an average per capita residential waste generation of 0.60 Kilogram per person per day (Muranga, 2014). As the population increases the per capita waste generation also increases, for instance, in 2015 it has been estimated that 3,200 tons of solid waste is generated per day, with the current population of the city being at 4 million (UNEP, 2015). Only 850 tons reach Dandora dumpsite with the rest remaining unaccounted for. Ecoforum (2005) describes massive volumes of plastic bag waste characterizing Nairobi stating that the problem in this city is only an indication of what has become a challenging national problem. It portrays major roads of Nairobi as being lined with more plastic than grass.

To maximize on the waste collection rates, the Nairobi City Council purchased new modern garbage collection trucks. Weekly clean ups were launched in the sub counties to encourage and sensitize residents about the need to have a clean environment. The NCC is also in the process of installing 700 3-tier litter bins across the Central Business District and its environs. Among the proposed strategies lined up to improve the garbage collection is the introduction of zoning in which a single private company is to be contracted to handle a certain locality. This will enhance monitoring, supervision, efficiency and accountability (Nairobi County, 2015).

2.2.3 Introduction to Municipal Solid Waste Management

In the Organization for Economic Co-operation and Development (OECD, 2013), the definition for municipal solid waste is waste collected and treated by or for municipalities. It covers wastes from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden wastes amongst others. It excludes waste from municipal sewage networks and treatment, as well as waste from construction and demolition activities (Mota, 2013). Waste management is viewed as part of a generation, collection and disposal system and the move to a more sustainable society requires greater sophistication in this management (see Figure 2.1). It incorporates feedback loops, is focused on processes, embodies adaptability and diverts wastes from disposal (Seadon, 2010).
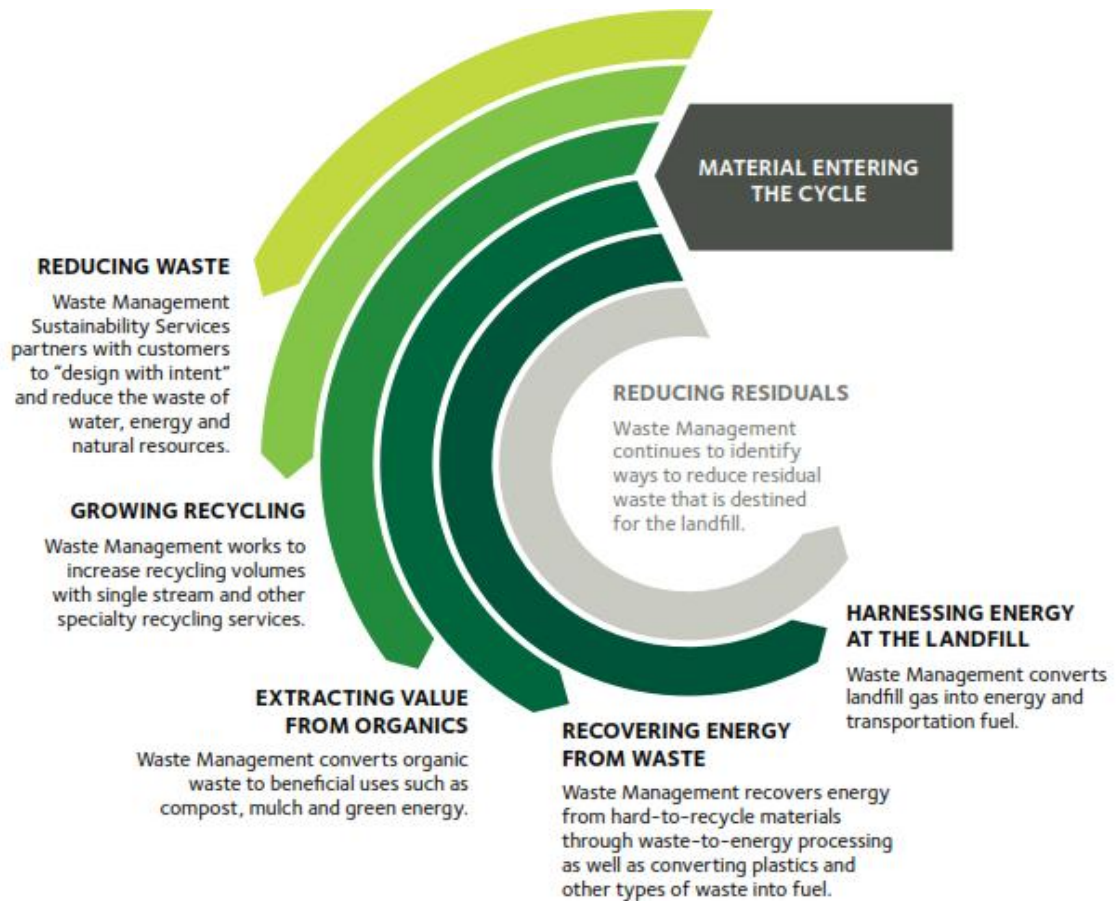
Figure 2.1: Waste Recovery and Recycling

Source: Waste Management Sustainability Report, (2014).

Upgrading the coverage of waste management and services and increasing their efficiency is a precondition for improving the environmental quality of cities. The involvement and participation of all the stakeholders such as the waste generators, waste processors, formal and informal agencies, non-governmental organizations and financing institutions is a key factor for sustainable waste management (Kurian, 2006). Sustainability thrives on integration of stakeholders and continuous improvements of practices (see Figure 2.2).

Figure 2.2: Steps to landfill free

Source: 3BL media website, (2015).

Among the factors contributing to waste generation in Juba for example, are rapid population growth and high concentration of the population in urban areas, industrial development, changes in eating habits and the widespread use of disposable containers and packages resulting in huge amounts of waste. Management of this waste is an important priority to the protection of community health as well as the environment (Ladu et al. 2011).

2.2.4 Municipal Plastic Waste

Waste plastics can be collected from residential areas, streets, parks, collection depots and waste dumps. However, unless they are bought directly from households, before they have been mixed with other waste materials, such waste plastics are likely to be dirty and contaminated. Plastics are voluminous but relatively light so that in terms of weight the proportion of plastics in municipal solid waste is relatively modest. The higher income groups also generate higher amounts of easily retrievable and valuable items as is expected of the study population (Arnold and Inge, 1995).

2.3 Waste Management Stakeholders

2.3.1 Description of the Main Participants and Their Respective Roles

Waste management strategies can only be effective if all the stakeholders work in tandem for a successful venture (Visvanathan and Trankler, 2013). Below, actors who participate in solid waste management in developing countries are listed and their roles defined.

2.3.1.1 Municipal Governments

Local municipal governments have a role in the set-up and operation of waste management systems. They have to implement laws and regulations in order to fulfill their statutory obligations. Local municipal governments interpret their mandate to include the delivery of services, sanitation, waste removal and disposal, within their political and geographic jurisdiction (Arnold and Inge, 1995).

2.3.1.2 Public (Participation and Awareness)

As generators of municipal solid waste (MSW), the public must be aware of the hazards posed by ineffective management of the refuse. The government, environmental organizations and other groups bring about this awareness through MSWM programs which in turn create a sense of ownership among the individuals developing keen interest for shouldering responsibilities. Once the public comprehend and acknowledge the main constraints and challenges in the system, participation can be noticed in forms like voluntary involvement in MSWM campaigns, following of rules and regulations concerning waste disposal, willingness to pay adequate fees and charges, source separation, effective use of the facilities and voicing any environmentally unethical behavior on the part of the public or the government.

This is a crucial issue which determines the success or failure of a solid waste management (SWM) system (Zurbrugg, 2002). Public participation is recognized in the Constitution of Kenya in Article (10) as a national value and a principle for good governance (Carlsson, 2013). One such example of the public participation is the work done by Seth Sevana (NGO) in Sri Lanka for 1,280 families in Moratuwa area who are encouraged to separate waste in their households that enables the NGO to establish small scale composting units and biogas generation, recycling of paper and sharing of information within the network for the benefit of the community (Visvanathan and Trankler, 2013).

2.3.1.2.1 Segregation Behaviour

Waste separation depends on citizen behaviours such as: motivation, are citizens motivated to separate waste? capacity, are citizens physically and mentally capable to separate waste? opportunity, are opportunities provided to enable citizens to separate waste? Figure 2.3 shows that if any of the factors affecting human behaviour is minimal, the resulting waste separation behavior will also be minimal.
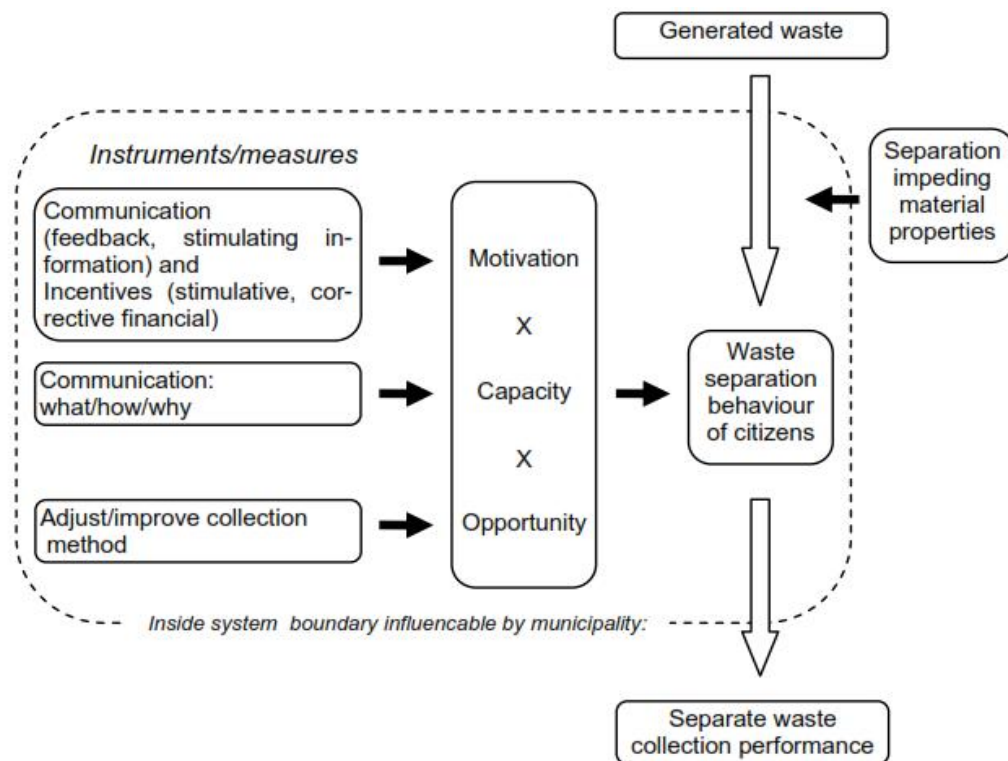
Figure 2.3: The Triade Model Applied To Waste Separation Behavior.

Source: Boer et al. (2005).

Traditionally, municipalities concentrate on optimizing the opportunity of the waste generators by offering the technical equipment of waste management systems (e.g., bins and containers offered) but motivation and capacity of citizens are often less focused upon (Boer et al. 2005).

2.3.1.3 The Formal Private Sector

The formal private sector refers to private sector corporations, institutions, firms and individuals, operating registered and/or incorporated businesses with official business licenses, an organized labour force governed by labour laws, some degree of capital investment and generally modern technology. Their main objective is to generate profit. They may participate in the waste management system in a number of ways including, entering into contracts paid by the municipality to perform collection, processing, disposal or cleaning services for compensation, purchasing the right to perform services and keep the income generated, entering into contracts with individuals or businesses for collection services, functioning as a purchaser of recovered materials from the municipality or the collector (Arnold and Inge, 1995).

2.3.1.4 The Informal Private Sector

Scavenging and waste collection is unavoidable in the developing countries due to their economic condition and can help in the recovery of resources for sale to recycling units (Visvanathan and Trankler, 2013). Informal activities are initiated personally and spontaneously in the struggle for survival. Consequently, the choice of materials to collect is determined by the value of the waste materials and by their ease of extraction, handling and transport (Arnold and Inge, 1995). The waste workers work as scavengers, collectors and sweepers despite health hazards. Recognizing the economic, social and environmental benefits of scavenging and recycling, governments started to change their previous attitude of opposition, indifference and intolerance, to active support (Castillo, 1990). One entrepreneur in a study on the Kenyan informal sector, claimed he earned up

to 11,000 KES (142 U.S dollars) a month from garbage collection and plastic recycling. The business of waste, at once a critique of modernity, is an enabler of innovation and a source of livelihood (Thieme, 2010).

2.3.1.4.1 Issues Surrounding Recognition of the Informal Sector

Authorities in developing countries display a wide variety of policies that deal with scavengers. The dominant view of scavenging sees it as inhumane, a symbol of backwardness and a source of embarrassment and shame for the city or country. Based on this, scavenging has been declared illegal and punished in many Third World cities, such as in several Colombian, Indian and Philippine localities, as recorded by González and Suremain (1991) representing views held in the past. There were cases where authorities would simply ignore scavengers and their operations, leaving them alone. Impartiality towards scavengers and their activities characterized a policy of neglect. Today, there are challenges of integrating the informal sector with the formal. This can only be attained if a systematic approach is followed and mutual difficulties openly acknowledged (Velis et al. 2012).

2.3.1.5 Community Based Organizations (CBOs)

The community and its representatives have a direct interest in waste management as residents, service users and tax payers. These communities will sometimes take the initiative to organize themselves into CBOs with the direct goal of self-help and improving their living conditions. They may hire, informal or formal, waste collectors,

they may make arrangements with local politicians for waste transfer points, they may start waste separation experiments and so on (Arnold and Inge, 1995).

2.3.1.6 Non-governmental Organizations (NGOs)

The NGOs play a crucial role in reaching the communities helping to create awareness about the environmental impacts associated with the disposal of wastes. A well-organized environmental program by NGOs can initiate motivation for involvement in the MSWM program thus ensuring continuous participation (Visvanathan and Trankler, 2013). The following are the typical motivations of CBOs and NGOs as is illustrated by Arnold and Inge (1995): motivated by an altruistic wish to improve circumstances both personal and for the community; advocating activities which in some manner serve the public interest; bringing outside resources to bear on the situation; outside of the formal decision making structures of municipal governments, but also not functioning as a private-sector business.

2.3.2 Actors in Solid Waste Management (SWM) in Nairobi, Kenya

In Nairobi, waste management stakeholders include: Waste Management Unit of NEMA and the Department of Environment in the Nairobi County Council (NCC) now the Nairobi City County; Ministry of Environment, Water and Natural Resources; Ministry of Lands, Housing and Urban Development; Non-governmental Organizations (NGOs); Community Based Organizations (CBOs); the private sector operating under regulation

of NCC, NEMA in public-private partnership (Carlsson, 2013) and the informal sector sometimes referred to as scavengers.

The National Government is responsible for establishing the institutional and legal framework for MSWM and ensuring that county governments have the necessary authority, powers and capacities for effective solid waste management (Arnold and Inge, 1995). Waste management in Nairobi is the responsibility of the NCC and it collects on average 430 tons/day (Carlsson, 2013) and the rest is mainly collected by private companies. Historically the NCC was the only provider of solid waste collection, until 1986 when private waste collectors were introduced to the city. Today there is an active process of collaboration between stakeholders aimed to achieve more effective coordination.

2.4 Policies and Regulatory Measures Governing Solid Waste Management

2.4.1 International Environmental Regulations

International standards include ISO 14000, a generic managerial system that supports organizational action designed to minimize harmful effects on the environment and achieve continual improvement of environmental performance. The Kyoto Protocol, an international agreement adopted in 1997 designed to limit emissions of greenhouse gases (GHGs) by industrialized nations (Dahlstrom, 2010), regulates the harmful effects of plastics when incinerated because they release GHGs.

2.4.2 Kenyan environmental regulations

In Kenya, all enterprises in the manufacturing sector should comply with environmental regulations by taking environmental audit and rectifying their activities which would be detrimental to the environment. USAID (1995) established compliance with the regulations as a key constraint faced by manufacturing industries. Additionally, a study by the Kenya Association of Manufacturers (KAM) showed that the cost of environmental management in majority of the firms interviewed was high.

2.4.3 Existing Institutional Frameworks in Nairobi County

Nairobi County Government has control over all the operations and activities within the city. It is responsible for proper storage, collection, transportation, safe treatment and disposal of solid waste in Nairobi. Its main responsibilities as regards solid waste management (SWM) are: provision of services for collection, transportation, treatment and disposal; regulating and monitoring the activities of solid waste generators; regulation and monitoring of private companies engaged in SWM activities; formulation and enforcement of relevant laws and regulations; and formulation and implementation of MSW policies (Nairobi County, 2015). However the NCC is allowed to enter agreements with third parties such as private companies to fulfill their duties (Carlsson, 2013).

Ministry of Lands, Housing and Urban development controls all the urban development, housing and lands activities. Ministry of Environment and Natural Resources comprises of the National Environmental Management Authority (NEMA), the ministry's environmental coordinating body and National Environmental Agency Plan (NEAP)

which has been responsible for formulating environmental policies and drafting the Environmental Management coordination Act (EMCA) and its supplementary legislations like the Legal Notice No. 122. It provides that waste generators will use cleaner production methods, segregate waste generated and the waste transporters should be licensed. It further states that no person will engage in any activity likely to generate hazardous waste without a valid Environmental Impact Assessment license issued by NEMA. The Environmental Management and Coordination (Waste Management) Regulations 2006, is the government's legal instrument that deals with waste management in Kenya.

In 1999, the Kenyan Parliament passed the Environmental Management and Coordination Act (EMCA) which came into force in January 2000. EMCA provides the framework for the coordinated management of the environment. The Act and its subsidiary provisions deal with waste management including standard setting, disposal site licensing, control of hazardous, industrial and hospital waste (Njoroge et al., 2014).

NEMA established by the Act, is the main body that coordinates environmental management activities in the country (ELCI, 2005). NEMA's duties are supervising and coordinating all matters related to the environment and serving as the principal instrument in the implementation of all policies relating to the environment in Kenya (EMCA, 1999). UNEP (2005) asserts that the enactment of EMCA and the creation of NEMA for its implementation provide a strong institutional base for the use of economic instruments to manage environmental problems. As Girum (2005) puts it, suitable

economic instruments to promote activities that benefit the environment, including duty waivers, tax exemptions, sanctions, are also being developed in close consultation with relevant ministries. Ministry of Health has the general responsibility under the Public Health Act to deal with health hazards arising from the problems of solid waste (JICA, 1998).

Kenya Revenue Authority (KRA) was established by an Act of Parliament in July 1995. Its purpose is to enhance the mobilization of government revenue and provide effective tax administration in revenue collection. In particular, the functions of the Authority are to assess, collect and account for all revenues and to advice on matters relating to the administration of and collection of revenues (KRA, 2005).

KEBS was established by an Act of parliament and started operation in July 1974. The objectives of KEBS relevant to this research are preparation of standards relating to plastic products, materials, processes, etc., quality inspection of imports at ports of entry and dissemination of information relating to standards. Standards are formulated by Technical Committees which consist of experts from various interest groups such as producers, consumers, technologists, research organizations and testing organizations in both the private and public sectors (KEBS, 2015).

KIPPRA is an autonomous public institute formed under the provisions of the country's State Corporations Act. Its primary mission is to conduct research and analysis leading to policy advice to government and the private sector. KNCPC on the other hand is a project

of the United Nations Industrial Development Organization (UNIDO) and the Kenya Industrial Research and Development Institute (KIRDI) (KNCPC, 2004). The Centre is mandated to build national capacity in preventive environmental management tools through a number of approaches comprising technical support, policy advice and cleaner technology transfer amongst others (KNCPC, 2004).

2.4.4 Kenyan Plastic Bag Sector

There are over 30 plastic bag manufacturers in Kenya, with a combined capital investment worth of over KES 5.8 billion (77.3 million US dollars) and employment of up to 9,000 people (Leah Oyake, 2012). The massive contribution of the sub-sector to the country's economy and the important role plastic bags play in people's daily life have led to massive use and accumulation of plastic waste in the environment (Leah Oyake, 2012).

In 2003, UNEP facilitated a technical working group to develop policy instruments for the management of plastic bag waste. Lessons learnt from the pilot in Nairobi were to inform the development of a national policy to handle the waste problems from plastic bags. To assist the policy implementation, a Plastics Management Fund (PMF) was to be created and managed by a committee comprising of representatives of the various stakeholders. The Minister for Finance overruled the negotiated plastic bag policy package and issued a stringent and judicious proposal for the management of plastic bags.

During the 2007/08 budget speech, the then Minister announced an immediate ban on manufacturing of plastic bags of less than 30 micron thickness and further proposed an

excise duty of 120 per cent on plastic bags to take effect in January 2008. The directive compelled manufacturers to abruptly upgrade their production technologies, amongst other consequences of the Ministers directive. Plastic manufacturers then transferred the financial burden of the excise duty to consumers (Leah Oyake, 2012).

The NCC, with United Nations Environmental Program (UNEP), then developed an Integrated Solid Waste Management (ISWM) plan, a planning framework for solid waste management focusing on three dimensions: practical and technical elements of the waste management system; the aspects of the local context that should be taken into consideration when planning a waste management system; and the stakeholders involved in the waste management (Carlsson, 2013). The plan incorporates the urgent decommissioning of Dandora dumpsite and the building of a sanitary landfill at Ruai in addition to two transfer stations. A further strategy involves building public-private-partnerships (PPP) including the use of community based organizations (CBOs) (UNEP, 2015).

KS 1794, a response to the growing plastic waste menace, was developed in November 2003 and gazetted in October 2004 entitled, 'polyethylene (PE) and polypropylene (PP) bags for general purposes.' KS 1794 has the following major provisions: in order to encourage reuse and hence reduce negative impacts on the environment, a minimum thickness is set for the various types of plastic bags, that is, LDPE (15μm), HDPE (10μm) and PP (20μm); bags manufactured for food products like bread and milk should be

printed with food grade pigments; it applies for monolayer PE and PP film bags for commercial and household packaging of products (Girum, 2005).

2.5 Resource Recovery and Recycling

2.5.1 Waste management hierarchy

Priorities of good waste management are expressed by reduce, reuse, recycle, recover and redesign (Memon, 2010). Waste reduction normally forms the top of the waste management hierarchy (see Figure 2.4). However, since there will still be some waste generated even with source reduction, an effective system to manage this waste is also needed (McDogall, et al. 2001). Plastic is collected from the waste stream and recycled into a durable application that when thrown away can be recovered for energy (McDonough and Braungart 2002).

Figure 2.4: The waste hierarchy
Source: Emma Cumming (2015).

It is estimated that 10,000 tons of waste, if used for recycling, can create 250 jobs, as compared with 20 to 40 jobs if incinerated and only about 10 jobs when disposed off in a landfill (Arvanitis, 2013). Using recycled plastic to produce useful new products requires less energy and fewer resources. In addition, recycling also supports the economy. Over 90 per cent of the material collected for recycling is sold to companies that produce goods ranging from vehicle parts to coffee cups (SPi, 2012).

Resource recovery in less developed countries is managed predominantly by informal sector entrepreneurs and is a major source of employment as Arnold and Inge (1995) note. For example in Kampala Uganda, as in other developing countries, urban waste has traditionally remained for municipal councils to manage, however, due to noticeable inefficiencies at municipal level, there is a manifest of low-income groups that take the initiative to extract and add value to materials from the waste stream (Kareem and Lwasa, 2011). In many low-income countries, the fraction of material that is won for resource recovery is very high. The work is done in a very labour-intensive way and for very low incomes. The situation in industrialized countries is different since resource recovery is undertaken by the formal sector (Appendix C), driven by law and a general public concern for the environment often at considerable expense (Visvanathan, Adhikari and Ananth, 2007). Today, Tang, Chen and Luo (2011) argue that in the absence of direct financial incentives to recycle or penalties for non-recycling for example, it is a challenge for local government to reinforce a positive attitude and to change attitude of entrepreneurs who view recycling negatively.

2.5.2 Plastic Recycling Systems

Post-consumer recycling comprises of several key steps including collection, sorting, cleaning, size reduction and separation, and/or compatibilization (see Figure 2.5) to reduce contamination by incompatible polymers (Arvanitoyannis and Bosnea 2001). The general trend is for collection of recyclable materials through kerbside collection alongside MSW. To maximize the cost efficiency of these programmes, most kerbside collections are of commingled recyclables such as paper/board, glass, aluminium, steel and plastic, even though it is reported that commingled (unseparated) collection of MSW increases the difficulty of recycling and handling (Hangtao and Yongfeng, 2001).
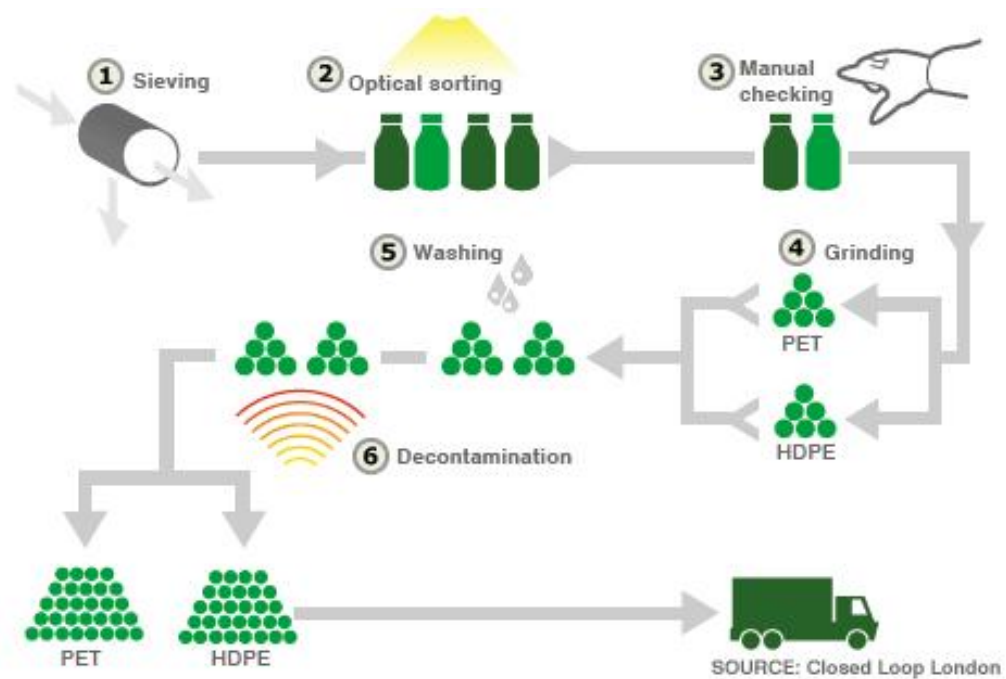
Figure 2.5: Closed loop process
Source: BBC (2015).

Innovations in recycling technologies over the last decade include increasingly reliable detectors and sophisticated decision and recognition software that collectively increase the accuracy and productivity of automatic sorting (WRAP, 2008). Curitiba, Brazil,

provides an example of how developing countries are innovatively addressing urban waste problems. The Green Exchange Program was a waste collection approach developed to encourage slum dwellers to clean up their areas to improve public health. The city administration offered free bus tickets and fresh vegetables to people who collected garbage and brought waste to neighborhood centers. In addition, children were allowed to exchange recyclables for school supplies or toys (Lehmann, 2011).

2.5.3 Economics of Plastic Recovery

The costs associated with plastics recovery can be divided into three main categories, raw material costs, production costs and transportation costs. The costs of raw materials for reprocessing differ according to the source, the quality and the type of waste plastics that will be used. The end product of one reprocessing stage, such as shredded material, can be used as the input material of the next stage, such as pelletizing. Arnold and Inge (1995) continue to explain that for each stage or activity in the recycling process, a separate cost/benefit analysis should be done. Improving the quality of the end product, such as by adding virgin plastics to the waste material will also add to the material costs.

The most important production costs are labour, electricity, water, equipment and rent. Generally it is difficult to obtain reliable data on production costs, since re-processors usually do not keep records. One way to reduce the costs of transporting such waste plastics is size reduction, by cutting or shredding. Also consider the distance to the reprocessing plant, the sources of plastic waste and customers, as well as the frequency of

collection. This frequency and waste collection rates are directly related to income levels as illustrated in Figure 2.6.
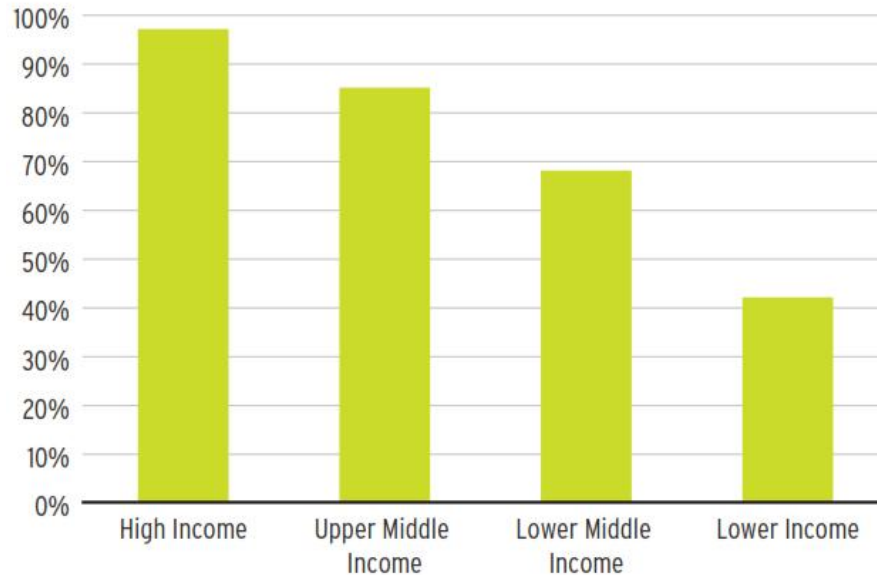
Figure 2.6: Waste Collection Rates By Region
Source: Hoornweg and Bhada-Tata (2012).

2.5.4 Linking Recycling Materials with Available Markets

One level of integration is to link the collection of materials for recycling with available markets for these materials. In Taiwan nearly 180,000 tons of used plastic were collected and turned into raw materials worth 140 million dollars, which cut down garbage disposal costs. Recycled plastic can be made into many products such as garments, flower pots, wigs and zippers.

2.5.5 Recycling Projects Boost the Economy in Developing Countries

Recycling projects provide an economic boost to developing countries that are scrambling to put together infrastructure to support a circular flow economy. Recycling jobs offer a strong social benefit in reducing poverty. The dual needs of environmental improvement and income generation that face communities have stimulated the implementation of many recycling projects in developing countries (Arvanitis, 2013). With the combined actions of the public, industry and governments it may be possible to divert the majority of plastic waste from landfills through recycling over the next decades (Jefferson et al. 2009).

2.5.6 Promoting Recycling

Society can promote recycling in many ways for example promoting technology development. As technology develops to collect and sort plastics more efficiently and economically, plastic can be recycled to specific higher-value uses. Governments can support recycling and waste reduction education in schools, sponsor television, radio or newspaper advertisements promoting recycling and emphasize the important role of sorting trash from recyclables or buying products with recycled content (Hill, 2004).

2.6 Plastics Innovation and the Future

2.6.1 Introduction

Looking ahead, we do not appear to be approaching the end of the 'plastic age' and besides, there are many ways in which plastics can contribute to society. The speed of

technological change is increasing exponentially such that life in 2030 will be unrecognizable compared to life today and plastics will play a significant role in this change. Plastics will play an increasing role in medical applications, including tissue and organ transplants; lightweight components, such as those in the new Boeing 787 which will reduce fuel usage in transportation; components for generation of renewable energy and insulation which will help reduce carbon emissions; and smart plastic packaging which no doubt enables preservation of perishable goods (Andrady and Neal 2009).

2.6.2 The Solution to Plastics Pollution

A group of Yale students and a professor, Scott Strobel, ventured to the jungles of Ecuador. They brought back a fungus new to science with a voracious appetite for polyurethane. The plastic is used for everything from garden hoses to shoes and truck seats. The fungi, Pestalotiopsis microspora, is the first found to survive on a steady polyurethane diet and more so, do this in an anaerobic (oxygen-free) environment, close to that at the bottom of landfills (Coren, 2012).

2.6.3 Sustainable Use of Plastics

Masdar City in Abu Dhabi relies on solar energy and other renewable energy sources. The waste management strategy for Masdar Institute is sustainable and awareness will be raised to reduce the amount of waste generated. In future all recyclable waste will be processed in Masdar City or as close by as possible (Masdar, 2015).

2.6.4 Bioplastics

Bio-plastics consist of either biodegradable plastics (plastics produced from fossil materials) or bio-based plastics (plastics synthesized from biomass or renewable resources). They offer a lot of advantages such as increased soil fertility, low accumulation of bulky plastic materials in the environment which invariably minimizes injuries to wild animals and reduction in the cost of waste management (Tokiwa et al. 2009).

2.7 The Plastic 'Controversy'

A function of packaging is to preserve its contents, especially food. It has been shown that the fraction of food residues in MSW is statistically related to the fraction of packaging residues in MSW, that is, the better preserved the food the less is spoilt and eventually thrown away. The statistical relation holds worldwide for metals, glass, paper and paperboard. This is not an argument for increases in packaging, but illustrates a major role of packaging in reducing other waste.

Another way in which lighter weight plastics packaging reduce the amount of MSW (Appendix D) is comparing the brick-pack and steel can packages for ground coffee as illustrated by Rattray (1990). Ground roast coffee can be packaged in a traditional tin plated steel can weighing approximately 113 tons of discards, occupying a volume of 35 cubic meters for 100,000 packages. The same amount of coffee can be vacuum packed in a multi-laminate pouch (polyester, aluminum foil, nylon and low density polyethylene) weighing approximately 1.7 tons, occupying 4.3 cubic meters for 100,000 packages. The

pouch was not recyclable at the time, but the metal can was. This, however, would not reduce solid waste discards unless 85 per cent of the cans were recycled or reused, which is a farfetched goal.

2.8 Conceptual Framework

After defining the problem and conducting literature survey, a conceptual framework is considered theorizing the relationship among variables: enhanced interaction with solid waste management company, motivation and participation of residents in segregation at source, healthier ecosystem and less dependence on plastics (independent, moderating, intervening and dependent variables respectively).

2.8.1 Definition of Terms

5 Rs approach to a closed system is described as follows: reduction of waste is the minimization of resources and materials used in manufacture of goods: reuse is where materials are used again for the same purpose; recycling of waste involves collecting, sorting and reprocessing waste into raw materials for manufacture of new products; recovery of materials includes recycling and composting while the recovery of energy usually involves incineration which is less preferred; and redesign where products are redesigned to suit easier recovery later on in the supply chain after use. Landfill as discussed in the literature review is where waste is dumped in a designated area.

Segregation of waste at source means dividing waste into different elements for example dry and wet or according to biodegradable and non-biodegradable. Zero plastic waste would be a result of illustrious systems that plastic waste is either avoided or recovered. This is a laborious task and is discussed below.

2.8.2 Introduction to Zero Plastic Waste

Sustainable waste management is fundamental in environmental protection, highlighting the invaluable link between the built environment and the natural environment. 100 per cent waste diversion would lead to zero waste. Segregation attests to a good waste management plan and good practice. This plan should expressly contain and monitor the amount of waste being generated, how much of it is recovered and how much leaves the system or home in this case. This monitoring in itself would provide a record of waste generated (which would give insight into the consumption patterns of generators) and the characteristics of the waste, this would in turn give a good sense of the amount of plastic waste accumulating in the terrestrial habitat if widely adopted. The aforementioned indicators demonstrate that a healthy ecosystem is predicated to the residents being motivated to participate in sustainable waste management (see Figure 2.7).
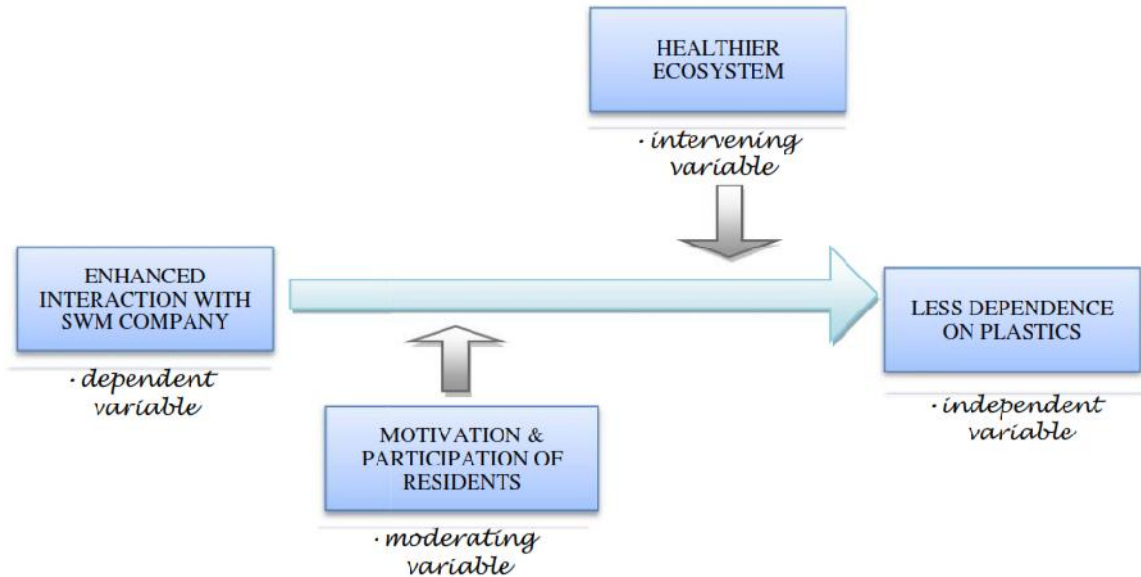
Figure 2.7: Conceptual Framework

Sources: Fieldwork (2015).

2.8.3 Discussion of the Conceptual Framework

The independent variable, enhanced interaction with the solid waste management company, is an approach where improved communication with residents could improve their waste management plans and consumption patterns to suit the natural environment. This is directly related to the dependent variable, less dependence on plastics. This is because residents will use fewer plastics or manage plastic waste more effectively and the result will be less plastic waste in the environment. The moderating variable, motivation and participation of residents, points out to the influence they have on their dependence on plastics. They control their consumption of plastics and control waste management in their homes. Finally, the intervening variable, a healthier ecosystem, implies that less

dependence on plastics is fundamental for a healthy environment that is able to replenish its natural reserves.

2.9 Conclusions

From the literature review it is clear to see that the variables that affect sustainable waste management are essential in the holistic management of plastic waste. These are, motivation and participation of public to segregate waste at source and having interaction with waste management companies and other stakeholders who support the sustainability agenda. It has been emphasized that most of the destruction the environment is facing is due to human behavior, meaning that by changing our behaviour we can change their future (and ours) for the better.

Zero plastic waste is much like the concept of zero waste where all the waste is repurposed and not disposed off in the environment irresponsibly (Figure 2.7). While this is difficult to actualize, the idea being proposed is that all waste has value, thus worth recovery. The circular economy/metabolism is much like the closed loop system that involves a comprehensive chain of events, integrated to avoid any waste leaving the system. LEED (U.S), GreenStar (Australia) amongst other rating systems enlist minimum requirements for a sustainable building and give credit to a sustainable waste management plan that has minimum waste leaving the system.

Linear metabolism cities consume resources and create waste and pollution at a high rate

Circulative metabolism cities reduce consumption and pollution, recycle and maximise renewables
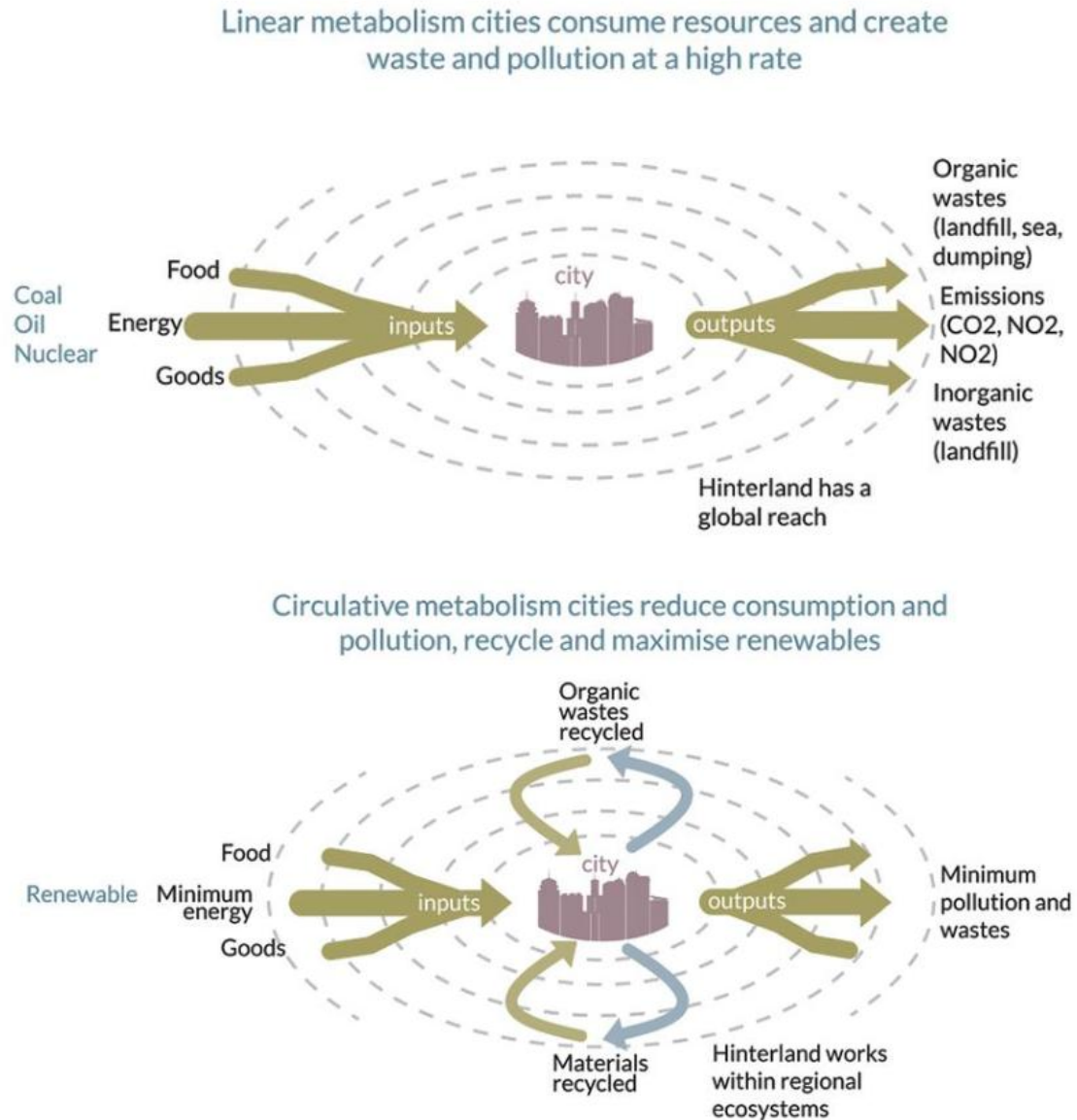
Figure 2.8: Comparison Of A Linear And A Circular City Metabolism
Source: Sebastian Florian, Schwarz (2014).

Legislatures and government are also encouraged to implement the laws and legislation that govern waste management and the environment. There needs to be greater partnership within stakeholders to create networks leading to the sharing of information that would orchestrate integration of resources and systems. This 'unity' is worth more than the individual parts of the system through synergies.

It is important to also consider technology as a solution to plastic waste pollution. Various replicable examples have been offered as a manifestation of the problem in the literature review and offer solutions with the potential to guide us. These should be given careful consideration, and furthermore, they should showcase their potential effects or lack thereof to the environment before being used to avoid a case of 'two wrongs.'

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

After a thorough study and analysis of the situational factors important to the problem statement, the researcher is ready to find a solution to the problem that will eventually inform decisions in the study area. This chapter comprises of a series of steps designed with the goal of finding answers through hypothesis testing. The key objective is to establish whether Runda residents are indifferent to how their behaviours impact on plastic waste management or not. It is clear that human behavior is putting pressure on ecosystems to deliver natural resources and studying these behaviours is therefore important to the environment. The researcher engaged in an informal interview with a Taka Taka Solutions (TTS) employee who gave invaluable insight into the large volume of plastic waste in the estate and the challenges they face in their pursuit to divert it from the Dandora landfill. The researcher compiles this information as gathered for analysis in chapter four.

3.2 Research Design

The research design is a layout for fulfilling objectives and providing answers to the problem. The design proposed for this study is hypothesis testing because it explains the nature of the relationships between the variables. This chapter describes qualitative and

quantitative analytical techniques used to draw inferences from the data regarding existing relationships between enhanced interaction with the sustainable waste management company, motivation and participation of residents in waste segregation and less dependence on plastics which would cumulate leading to zero plastic waste and a healthier ecosystem. The quantitative approach is aimed at testing and verifying facts, measurements and analysis while the qualitative approach is aimed at understanding, interpreting and generalizing abstract notions which are gathered in a narrative form through the data collection methods.

3.3 Sources of Data

This involves the analysis and documentation of relevant documents to expound on the researchers selected area of study. This research collects data from both primary and secondary sources. Primary data is collected through structured questionnaires and interviews while secondary data is gathered from perusing books, journals, published articles and internet sources through Google Scholar and Google books.

3.4 Data Collection Methods

For the purpose of generating data and relevant information, primary data is collected through questionnaires and supplemented by interviews. The questionnaires are both open ended and closed ended. These are administered to available residents in the study area. The researcher uses the same questionnaire structure for interview schedules used to collect data from key informants.

3.4.1 Questionnaire Survey

The research questionnaire aims to fulfill the following objectives: to establish the nature of plastic (material and product) consumption patterns in Runda Estate; to find out the extent to which Runda residents are aware of the need for appropriate waste management plans in their homes; to establish the scale to which residents are informed of the relationship between plastic consumption patterns and their effect on the environment. This is carried out to get first-hand information on the variables which directly translate to the problem of plastic waste pollution. Questionnaires are used because they are a less intrusive manner of questioning the respondents, they reduce bias, are familiar to most people and are relatively easy to analyze because they collect data in an organized manner.

3.4.1.1 Response Rate

The questionnaire is made straight-forward to encourage responses. During the administration of the questionnaires, in cases where the homeowner is away but is to return within the two days allocated to respondents for answers, the watchman or care-taker is left in possession of the questionnaire. The response rate is calculated using the following formula:

$$R.\,R = \frac{R.\,Q}{G.\,Q} X100$$

(Where: R.R = response rate; R.Q = returned questionnaires; G.Q = given questionnaires)

3.4.2 Interviews

These are held with representatives from Taka Taka Solutions (TTS) and Runda Water Limited (RWL) because they have experience with the Runda residents and can give a more objective opinion due to their oversight role in the estate. They can well articulate the relationship between waste and the environment offering legitimate representation of the variables being studied. The TTS representatives are also in a position to compare the situation in Runda Estate with other areas of the country where the company services. Interviews are chosen as a data collection method because respondents' perceptions can be well captured. The researcher is also able to pose extra questions whenever more clarity is required. Due to the interview guide being the same format as the questionnaire, there is a systematic recording of information that eases the analysis of data collected.

3.5 Study Population and Area

Runda Estate covers a part of Western Nairobi, Kenya, which is also called Westlands. It is bordered by Limuru Road to the west, Ruaka Road to the south, Kiambu Road to the east and coffee plantations to the north. Runda Estate encompasses the following: Closeburn Estate, Mimosa and Old Runda, Mumwe and Whispers, and New Runda and Muringa (as shown in Appendix F). It enjoys a cool microclimate due to its proximity to Karura forest. This area was purposively selected because of its socio-economic influences. It is one of the most affluent neighbourhoods in Nairobi. The homes are palatial with well manicured gardens and well maintained streets courtesy of Runda Water Limited, a company that provides services to the residents.

Runda Estate has various establishments from hotels to schools and offices, but the population of interest for this study is the residents who live here and have their solid domestic waste managed by TTS. Taka Taka Solutions (TTS) was licensed in June (2014) to provide sustainable waste management services. They consequently replaced garbage.co, a solid waste management company that had been serving Runda Estate. The volume of waste in the estate as recorded by TTS since they began operations in December (2014) is approximately 57 tonnes per month of which 12 per cent is estimated to be of plastic waste.

Runda Water Limited (RWL) is in contract with the waste management company on behalf of Runda residents. The researcher studies a reasonable sample population to represent the greater area of Runda Estate that is reported to have just over 1,100 households and as observed by the RWL representative, the population of the estate is estimated to be at about 13,000.

3.6 Sampling Design

The study employs a probability sampling design that is convenient for geographical clusters, that is the area sampling method. Being in the same geographical area, the Runda Estate residents are assumed to provide a standardized pool of samples. Runda Estate has a network of streets, avenues and drives from which the houses are accessed. The researcher selects Mimosa area and further chooses Mimosa Close, Mimosa Annex, Mimosa lane and Mimosa vale which have about 40 homes collectively, to obtain data from residents therein (see Appendix F).

Mimosa Area was selected because of its accessibility. From the attached map of Runda Estate, the Mimosa area is shown to be in close proximity to Limuru road (to the west) and the Northern corridor bypass. They are also familiar with Mimosa from previous data collection and research done in Runda Estate and thus already had rapport with residents within this area that eased the process.

3.6.1 Sample Size

The area sampling method is used to gather information on the behaviours of Runda residents who are believed to have an exorbitant lifestyle. Their consumption habits leading to waste generation patterns are crucial for this study. A pre-determined list of samples is not prepared for this research as some residents, for example those who work for the UN and other NGOs, are oftentimes traveling for work related purposes. In such a household, it would not be reasonable to expect response. Therefore, the researcher intends to list the households that would be available and receptive as they took to the exercise of handing out questionnaires. The sample size was calculated using a formula as shown below where n=21 with a confidence level of confidence of 95% (see Appendix E).

$$n = Nz^2pq/(E^2(N-1)+ z^2pq)$$

The population is considered to be normally distributed. Any data taken from a sample of this population is distributed according to the t distribution regardless of the sample size. It is therefore assumed that 21 respondents will represent and is generalisable to the greater population of Runda Estate.

3.6.2 Variables

The variables in this study that lend themselves to measurement are enhanced interaction with solid waste management company, the independent variable, and less dependence on plastics which is the dependent variable. This means, with effective and efficient interation, Runda Estate can reach optimum health in its ecosystem as a result of functional mechanisms towards achieving zero plastic waste in particular and zero waste in general. With the important variables established in a conceptual framework as in chapter two, the researcher is in a position to test whether the relationships theorized in fact hold true.

3.7 Data Entry and Coding

Analysis and interpretation of data is done using themes and sub-themes that are derived from the objectives of the study that were used to generate research questions. Data from the questionnaires and interviews is coded and entered into Microsoft excel for presentation.

3.8 Data Analysis

All the data collected is analyzed in three steps, data preparation, descriptive statistics and inferential statistics. Data preparation involves checking data for accuracy, entering the data into the computer, transforming the data and developing a database structure. Descriptive statistics involves use of simple graphics, charts and bar graphs. This is to give summaries about the samples and their measures. Inferential statistics involves

testing the data and hypothesis. The t-test is used to make inferences from our data to more general conditions. It is also favourable because the researcher uses a small sample size as discussed in previous sections (see section 3.6.1).

3.9 Reliability and Validity

In conducting interviews and during the analysis stage thorough literature review of sustainable waste management is conducted to ensure an appropriate framework for analyzing the data, measurement and internal validity is used. For external validity, to check that the result can be generalized beyond the research context, the researcher intends to share the same findings with representatives from Runda Water Limited and Taka Taka Solutions to verify the information gathered. This is because they are in a better position to claim that the findings are representative of the larger population of Runda Estate. For external reliability, the questionnaires and interview guides are designed to be straight forward and comprehensive to avoid misunderstanding or misinterpretation of the questions.

3.10 Strengths and Weaknesses

The survey in this research study is restricted to private homeowners in this high-end estate. This is arguably limited and a narrow scope or selection of a focus group. However this is a risk that has to be taken bearing in mind that all research methods have their weaknesses. 'Strength' is the applicability of the information to the local waste management context.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION

4.1 Introduction

This chapter aims to report and present findings gathered through the data collection techniques as elaborated in chapter three. The aim of the survey questionnaire used for this research is to clarify and explore information obtained in chapter two and seeks views from homeowners who are served by a private waste management company (Taka Taka Solutions (TTS) who provide sustainable waste management services in Runda Estate, Nairobi). Questionnaires were also administered to Runda Water Limited (RWL) and TTS with the aim of validating information collected from the residents. A quantitative and qualitative approach was used to analyze the data and the findings were presented according to the following objectives of this study:

1. To establish the nature of plastic (material and product) consumption patterns in Runda Estate.

2. To find out the extent to which Runda residents are aware of the need for appropriate waste management plans in their homes.

3. To establish the scale to which residents are informed of the relationship between plastic consumption patterns and their effect on the environment.

The distribution of the respondents was such that, out of 21 questionnaires issued 18 were returned giving a 90 % response rate (Table 4.1).

Table 4.1: Response rate

	Administered	Returned	Percentage
Residents	19	15	79%
Authorities	3	3	100%
Total	22	18	82%

Source: Fieldwork (2015).

The researcher mainly uses the Likert scale where 1 represents strongly agree, 2 represents agree, 3 represents indifferent, 4 represents disagree and 5 represents strongly disagree. The means and standard deviations were computed and results illustrated as in the following text. The responses with a means of 1 and below signified strongly agree, means between more than 1 and less than 2 signified agree, means between 2 and less than 3 signified indifferent, means between 3 and less than 4 signified disagree while means between 4 and 5 signified strongly disagree. The standard deviation shows how far the responses deviate from the mean. A low standard deviation is testament to responses close to the mean whereas a high standard deviation testifies to responses spread out over a large range of values. A standard deviation of more than 1 signifies a great deviation from the mean.

4.1.1   Distribution of Respondents

Through the sampling design (area sampling) discussed in chapter three, the respondents were selected from 4 streets: Mimosa Annex, Mimosa Close, Mimosa Lane and Mimosa Vale. The survey questionnaire consisted of some structured questions that required one

answer out of the given choices, however some respondents opted for more than one while others included choices that were not given causing variations in the numbers. Coding of data was made considerably easy by already having numbered options and thus easy to transfer. Some of the coded questions were checked for accuracy during and after the exercise. Pie, radar, doughnut, histograms and tables were used for the presentation of data collected. The report is presented under sub-titles as follows:

4.2 Consumption Patterns

4.2.1 Frequency of Shopping

The questionnaire sought to find out from the residents their frequency of shopping as a key factor in the study of their consumption patterns. 73% of the respondents stated that they did weekly shopping, 20% monthly and daily shopping was at 0%. The choices given did not enlist an option for those who went shopping every fortnight for example, therefore the 'grey areas' were recorded as other at 7%. The results show that the frequency of shopping for most Runda Estate residents is at 73% (Figure 4.1). This weekly shopping means that residents buy supplies and household goods in bulk. Most of these goods are made of plastic (as plastic is the most versatile material due to its improved performance over the years and qualities such as being water tight and air tight). There is also expected to be a lot of packaging from the weekly shopping. Their frequency of shopping gives insight into their consumption patterns and therefore, the magnitude of the problem of plastics.

The Runda Water Limited (RWL) representative explained that these results were as a result of Runda Estate not having shopping centers within and therefore daily shopping was the least probable option. 73% of respondents opt for weekly shopping because their homes need supplies to keep running whereas monthly shopping at 20% is mostly in homes where the owners travel a lot and do not have resident care takers or housekeepers.
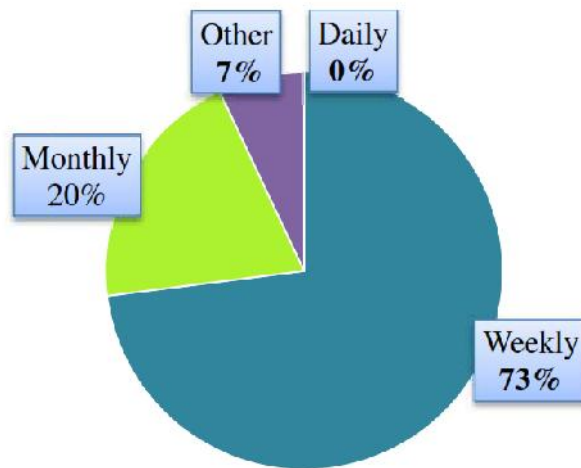
Figure 4.1: Frequency of shopping

Source: Fieldwork (2015).

4.2.2 Organization

The respondents were required to state whether while shopping they use shopping lists. About 33% use shopping lists, 20% do not, the rest at 47% stated that they did use lists sometimes (Figure 4.2). From the results, there is a small difference between residents who prepare shopping lists and those who do not.

The RWL representative reported that some of the residents do not have time to go shopping and therefore, any other person sent on their behalf will be handed a list. The

TTS representative was keen to report that not using a list indefinitely leads to impulse buying and this in itself adds to the volume of waste generated. Organized shopping therefore helps keep both consumption and generation rates in check. It therefore means that making lists affects consumption of goods. They are also a tool that we can use to tame our consumption of plastics and practically obliterate our plastic addiction. We can explicitly include in the lists the need to stay away from plastic packaging, wrapping and paper bags as a reminder and as mitigation to plastic pollution.
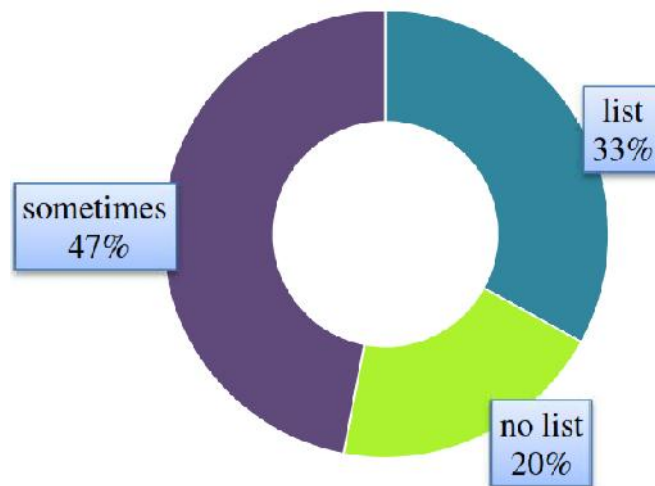
Figure 4.2: Organized shopping

Source: Fieldwork (2015).

4.2.3 Environmental Awareness

4.2.3.1 Eco-friendly labels

The questionnaire sought to find out whether whilst shopping the residents were careful as to the types of products they selected and most specifically, if they were eco-friendly goods. From the results it is noted that about 64% of the residents are 'very likely' to consider the eco-friendly goods over others. 'Likely' to consider these goods are 0% of

the shoppers. Most residents shop for eco‑friendly labels than those who do not (Figure 4.3).

As the representative from RWL explained, there are many residents who work for the UN and other NGOs and are therefore very aware of the need to protect the environment by selecting such products (these include make‑up, types of hair and most especially children's toys). Those who are neither 'likely' nor 'unlikely' were at 9% of the respondents. At 'unlikely' and 'very unlikely' 18% and 9% respectively, who combined are a lot less than those who are very likely to opt for eco‑friendly goods. There is also the argument that not many products in Kenya currently, are labeled as eco-friendly goods and therefore there is really not much to choose from. From earlier reporting it was noted that the issue with our consumption patterns is that we are consuming more and more products that are less and less compatible with the natural environment. It is therefore important that the manufactures of goods give the masses more eco-friendly options to choose from. The government can also encourage the entry of such goods by allowing exemption of tax amongst other financial instruments.
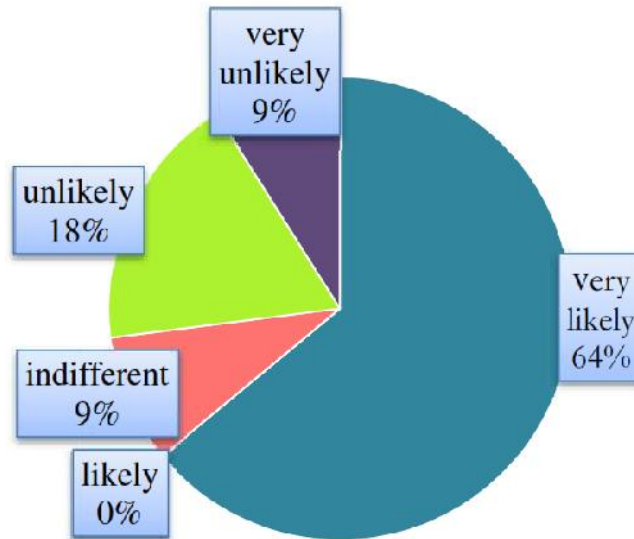
Figure 4.3: Eco-friendly labels

Source: Fieldwork (2015).

4.2.3.2 Sustainability

Respondents were asked whether they assessed packaging when buying goods; from the results it is clear that the respondents are indifferent to the need to assess packaging while shopping (see Table 4.2). It is important to assess packaging because a lot of plastic is used and yet as soon as the good is unwrapped, all of the plastic ends up in the garbage bag. These could easily be reused by the same manufacturer or another because they primarily have not been used. Throwing these packaging materials into the garbage bags with other wastes however, would make them difficult to retrieve and recover.

The TTS representative made an attempt at describing this saying they did not have a distinct preference nor dislike for recyclable packaging and therefore indifferent to the

need to assess packaging for recyclable options. The TTS interviewee added that it was important to think of the environment when shopping.

Table 4.2: Sustainability

Descriptive Statistics			
	Mean	**Standard Deviation**	**n**
Group A	2.25	1.2154	18
One Sample t-Test			
t-Statistic	0	**Result**	
Degrees of Freedom	17	Do not reject the null hypothesis.	
Critical Value	2.2010	**Conclusion**	
95% Confidence Interval	[1.4777, 3.0223]	Group A is not significantly different from the population mean, t = 0, p > .05.	

Source: Fieldwork (2015).

4.2.3.3 Preference for recycled materials

This questionnaire sought to establish the magnitude of their preference for products with already recycled content. Around 50% are 'very likely' to go for goods with recycled materials, 'likely' are at 20% (Figure 4.5). Those who are 'very unlikely' to buy goods with recycled content are recorded at 10%. Those who are indifferent to these types of goods are 20%. Therefore residents who are more likely to buy goods with recycled content are more than those who are not.

The TTS representative noted that the residents might be willing and might have an actual preference for goods with recycled content but it does not reflect in the waste

collected from their homes. This is because goods with recycled materials have not made their way into the shelves of supermarkets and shopping centers enough for them to be traceable. There could also be the 'green-washing' phenomenon where goods are marketed as those containing recycled content whereas they do not. This could lead to the purchase of goods that the shopper did not intend to buy but is merely attracted to because of the claim, that they contain recycled material. Residents could innocently buy these hoping to make an impact or change the world. For this they cannot be faulted as their intentions are good.
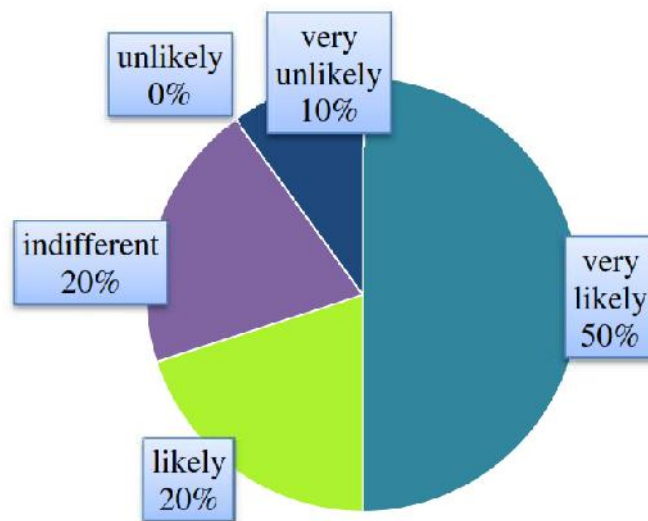
Figure 4.4: Preference for recycled materials

Source: Fieldwork (2015).

4.2.3.4 Reasons for using plastic packaging

The questionnaire sought to establish why residents use plastic packaging after the shopping experience. 70% use them for their functionality, that they can be rewound.

20% like that they are light and therefore easily portable while only 10% consider them for their cost (Figure 4.6). The residents as discussed seem to use plastic bags for their reusability.

The TTS representative commended the fact that residents use plastic packaging for the possibility of reuse. However, most of these low grade plastics are not recyclable because the machinery to do so is currently not present in the country. This means, at the end of use, say after being reused five times or so, the same bags end up in the garbage with no means of recycling them. Therefore as discussed in the literature review, residents should consider avoiding the plastic bags altogether. The Rs (reduce, reuse and recycle) give precedence to the fact that these plastic wastes can be avoided. That is, not using them at all so that there is no need to manage them later on, say after use or after being discarded.
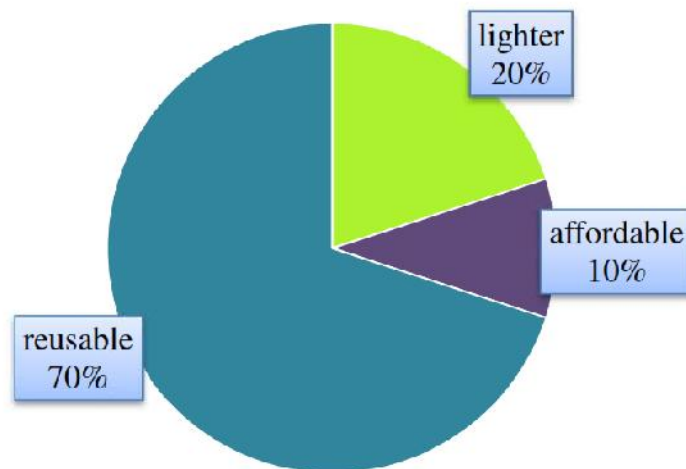
Figure 4.5: Reasons for using plastic recycling

Source: Fieldwork (2015).

4.2.3.5 Reuse of shopping bags

On the same topic of reuse, the residents were questioned about whether they carry their own bags when going shopping. 57% do not carry their own bags, 29% do while 14% do so once in a while (Figure 4.7). Thus the residents mainly do not carry their own bags when they go shopping.

The RWL representative was of the opinion that most of these residents shop in high end supermarkets and grocery stores and it was more likely that they would re-buy reusable bags than carry their own when going shopping. Reuse is the second most important means of managing plastic waste, after use, respondents should get into the habit of reusing shopping bags. For example, if they collect 5 shopping bags from one weekend of shopping, that makes about 20 shopping bags ending up in the waste stream per month. However, if they were to recycle the same, three times or more, they would have used the same 5 bags at the end of the month. Respondents should therefore be encouraged by the waste management company and other stakeholders to make such initiatives that would change the amount of plastic waste collected from their homes. These have been introduced in major supermarket chains (e.g., Nakumatt) but are not given the much attention they deserve. Some use them and as a fad just like fashion, it comes and goes.
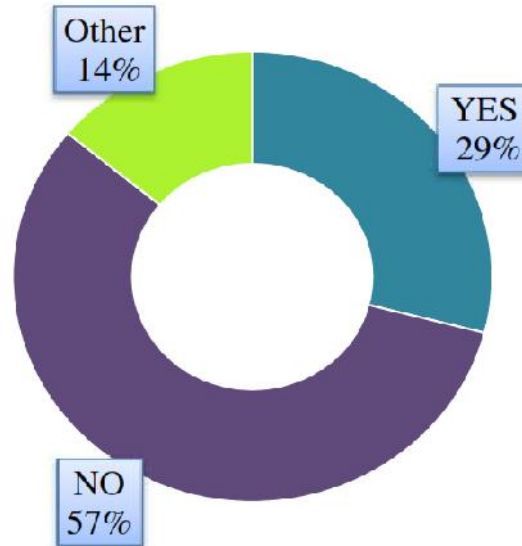
Figure 4.6: Reuse of shopping bags

Source: Fieldwork (2015).

4.2.3.6 Biodegradable packaging bags

The questionnaire sought to find out whether residents and shoppers were aware of biodegradable packaging bags at the places they shop. 50% of them said that they did, 25% did not and others, at 25%, knew that there were biodegradable bags but were not sure whether their shopping spots offered them (Figure 4.8). It is evident that there is a notable difference in those who are aware of the bags from those who are not.

The TTS representative commented that the 50% should therefore, aside from being exposed to these options, go ahead and use these bags because they have less negative impacts to the environment. These alongside other types of biodegradable types of plastics as discussed in the literature review, bio-plastics from renewable resources, are good for the environment because they degrade biologically and therefore do not harm

wildlife, enrich soils and definitely do not accumulate in the environment as many complain that they are an eye sore.
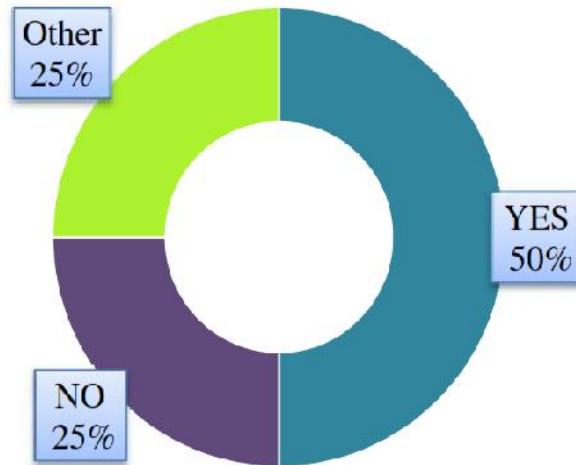
Figure 4.7: Biodegradable packaging bags

Source: Fieldwork (2015).

4.2.3.7 Change of taste and preference

The residents in Runda Estate were asked what they thought about peoples' tastes and preferences for recycled goods, whether people were tending towards these goods now more than ever before. They were of the opinion that people were not becoming more aware of the environment. Evidently more residents are in support of the statement that people are acquiring a taste for recycled goods. However, their opinion is not significantly different from those who do not support the statement.

The Runda Water Limited representative noted that the goods residents were referring to in this context of taste and preferences were most likely paintings, carpets, vases amongst other durable goods that are not easy to detect in the garbage collected three times a

week. Therefore in the daily, or weekly consumption as noted in this estate, the tastes and preferences of residents can be said to not have changed.

Table 4.3: Change of taste and preference

Descriptive Statistics			
	Mean	Standard Deviation	n
Group A	1.5833	0.5149	18
One Sample t-Test			
t-Statistic	0.0224	Result	
Degrees of Freedom	17	Do not reject the null hypothesis.	
Critical Value	2.2010	Conclusion	
95% Confidence Interval	[1.2562, 1.9105]	Group A is not significantly different from the population mean, t = 0.0224, p > .05.	

Source: Fieldwork (2015).

4.2.3.8 Creation of awareness

The questionnaire sought to establish the level of awareness that these residents have, by asking whether they had heard advertisements, messages and campaigns on the need to protect the environment. 90% of them reportedly had experienced the awareness campaigns and none of them had not (Figure 4.10). This large number of residents is undoubtedly proof that residents are aware of the need to protect the environment. However, about 10% had heard the same messages but were not convinced that the

messages were conclusive. One scribbled in their questionnaire leaflet and expressed their concern for the lack of practical solutions to the problems campaigned about.

The representatives from RWL and TTS reported that the Runda Association newsletter distributed to all residents at no fee has comprehensive information on how the estate and residents can protect the environment making claims by the 10% above, inconclusive. There have also been advertisement and messages on national television from NEMA, KAM and other institutions promoting and creating awareness about the environment and the need to be mindful of our activities and the way they affect it.
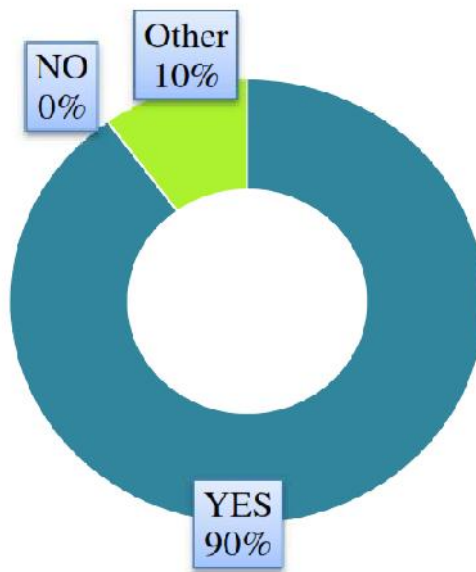
Figure 4.8: Creation of awareness

Source: Fieldwork (2015).

4.2.3.9 Personal initiative

The questionnaire aimed to find out whether the residents engaged in conversation about problems that affect our environment. From the results and the statistics shown below, the residents exhibit indifference to the need for such conversation. Conversation is a tool that can be used to increase the much required awareness in this estate.

Other communities around the world for example, the NGO is Sri Lanka as discussed in the literature review, use the framework of communities to come up with initiatives that help the whole community. The community establishes small scale composting units and biogas generation, recycling and eventually shares information within the network for the benefit of the community. The role of sharing information is to improve processes, get feedback and finally implement. Having the framework ensures that the whole community feels accountable.

P value and statistical significance:
The two-tailed P value is less than 0.0001
By conventional criteria, this difference is considered to be extremely statistically significant.

Confidence interval:
The hypothetical mean is 0.00
The actual mean is 3.00
The difference between these two values is 3.00
The 95% confidence interval of this difference:
From 2.57 to 3.43

Intermediate values used in calculations:
$t = 15.2971$
$df = 16$
standard error of difference $= 0.196$

MEAN **3.00**

SD	**0.71**
N	**18**

Figure 4.9: Personal initiative

Source: Fieldwork (2015).

4.3 Waste Management at Home

4.3.1 Waste Recovery

4.3.1.1 Reuse and/or recycle

The questionnaire sought to establish whether residents thought reusing and/or recycling waste was a worthy cause. 50% 'strongly agreed' that the practice of reuse and/or recycling makes sense. Those who 'agreed' were at 10% while 'disagreeing' and 'strongly disagreeing' were 0% and 10% respectively (Figure 4.12). Those who neither agreed nor disagreed were set at 30%. The number of residents who thought the practice is important versus those who do not proves that more respondents were in agreement that reuse and/or recycling practices are a worthy cause.

The number of residents who are indifferent to the practice however shows that there are residents who are still not educated or aware of the need for sustainable waste management practices. It makes sense because it reduces the consumption of plastics. Putting plastic waste to good use also reduces the need to purchase more.
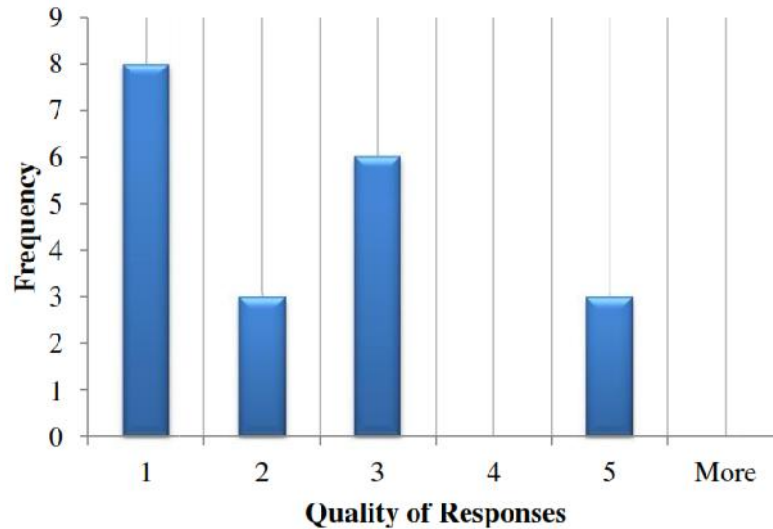
Figure 4.10: Reuse and/or recycling

Source: Fieldwork (2015).

4.3.1.2 Materials reused and/or recycled at home

The questionnaire posed a question to establish the materials reused and/or recycled in these residences. They had varied responses but those relevant to this study include: plastic bags, plastic milk bottles and plastic containers which come with a variety of goods for example coffee, from detergents' packaging, disposable utensils amongst others. Plastic waste and organic waste volumes in the estate are almost equivalent while in low income areas, the volume of organic waste is considerably more than that of plastics. The TTS representative added that despite Runda Estate having a large volume of waste in plastics as compared to other low income areas they work in, the plastic waste in this estate is easily recoverable for reuse because it is still in good form. Noteworthy is that plastic recycling is not currently taking place in these households.

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4.3.1.3 Incineration

Incineration is a method of waste management and it is banned in Runda Estate therefore residents are not allowed to burn their waste. The results for this question are therefore biased to that effect. 50% of residents burn their waste while 50% do not (Figure 4.13). The residents are neither for burning waste nor against it thus they are indifferent. RWL has been campaigning against this practice for a long time and the latest Runda Association newsletter (March/April 2015) reports that the residents who continue with the practice will be named and shamed in newsletters to come.
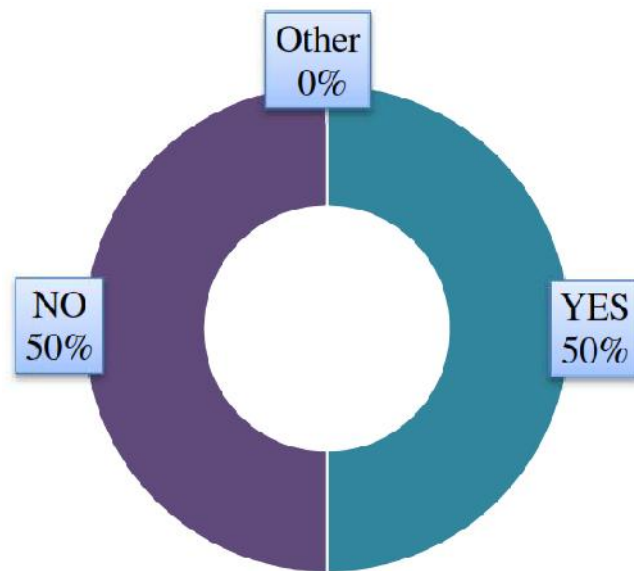
Figure 4.11: Incineration

Source: Fieldwork (2015).

The RWL representative was quick to talk about the ban in Runda Estate and the milestones they have made with it in place. However, they are not in control of the goings on in each household and therefore the scope of implementation of the ban is limited. The representative from TTS said that the residents now have a choice not to incinerate

because there are opportunities three times a week for them to give out the waste they want to get rid of instead of burning it. Burning waste is not good for the environment, the residents and their neighbours. Incineration is a process that can also provide energy. This is usually done for waste that cannot be reused nor recycled. This is instead of throwing it into a landfill where it accumulates into unsightly filth. This kind of incineration is not done in homes because it requires certain apparatus and expertise. It is a process that has an output, energy. The kind of incineration done in homes is only to get rid of the waste with no anticipated output.

4.3.2 Waste Monitoring

    4.3.2.1 Waste management plans

It is clear to say that most residents in Runda Estate have waste management plans in their homes because 64% of the respondents 'strongly agreed' while 18% 'agreed' to this practice. 9% 'strongly disagreed' while 9% of these residents were indifferent (Figure 4.14).

The RWL representative reported that the residents have come a long way in waste management practices and the results of this question attest to that. There is more efficiency now and with the entry of TTS, the residents are being encouraged to segregate their waste. This is slowly changing their attitudes and behaviours. Residents claim that TTS is more organized and gives a much improved service, while the 'separate garbage bags' increase their capability to segregate waste.

Waste management plans are essential in the struggle to achieve sustainable waste management. Sustainable waste management means reducing the volume of waste, reducing waste and segregating it for easy recovery. Without a plan, it is difficult to know how much has been reduced, reused or segregated for recovery. It would be difficult to know if the resident was making strides towards sustainability or not because of the lack of planning through the waste management plans.
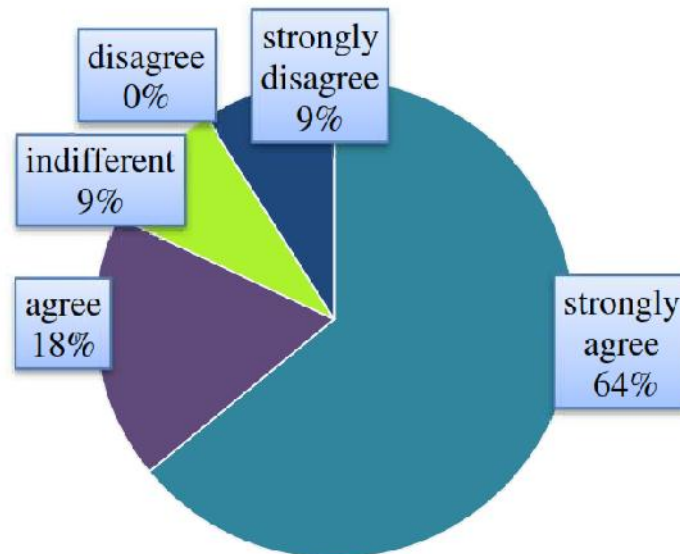
Figure 4.12: Waste management plans

Source: Fieldwork (2015).

4.3.2.2 Monitoring and recording

A good waste management plan involves monitoring and recording of waste. 60% of residents monitor and track waste going out of the house while 40% do not (Figure 4.15). This is however criticized because most of the residents are too busy to do this on a daily

or weekly basis. Additionally, the housekeepers and others who handle the solid waste are not well educated on the essence of doing this and this issue therefore does not take precedence. As discussed under waste management plans, the residents need to monitor and record their waste in order to mark progress or lack thereof. This would lead to better decision making.
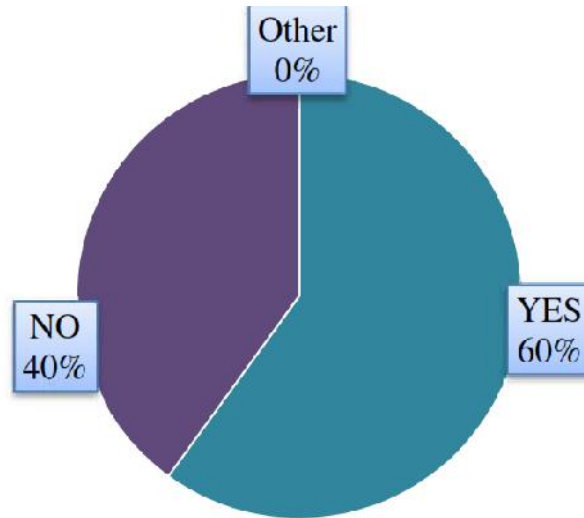
Figure 4.13: Monitoring and recording

Source: Fieldwork (2015).

4.3.2.3 Cleaning for easy recovery

Cleaning plastic waste and containers is a way of making sure that it is easily recoverable. Organic waste for example or other dirt that collects in these materials, have the potential to deteriorate its value. Only 27% of the respondents are akin to this practice, 55% are recorded at 'very unlikely' with 9% at 'unlikely'. The numbers who are indifferent are at 9% (Figure 4.16). The data shows that the majority of residents do not clean their plastic waste.

The TTS representative complemented this data saying that in the state the plastics are after use is the same state they are when thrown away and later on collected by the company. This poses a problem because recycling companies do not accept dirty plastics due to extra costs they would incur to clean. From the literature review, a Japanese study reported that plastics can accumulate and concentrate persistent organic pollutants from the environment. Therefore, despite the plastics being costly to clean they could potentially continue to become an environmental hazard if left dirty. Their waste management plans should therefore include cleaning of the plastic waste since immediately after use the dirt is not difficult to handle.
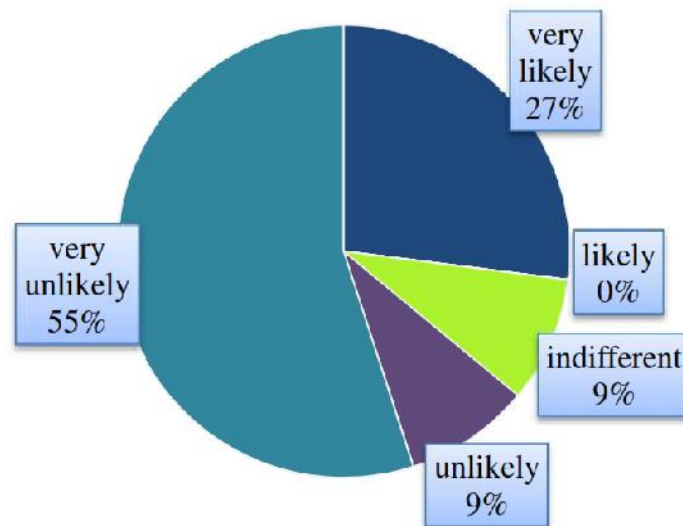
Figure 4.14: Cleaning for easy recovery

Source: Fieldwork (2015).

4.3.2.4 Delegation

Because of busy schedules the residents delegate most of the housekeeping work and other maintenance duties to helpers who perform them on their behalf. 73% of the residents 'strongly agreed' to delegating their waste management responsibility, 9% 'agreed' while 9% 'strongly disagreed' and 9% shown indifferent (Figure 4.17). A large proportion of the residents delegate waste management duties as seen from the gathered information.

The RWL representative emphasized that these residents are busy and do not care to perform these duties themselves. However, they have to be done and that is why they employ people to do it. A few, for example those who work from home, might create time to do it as required. From the literature review the researcher has emphasized the significance of human behavior and therefore, we cannot be too busy as to not address these issues because they are our business. Delegating the work is a good step in making sure things are done. Also, the residents might get phased by the sight of waste and not be able to handle it effectively. It helps to have other people around who can do it on their behalf so that waste management plans are implemented.
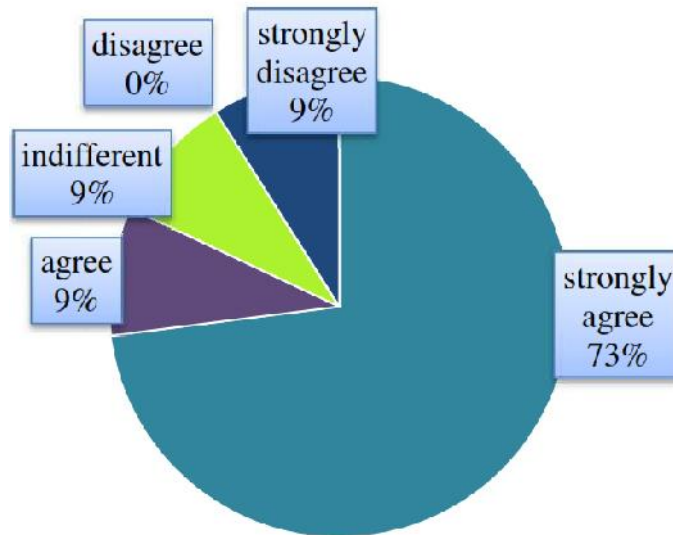
Figure 4.15: Delegation

Source: Fieldwork (2015).

4.3.2.5 Active participation in waste management

The questionnaire attempted to find out whether the residents sought an active role in the waste management of their homes. They could be active whilst delegating by giving direction and constantly inquiring to find out how well the employees perform these duties. The data below shows that the residents were indifferent to assuming an active role in the waste management of their homes (see Table 4.4). When the Runda Association newsletter discusses issues related to waste management there should be people already engaged and willing to execute.

This is how this system functions as a whole to eventually give an output. The newsletter gives insight into the waste management plans and activities that should take place in homes. The residents should take to performing these tasks as shown and prescribed. If

not themselves, then the helpers should be brought up to speed with the information and left to action it out. They should then, give feedback to the homeowner who in turn provides the same feedback to the Runda Association through the various platforms provided in the newsletter. The waste management company or proposer of the insights then addresses the issues raised and possible solutions and improvements. This is as per the process discussed in Chapter two where stakeholders are involved and there is incorporation of feedback to inform and improve processes proposed.

Table 4.4: Active participation in waste management

Descriptive Statistics			
	Mean	**Standard Deviation**	**n**
Group A	2.4167	1.3114	18
One Sample t-Test			
t-Statistic	-0.0088	**Result**	
Degrees of Freedom	17	Do not reject the null hypothesis.	
Critical Value	2.2010	**Conclusion**	
95% Confidence Interval	[1.5835, 3.2499]	Group A is not significantly different from the population mean, t = -0.0088, p > .05.	

Source: Fieldwork (2015).

4.3.3 Littering

The residents according to the subject matter, littering, are seen to be keen towards the cleanliness of the environment (Figure 4.19). 82% 'strongly agreed' to avoiding litter in

their homes and compounds, and consequently even out of their homes. 9% 'strongly disagreed' while another 9% are indifferent. The RWL representative in an effort to explain these results said residents view waste management as a fundamental function of the household. Litter therefore has no place in their homes and they easily adopt the same habits even when out of their compounds. Those who strongly disagree, meaning that they litter, are possibly displaying arrogance, questioning the role of their employees and the city council if not to clean up after them.

Littering being a human behavior means that the unresponsive residents need to change their habits. This has been discussed in previous chapters and the importance for messages and alerts have been emphasized. These should probably be designed to address the arrogant residents because they might already know that they should not litter. There used to be bins at certain locations in the estate that were said to help with this problem of littering within the streets but Runda Water Limited uninstalled these said bins. The streets nowadays have more litter and are laced with plastic wrappers all through. This is a situation that could get out of hand as all big problems start from somewhere. Waste management plans should therefore be anti-littering.
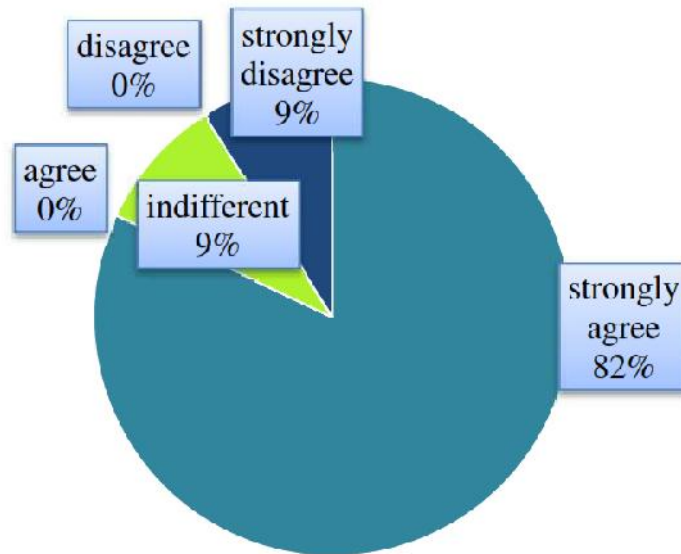
Figure 4.16: Littering

Source: Fieldwork (2015).

4.3.4 Economic Sense

The questionnaire sought to explore the economic advantages of recycling by asking the residents whether they thought the practice saves money. 46% 'strongly agreed', 9% 'agreed', 9% 'disagreed' while 18% 'strongly disagreed'. 18% were found to be indifferent (Figure 4.20). Thus majority were of the opinion that recycling plastics saves money.

The TTS representative inserted that the waste management plan for residents did not include recycling. They leave the recycling part of operations to the waste management company therefore not likely to realize any economic relief that is sort for example by the informal sector. Reuse and/or recycling make sense to those companies or individuals that recycle waste because they get financial relief from their recovery. This is because

the plastics can be used to manufacture other goods instead of using virgin material. This reduces production costs for manufacturers.
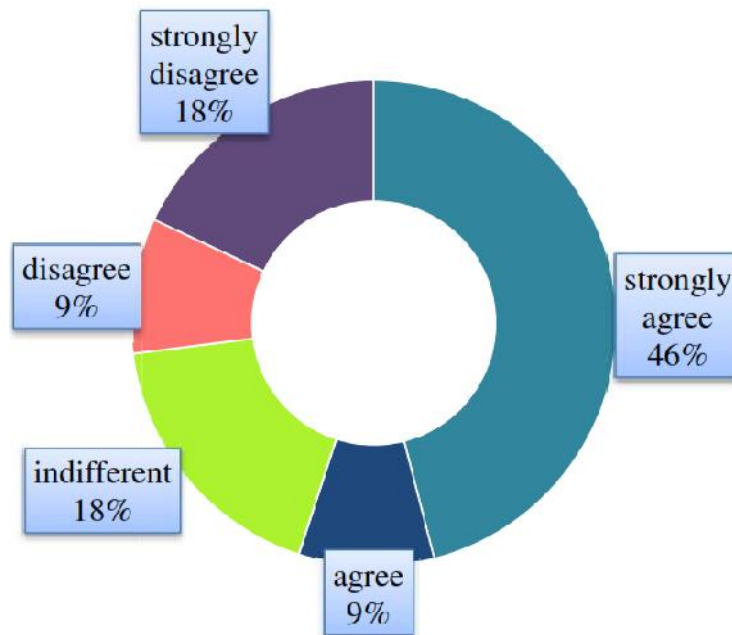
Figure 4.17: Economic sense

Source: Fieldwork (2015).

4.3.5 Tax and Excise Duty

Taxes on plastics have been proposed in various countries and governments as a way to stop or reduce the increase of plastic use and consequently its generation. It is a good initiative to reduce plastic waste pollution and manage waste. The residents did not take well to this proposal with most of them citing strong disagreement. 20% 'strongly agreed', 60% 'strongly disagreed' while 20% are indifferent to the use of tax and excise duty to reduce use and disposal of plastics (Figure 4.21).

The RWL representative cited that the disagreement is not much about the consequent high prices that trickle down to the consumers, as much as the fact that residents do not like the approach. Taxation in Kenya has a bad connotation and that is deduced to be the reason for the high number of residents in disagreement, despite the fact that it would not directly inconvenience them (because they get free plastic bags from their places of shopping).
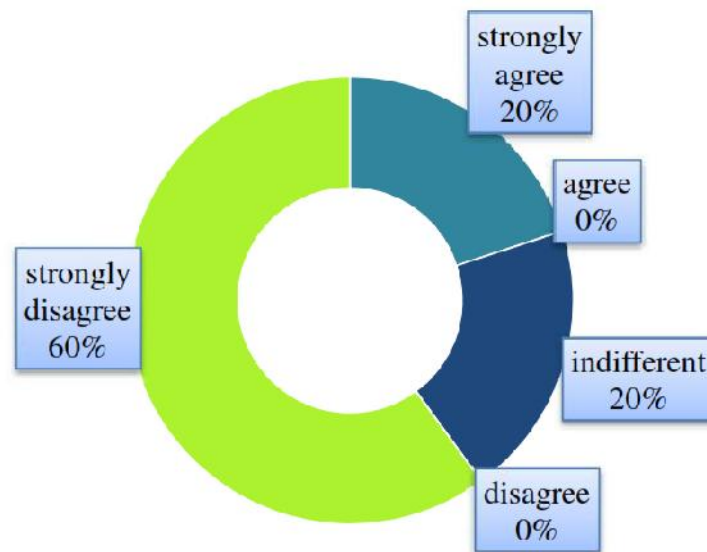
Figure 4.18: Tax and excise duty

Source: Fieldwork (2015).

4.3.6 Waste Segregation

The researcher sought to establish the shared responsibility in segregation of waste by asking whether others in the house were engaged in the exercise. From the results the residents seem indifferent to exercise segregation of waste in their households and involving others in their waste management plan.

Some residents lament that having 1 bin as the mode of waste collection from previous management does not support the new separate bags method. Therefore getting separate bins would be a good incentive. The RWL representative was of the opinion that the more people there are included in waste management, the better and more efficient the practice will be. The young can use this as training ground to learn how to manage waste as a major contribution to environmental protection.

P value and statistical significance:
The two-tailed P value is less than 0.0001
By conventional criteria, this difference is considered to be extremely statistically significant.

Confidence interval:
The hypothetical mean is 0.00
The actual mean is 2.25
The difference between these two values is 2.25
The 95% confidence interval of this difference:
From 1.43 to 3.07

Intermediate values used in calculations:
t = 6.0512
df = 17
standard error of difference = 0.372

MEAN **2.25**
SD **1.29**
N **18**

Figure 4.19: Waste segregation

Source: Fieldwork (2015).

4.4 Point of Contact between the Waste Generators and Collectors

4.4.1 Responsibility

The questionnaire sought to find out whether the residents segregate waste because Taka Taka Solutions has provided separate bags or as their own initiative. 46% 'strongly agreed' to segregating waste as their own initiative, 9% 'agreed' while 18% 'strongly disagreed' and 9% 'disagreed'. Leaving 18% indifferent (Figure 4.23). Those who argue that it is their own initiative are more than those who refute it.

The representative from RWL insisted that the intentions of the residents might be to separate waste but because they leave the duties to their employees the exercise runs the risk of oversight and omission. Interaction between the company and the residents would solve this problem by encouraging participation of the residents.
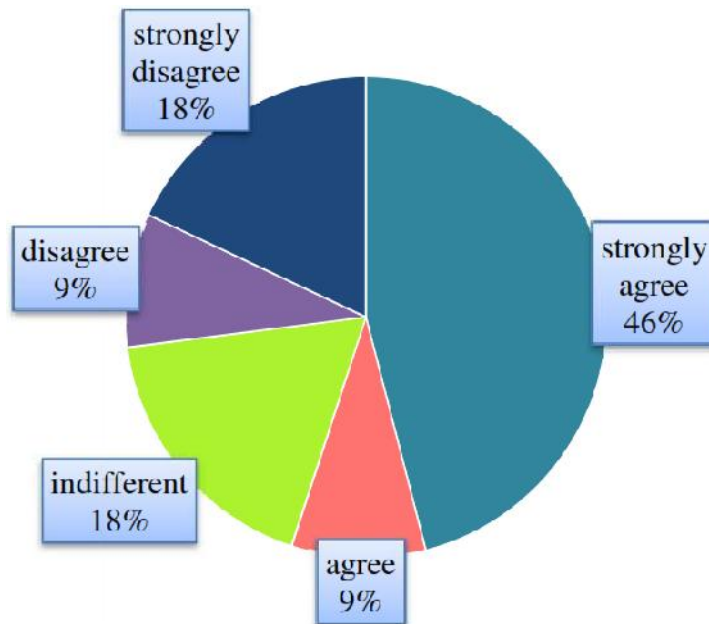
Figure 4.20: Responsibility

Source: Fieldwork (2015).

4.4.2 Compliance to Sustainability Claims

The questionnaire sought to find out how residents would feel if TTS still dumped waste in the Dandora landfill despite claims of being a sustainable company with 100% waste diversion. The respondents would be indifferent if TTS did not actualize their vision for the estate and the company.

The TTS representative stated that it was difficult to divert all the waste due to complexities in the waste constituents found in the solid waste collected from the estate. For example a lot of diapers and hair are found in their waste. These are eventually compressed to reduce the volume and impact they have on the landfill. Landfills around the world are becoming ever filthier and fuller due to such wastes. The discovery of a fungus new to science with an appetite for polyurethane is one of the solutions to the landfill problem. This is because it can survive in conditions that are found in the landfill.

P value and statistical significance:
The two-tailed P value equals 0.0010
By conventional criteria, this difference is considered to be very statistically significant.

Confidence interval:
The hypothetical mean is 0.00
The actual mean is 2.25
The difference between these two values is 2.25
The   95% confidence interval of this difference:
From 1.13 to 3.37

Intermediate values used in calculations:
$t = 4.4171$
$df = 17$
standard error of difference = 0.509

MEAN	**2.25**
SD	**1.76**
N	**18**

Figure 4.21: Compliance to sustainability claims

Source: Fieldwork (2015).

4.4.3 Backward Steps

The questionnaire sought to find out how frustrated residents would be if Taka Taka Solutions went back to the 1 plastic (pink) bag policy for waste collection (from the two blue and green bags). 'Very likely' was at 20%, 'likely' at another 20% while those 'very unlikely' were represented by 30%. The indifferent residents were also at 30% (Figure 4.25). This shows that the residents are collectively indifferent. Additionally, some claim that the current separate bags are not efficient because they are smaller and lighter than they were before.

The TTS representative explained that due to lack of segregation of waste by (some) residents the use of two bags might be reversed back to the one garbage bag policy. For them two bags are more costly and present negative financial implications. However cheap the 1 bag may sound, it is would not support the few who have already adopted the practice of segregating. Commingling waste would make it more difficult for the company to recover the waste. They would also have to incur more costs to clean the same and they would eventually not make any savings. They should spend their time to

interact with the residents to explain the challenges they go through, financial and service delivery wise. This would motivate the residents to participate in the change.
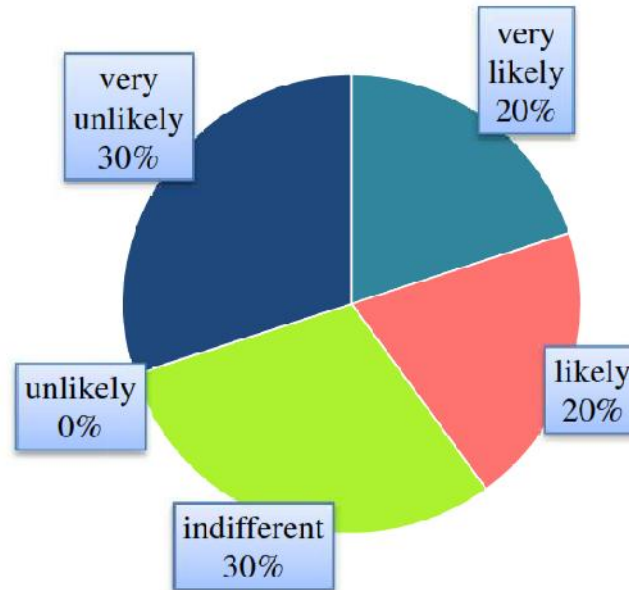
Figure 4.22: Backward steps

Source: Fieldwork (2015).

4.4.4 Service Charges

The residents were asked about their opinion on the service charge and whether it was commensurate to the services rendered. 100% of the residents thought that the waste management service charge was commensurate to the services rendered (Figure 4.26). The TTS representative reported that despite the fact that not all residents comply with the service charge, all the waste is collected from the streets without discrimination (as to whether residents have paid the service charge or not). This can attributed to their status and socio-economic influences.
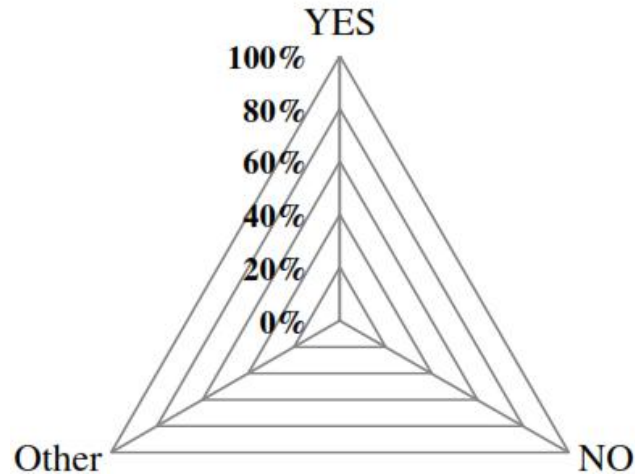
Figure 4.23: Service charges

Source: Fieldwork (2015).

4.4.5 Interaction Between the Waste Collectors and the Waste Generators

4.4.5.1 Level of concern

The researcher in a bid to establish the level of concern toward the service offered by Taka Taka Solutions (TTS) asked the residents if they pay attention to the service rendered. 25% of the residents 'strongly agreed', 8% 'agreed' while 17% 'strongly disagreed'. The proportion of residents who are indifferent is set at 50% (Figure 4.27). Meaning most of the residents are indifferent to the quality of service offered by the company. The indifference towards the service offered shows a lack of interest. However, it is important that they follow up because any faults in service delivery may go unnoticed whereas the residents could take charge and encourage the company to perform even better.
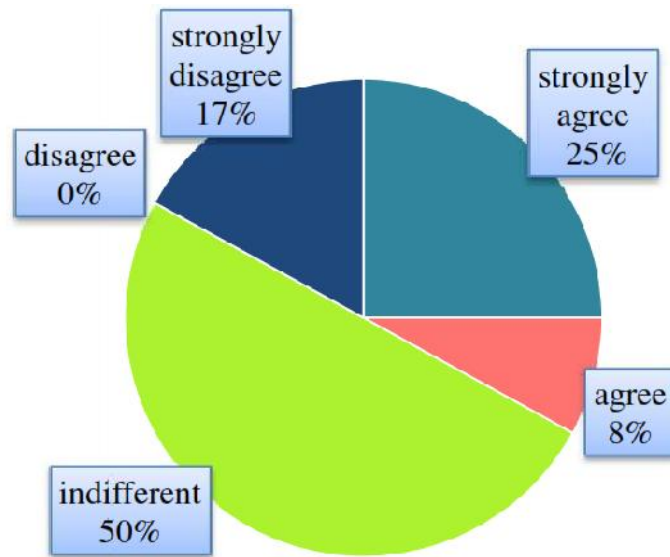
Figure 4.24: Level of concern

Source: Fieldwork (2015).

4.4.5.2 Monitoring waste management service

The questionnaire sought to find out how often residents go out of their way to find out whether TTS is doing their work right. Some of the responses were: every twice in a week or as often as they collect the garbage, rarely and others who sought them once in a while. 81% of the responses proved that the residents do not follow up on the company nor are they interested in the quality of the service provided.

The representative from RWL explained that the residents do not bother with such matters because they have left them in charge (alongside with the Runda Association of residents), to manage the waste management service on their behalf along with other services offered within the estate like security, road maintenance and lighting.

4.4.5.3 Interaction

Communication is a link between the waste generators and the collectors that requires careful management. The residents are queried about the opportunities they have to interact with the waste management company. 25% said they have opportunities to interact with them, 58% said they do not and 17% recorded as other (Figure 4.28). Most residents note that communication with the waste management company is wanting.
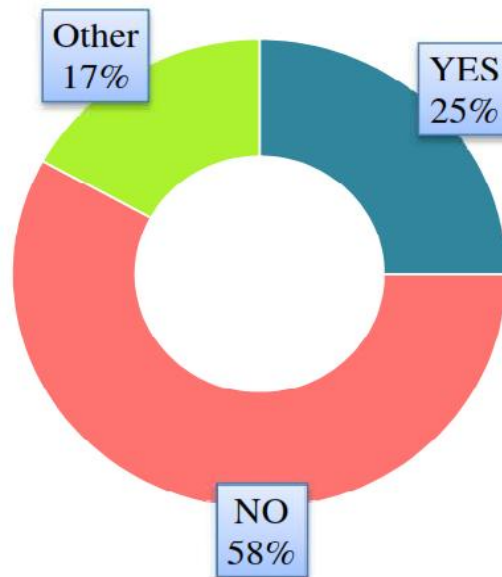
Figure 4.25: Interaction

Source: Fieldwork (2015).

They get in touch with RWL through phone call, email and consultation, and RWL in turn relays information to the rightful persons in TTS. The TTS representative stated that residents are called upon to meet with them to learn more about their services but they do not show up in their acute numbers. He claimed that these people are likely to be represented by the 17%. The representative from TTS explained that they communicate to residents through a weekly call to the Runda Association who receive this communication on behalf of the residents.

4.4.5.4 Communication and information

The researcher inquired about the residents' opinions on whether more interaction with Taka Taka Solutions would create more opportunities for communication and exchange of information. From the data residents agree that interaction would lead to better communication. It supports the statement that more interaction would lead to increased awareness.

The constitution recognizes the role of the public in policy development and encourages their participation. This would open up channels of information flow that would be beneficial to both residents and the waste management company. It would encourage awareness of the relationship between plastic waste and the environment.

Table 4.5: Communication and information

Descriptive Statistics			
	Mean	**Standard Deviation**	**n**
Group A	1.6667	0.8876	18
One Sample t-Test			
t-Statistic	0.1821	**Result**	
Degrees of Freedom	17	Do not reject the null hypothesis.	
Critical Value	2.2010	**Conclusion**	
95% Confidence Interval	[1.1027, 2.2306]	Group A is not significantly different from the population mean, $t = 0.1821$, $p > .05$.	

Source: Fieldwork (2015).

4.4.5.5 Active participation in decision making

The residents were asked whether they would like to be involved in the decision making of waste management in the estate. 66% said yes they would like to be involved, 17% did not want to be involved while 17% were reportedly indifferent (Figure 4.30). Thus, the larger population claims they would like to be active in decision making.

The TTS representative said that they would try reaching the residents more rigorously even though the residents do not show up for planned meetings. Their participation herein would lead to their engagement in decision making. The waste management company however, needs to tailor their messages to the people of this estate. Meeting with people of low income areas and the high income areas is not the same. There are different incentives that drive either of those people. The company should explore these factors in order to have better turn up.
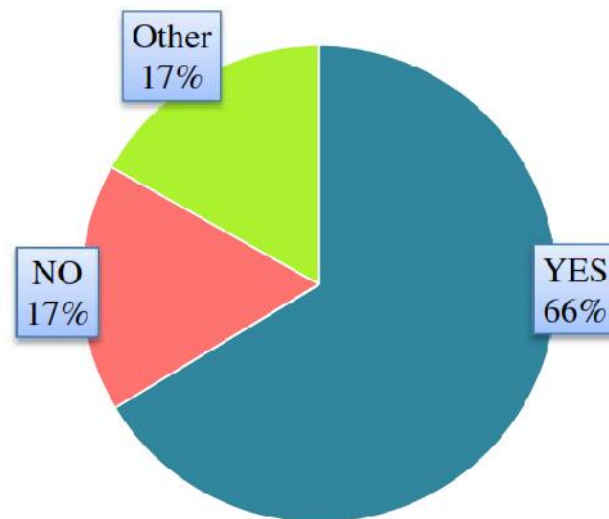
Figure 4.26: Active participation in decision making

Source: Fieldwork (2015).

4.4.6 Suggestions for Plastic Waste Management

The residents suggest the following for plastic waste management: a set up programme for the recycling and/or reusing of plastics that involves the participation of all; after separation residents should be shown how to reduce/reuse the waste; and that people should make reusing and/or recycling a habit.

As discussed in the literature review, different programs work for different countries because of different environments and situations. Therefore, programs that are aimed to involve the residents need to illustrate how they meet their needs. This interaction should show the relationship between plastic waste and the negative effects it has to the environment.

4.4.7 Recognition of the Informal Sector

     4.4.7.1 Role of informal sector

Residents were inquired about the role of the informal sector in plastic waste management. 62% of residents 'strongly agreed' that the informal sector has a role in plastic waste management while 15% 'strongly disagreed'. 23% were indifferent as to whether they had or had not a role (Figure 4.31). Thus a higher number of respondents concur that the informal sector has a role in plastic waste management.

The representative from TTS however did not support this explaining that the informal sector is disorganized. The scavengers do not offer waste management services, they only take the waste and earn from it (which would otherwise be a profit for TTS). They

continue to explain that the service charge is exhausted on the collection of garbage, and from the sale of recyclables they pay for the sorting of the garbage. This shows the already existing competition there is for the waste resource.
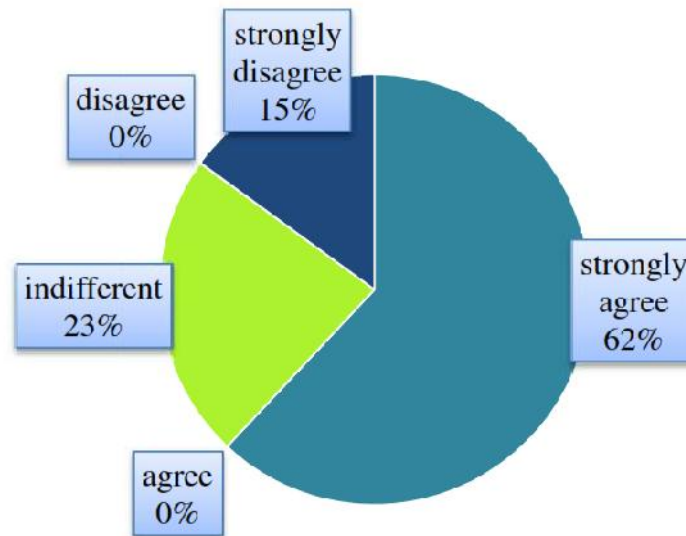
Figure 4.27: Role of informal sector

Source: Fieldwork (2015).

4.4.7.2 The scavenger 'nuisance'

The residents, despite acknowledging that the informal sector has a role to play in the management of plastic waste, get annoyed when they find scavengers rummaging through their waste. 67% of residents are 'very likely' to get annoyed, 17% are 'very unlikely' to while 17% are indifferent (Figure 4.32). Most of the residents do not like the inconvenience of finding other people going through their waste because they leave a mess afterwards.

The representative from RWL stated that these scavengers are youth from a nearby slum and usually come round on Saturdays. The TTS representative insists that the informal sector is only a challenge for them and they are changing their collection days to Fridays (from their previous Saturday collection day) to make sure scavengers do not have a chance to create a mess leaving the company to clean up.
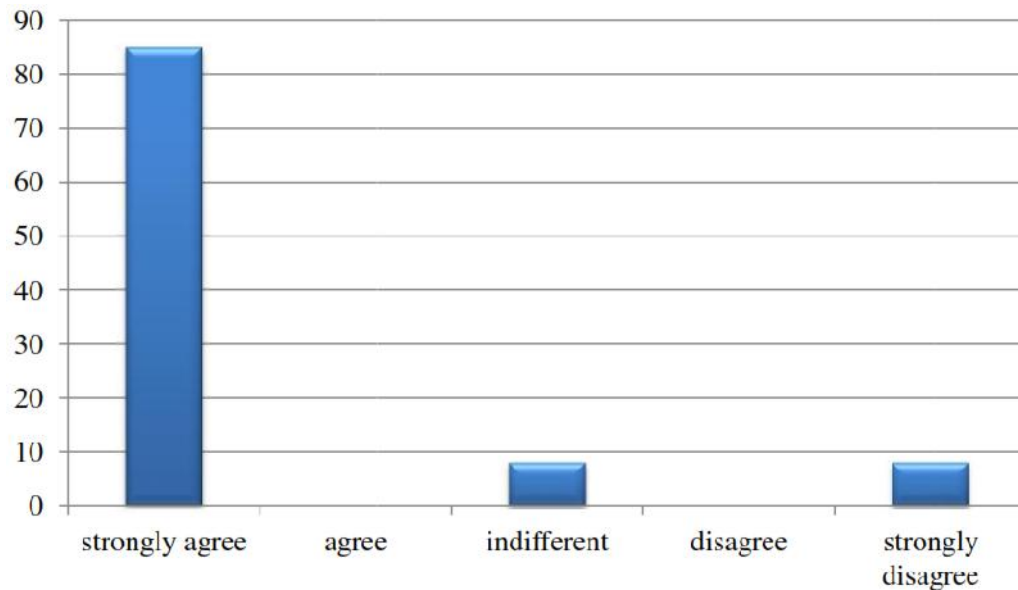
Figure 4.28: The scavenger 'nuisance'

Source: Fieldwork (2015).

4.4.7.3 Integration of the informal sector

As a solution to the scavenger 'nuisance' the researcher asks the residents if an incentive system should be instituted for companies that integrate the informal sector in their operations. 85% of the respondents 'strongly agreed' to this while 8% did not. 8% of the proportion is of indifferent residents (Figure 4.33). This shows that a high number of the residents support the idea of the informal sector being integrated into the formal.

However, the representative from TTS said that most of these youth are still in school and integration would be difficult because their time during the week is dedicated to studies.
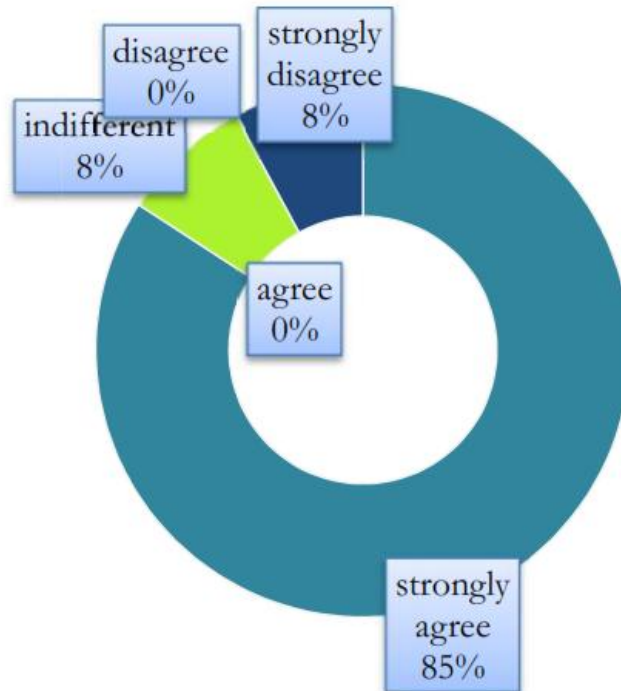
Figure 4.29: Integration of the informal sector

Source: Fieldwork (2015).

The informal sector as discussed has an important role to play in the solid waste management of the population in developing countries. The formal sector and the informal sector should liaise and agree on their terms of engagement. Both should compromise their methods of working in order to accommodate the other.

4.4.8 Resident Participation in Recycling Programmes

The researcher sought to find out whether the residents would be willing to participate in recycling programmes for improved plastic waste management. As the results show, 100% of the residents are willing to participate in these efforts and therefore both Runda

Water limited and Taka Taka Solutions should find a better way to lure and integrate them.
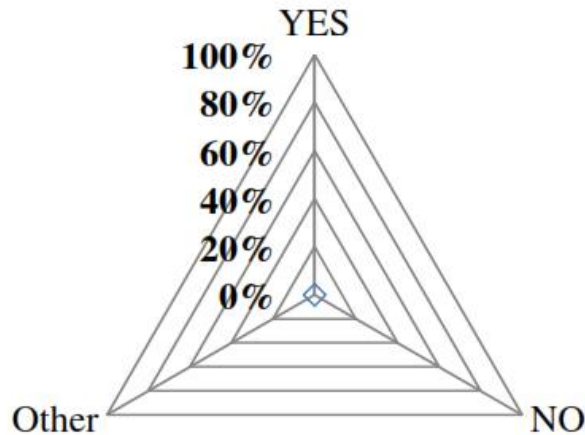
Figure 4.30: Resident participation

Source: Fieldwork (2015).

4.4.9 Plastics Controversy

The questionnaire sought to find out whether the residents consider plastics the better option as it preserves the environment by reducing the other types of wastes that would otherwise be used. 58% agreed that they are good for the environment, 33% said no to this idea while 8% of respondents are indifferent (Figure 4.35). From the results it is safe to say that a considerable number of respondents, that was not anticipated, think plastics preserve the environment.

The representative from TTS stated that plastics help to reduce the volume of other types of waste. However, these plastics are not recyclable whereas the other options of glass, metal and paper among others are recyclable. A down side to these other options is that

they cover a larger area than plastics do as evidenced in literature review. Another way that plastics preserve the environment is that they are used in the manufacture of poles reducing the need to cut trees. In the future, plastics will be used to generate renewable oils from which they are made. This would be a way to supply the much demanded resource without excavating or drawing it from the natural environment.
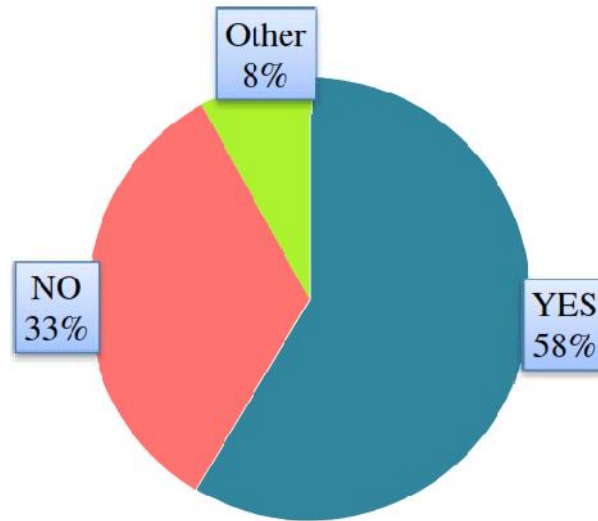
Figure 4.31: Plastics controversy

Source: Fieldwork (2015).

<center>**CHAPTER FIVE**</center>

<center>**CONCLUSIONS AND RECOMMENDATIONS**</center>

5.1 Introduction

The data gathered are quantitatively and qualitatively analyzed to determine if certain conjectures are substantiated and hypothesis generated has been supported. In this chapter the researcher through deduction seeks to arrive at a conclusion by interpreting the meanings of the results of data analysis in chapter four.

5.2 Conclusions

5.2.1 The Nature of Plastic Consumption Patterns in Runda Estate

The data reported in chapter four shows that 73% of Runda residents shop weekly. 70% of these residents claim to use plastic bags because they are reusable even though 57% of them do not reuse their shopping bags as shown from the survey. From the results, it is also clear that the residents are knowledgeable about biodegradable bags; however, 25% of them are not aware of their prevalence or where to find them and are therefore not able to use them.

The data shows that the larger population goes shopping weekly and they use plastic bags because they are reusable; this is despite having knowledge of biodegradable bags that are not only reusable but also environment friendly. Of these residents, majority do not reuse their shopping bags meaning that the plastic bags gained from the weekly shopping

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experience ends up in the waste stream. This adds to the 12 per cent of plastic waste found in the 57 tons of solid waste generated in the estate every month as discussed in chapter three. In order to care for the environment, these residents need to depend less on plastics. Prices can be used to deter consumers from using non-biodegradable plastics (e.g., prices for the non-biodegradable plastics must be increased but an option for affordable bio-degradable plastics must be availed.

5.2.2 Awareness of Need for Appropriate Waste Management Plans

82% of the residents have waste management plans in their homes and 60% of them are seen to record and monitor waste as it leaves the home. From an operational perspective, monitoring of waste volumes is the way to start measuring the amount of plastic wastes. There has been a lot of improvement in the waste management of the estate and the attitudes of the residents due to the entry of Taka Taka Solutions.

The residents have basic waste management plans in their homes because they do not recycle waste and it is evident from the nature of their plastic consumption that they need to exercise the reduction approach. They have a discrete sense of reusing plastics since they do not reuse plastic bags which are very prevalent. On the issue of recycling, the government should empower plastic waste recycling companies in the country to increase recycling rates. The machinery to perform this should be availed in the country and made affordable. The researcher concludes that the level of awareness for appropriate waste management plans in their homes is therefore limited. Having limited reduction and reuse, and no recycling in these homes, leaves most of the waste management work to the

waste management company. Meaning that the least they could do is segregate their waste 100% to ensure that TTS is able to recover as much as is practically possible. TTS should therefore find a way to slowly change their waste management plans and motivate them to segregate as well as pick up the other wholesome waste management practices (the Rs).

5.2.3 Relationship between Plastic Consumption and the Environment

58% of the residents are of the opinion that they do not have opportunities to interact with TTS while 77% of the residents agree that interaction with TTS would bring about better communication, exchange of information about their services. This is noteworthy because knowledge gained from such interaction is key to bridging the gap between collectors and generators, as well as creating awareness of the impacts plastic waste has on the environment.

64% of these residents claim that they would be disappointed if TTS was still dumping waste in the Dandora landfill despite claims of diverting the waste. However, the same residents generate waste that cannot be diverted from the landfill. This points to the knowledge gap between the collectors and generators that needs to be closed through interaction to make them aware that the diversion is not possible because of their own consumption patterns.

The National Government was involved in the drafting of the Integrated Solid Waste Management (ISWM) plans alongside UNEP and JICA. This would see to it that plastic

waste management is undertaken nationally. It would also enable the achievement of vision 2030 and the milestones set for waste management and the environment.

This study has taken a look into the issue of consumption and generation of plastics. The diversity and functionality of plastics that is ever growing to meet market needs contributes to the difficulty already existent in getting rid of plastics. In conclusion, reduction, reuse and recycling involve changes in human attitudes towards their consumption patterns. As American cultural anthropologist Margaret Mead once said, "Never doubt that a small group of thoughtful committed people can change the world: Indeed it's the only thing that ever has!" (wikiquote, 2015).

Analysis of the hypothesis shows that these residents are indifferent to the way and/or manner their behaviours impact plastic waste management as demonstrated below (Table 5.1).

Table 5.1: Hypothesis Testing

Hypothesis Test		
r	1	Result
Degrees of Freedom	16	Reject the null hypothesis.
Critical Value	0.707	Conclusion
N	18	Group x and Group y are significantly correlated with one another, $r(6) = 1$, $p < .05$.

Source: Fieldwork, (2015)

5.3 Recommendations

The first objective was concerned with establishing the nature of plastic consumption patterns. As in the conclusions, it is noted that for the residents need to curb their plastic consumption to protect the environment. The researcher recommends that the international 'green consumer day' of 28th September (which is keen on highlighting the problems of consumerism and its impacts on the environment), be properly exploited to promote sustainable products. It would be a commendable way to create awareness whilst giving a global perspective to a matter of global concern.

The second objective sought to find out the extent to which residents were aware of the need for appropriate waste management plans in their homes. From the conclusions section, it is noted that the residents have basic waste management plans in their homes. To assist with the role of monitoring, there should be initiatives in the development of automated waste monitoring systems. These could be used to monitor the amount of waste that leaves the 'Runda Estate' system. There should be integrated waste management for Runda Estate for synergies. With integration, circular economies and zero waste are attainable. The study also recommends that stringent policies be put in place to enhance recycling and incentives for private companies in the business of waste (e.g., less taxation). There should be integration and consideration of the informal sector instead of shunning them and leaving them to work in deplorable states.

Finally, the researcher sought to establish the scale to which residents were informed of the relationship between plastic consumption patterns and their effects to the

environment. From the conclusions discussed in previous sections, it is noted that interaction between the collectors and the generators of waste could solve numerous problems in solid waste management of the estate. The researcher makes recommendations on how the plastics waste management problem could be solved. Stakeholders should implement interventions to build capacity. Management should establish a forum for information exchange to stimulate exploration of actions that each resident may take to acquire practical resolve. They should also do feasibility of separating waste at source that would educate residents further on benefits of the practice.

Due to the past failures in adoption of plastic bag legislation and the lack of enforcement thereafter, there needs to be more involvement of the private sector. Consultations with the private sector should help the government realize other means of going about the problem as they together channel resources into research and development of the same.

5.4 Areas of Further Study

- Structures for a circular economy should be researched on as the ultimate sustainable waste management plan. These should be contextualized to our local scene for relevance and applicability.
- A growing number of projects are pushing towards zero targets in carbon, waste and toxics, and the Government should adopt and promote both zero carbon targets for new build and escalate retrofitting of existing buildings. In future, people will develop zero waste cities by producing less waste, by collecting all waste from the city, by

100% recycling and resource recovery and by ensuring sustainable resource use and consumption as well depicted by Zaman and Lehmann (2011).

- There needs to be more resources expended in training and educating professionals within the built environment on matters sustainability. The researcher lays special emphasis on the significance of involving every professional in sustainable development and not only those who hold LEED and GREENSTAR certification. It should be part of the school curriculum for students in construction.

- The Kenya Green Building Society (KGBS) launched in 2014 should adopt innovative and affordable ways to offer sustainability services to Kenyans. The challenge is that the services are too expensive for the average Kenyan. The rating system is a good tool to establish sustainable mechanisms within the built environment with inbuilt reverence for integration leading to a healthier relationship with the natural environment. e.g., the IFC Edge tool is internet based and offers the same services, is easily accessible and available.

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APPENDIX A

University of Nairobi

MA Construction Management

RESEARCH QUESTIONNAIRE FOR RUNDA RESIDENTS

[A] CONSUMPTION PATTERNS

1. **On average how often do you buy items from the supermarket?**

   ☐ daily   ☐ weekly   ☐ Monthly

2. **When shopping, I always use a shopping list.**

   ☐ YES   ☐ NO   ☐ Sometimes

3. **When I go shopping, I look for the eco-friendly labeled goods**

Very likely	1	2	3	4	5	Very unlikely

4. **When shopping, I assess the type of packaging and choose one that is recyclable**

Very likely	1	2	3	4	5	Very unlikely

5. **I prefer products with recycled content, to those without.**

Strongly agree	1	2	3	4	5	Strongly disagree

6. **I prefer plastic packaging because it is:**

   ☐ Lighter   ☐ Affordable   ☐ Reusable

7. **I use my own bag when going shopping, rather than those provided for by the shop**

   ☐ YES   ☐ NO   ☐ I am not sure

8. **Are you aware of the existence of biodegradable packaging bags provided in the (some) supermarkets as alternatives to polythene bags?**

☐ YES   ☐ NO

9. **In your opinion, are people acquiring a taste for recycled goods now more than ever before?**

☐ YES   ☐ NO   ☐ I don't know

10. **I have heard advertisements and messages on the need to protect the environment.**

☐ YES   ☐ NO

11. **I talk with friends about problems related to the environment.**

Very likely	1	2	3	4	5	Very unlikely

[B] WASTE MANAGEMENT AT HOME

1. **Reusing and/or recycling waste makes sense.**

Strongly agree	1	2	3	4	5	Strongly disagree

2. **What types of materials do you reuse and /or recycle in your house?**

_____

_____

3. **Do you burn any of your waste?**

☐ YES   ☐ NO   ☐ I am not sure

	Strongly agree			Strongly disagree	
	1	2	3	4	5
4. I try to influence others in the house to segregate waste.					
5. I seek an active role in the management of solid waste in					

my house.					
6. We have set rules around the house as to how to handle waste.					
7. Because of busy schedules, we sometimes leave the helps and care takers to handle the waste management at home.					
8. I always make sure waste is collected in bins and bags and doesn't land on the ground (no littering) even outside our home.					

9. Do you assess what waste goes out and what waste can be reused?

☐ YES   ☐ NO   ☐ I am not sure

10. Recycling plastics saves money.

Strongly agree	1	2	3	4	5	Strongly disagree

11. I clean plastic containers before throwing them away.

Very likely	1	2	3	4	5	Very unlikely

12. Taxes on plastics would be a good way to stop or reduce the increase in plastic use and waste.

Strongly agree	1	2	3	4	5	Strongly disagree

[C] POINT OF CONTACT BETWEEN THE GENERATORS AND COLLECTORS

1. I segregate waste as my own initiative and not because Taka Taka Solutions (TTS) has provided the separate bags?

Strongly agree	1	2	3	4	5	Strongly disagree

2. I would be disappointed if I found out that TTS was still dumping waste in the Dandora landfill despite claims of being sustainable.

Very likely	1	2	3	4	5	Very unlikely

3. **To what extent would it frustrate you if TTS went back to the 1 plastic (pink) bag policy for waste collection (from the two blue and green bags)?**

Very likely	1	2	3	4	5	Very unlikely

4. **Do you think the fee you pay is commensurate to the services rendered?**

☐ YES   ☐ NO   ☐ I don't know

5. **I pay a good deal of attention to the quality of service offered by Taka Taka Solutions (TTS).**

Strongly agree	1	2	3	4	5	Strongly disagree

6. **In the past month, how often would you say you have sought to find out whether TTS is doing their work right?**

_____

_____

7. **I have opportunities to interact with Taka Taka Solutions.**

☐ YES   ☐ NO   ☐ I am not sure

8. **If there were more interaction, there would be more opportunities for awareness and exchange of information.**

Strongly agree	1	2	3	4	5	Strongly disagree

9. **Would you like to be involved in the decision making of this waste management?**

☐ YES   ☐ NO

10. **What suggestions would you give to better plastics' management?**

_____

_____

_____

11. The informal sector has a role in plastic waste management.

Strongly agree	1	2	3	4	5	Strongly disagree

12. How annoyed do you get when you find scavengers rummaging through your waste?

Very likely	1	2	3	4	5	Very unlikely

13. An incentive system should be instituted for companies that integrate the informal sector in their operations

Strongly agree	1	2	3	4	5	Strongly disagree

14. I am willing to participate in recycling programmes for improved plastic waste management?

☐ YES   ☐ NO

15. Do you think that plastics help preserve the environment by reducing other types of waste e.g., metal and glass?

☐ YES   ☐ NO   ☐ I am not sure

Comments

_____

_____

_____

Thank you for your time

APPENDIX B

University of Nairobi

MA Construction Management

RESEARCH QUESTIONNAIRE FOR MANAGEMENT (TTS AND RUNDA WATER)

[A] CONSUMPTION PATTERNS

	Very likely				Very unlikely
	1	2	3	4	5
1. When sorting waste we find material with environment friendly labels					
2. When sorting waste how much recyclable packaging do you find?					
3. Residents clean plastic containers before throwing them away.					
4. How annoyed do you get when you find scavengers rummaging through your waste?					

[B] WASTE MANAGEMENT AT HOME

	Strongly agree				Strongly disagree
	1	2	3	4	5
1. The informal sector has a role in plastic waste management.					
2. The residents always make sure waste in contained in the garbage bags					
3. The estate has a littering problem					
4. Runda residents are acquiring a taste for recycled goods now more than ever before					
5. Residents are willing to participate in recycling programmes for improved plastic waste management					
6. Residents segregate waste with or without separate bags					
7. I wouldn't mind the company transiting back to the 1 garbage bag policy (from the two blue and green bags)					

8. Taxes on plastics would be a good way to stop or reduce the increase in plastic use and waste.					

[C] POINT OF CONTACT BETWEEN THE WASTE GENERATORS AND COLLECTORS

1. **The company (TTS) has opportunities to interact with residents**

   ☐ YES   ☐ NO

2. **Residents are compliant to the service fees**

   ☐ YES   ☐ NO

3. **Residents are involved in waste management and decision making in the estate**

   ☐ YES   ☐ NO

4. **What suggestions would you give to plastics' better management?**

   _____
   _____

5. **Since the beginning of the year, how often would you say you have sought to find out what the residents think of the waste management service?**

   _____

6. **If there were more interaction, there would be more opportunities for awareness and exchange of information.**

Strongly agree	1	2	3	4	5	Strongly disagree

7. **We advertise and engage in messaging to inform the residents about the need to protect the environment.**

   ☐ YES   ☐ NO   ☐ I don't know

8. **Do you think that plastics help preserve the environment by reducing other types of waste e.g., metal and glass?**

   ☐ YES   ☐ NO   ☐ MAYBE

Comments ?

_____
_____
_____
_____

Thank you for your time

ECONOMIC POTENTIAL

ECONOMIC POTENTIAL

American Chemistry Council | Plastics-to-Oil Technologies Alliance

FOR PLASTICS-TO-OIL TECHNOLOGIES IN THE US

The U.S. could support up to 600 PTO facilities, generating nearly 39,000 jobs

Companies are transforming used, non-recycled plastics into oil and petroleum-based products. These plastics-to-oil technologies, which complement ongoing recycling efforts, are being embraced as a way to recover clean energy from plastics that cannot be economically recycled. Growing interest and investments in plastics-to-oil technologies can reduce the amount of waste sent to landfills and generate oil and other useful products to help power America's transportation system and local economies.

38,900 jobs

$6.6 billion
investment to build new facilities

8,800 directly employed

17,200 employed in supply chain industries

12,900 payroll-induced jobs would be supported

$2.1 billion in annual payrolls generated

$8.9 billion U.S. economic output from PTO operations
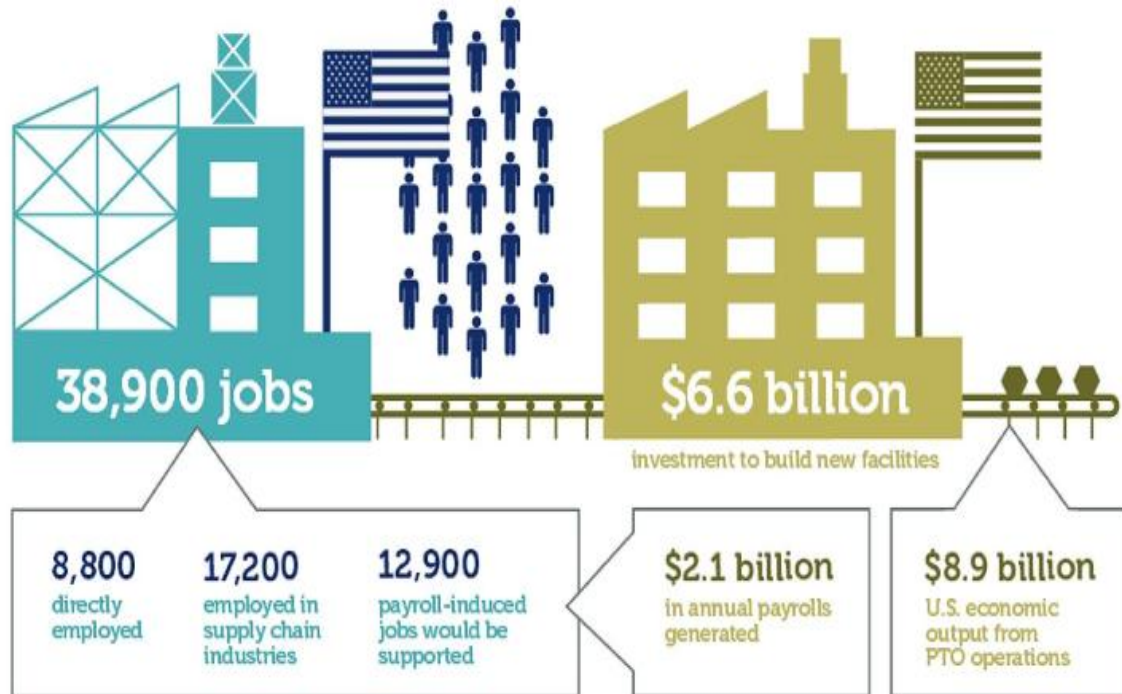
Source: Russell, (2014)

APPENDIX D

ESTIMATED SOLID WASTE MANAGEMENT COSTS

Estimated Solid Waste Management Costs by Disposal Method [1]

	Low Income Countries	Lower Mid Inc Countries	Upper Mid Inc Countries	High Income Countries
Income (GNI/capita)	<$876	$876-3,465	$3,466-10,725	>$10,725
Waste Generation (tonnes/capita/yr)	0.22	0.29	0.42	0.78
Collection Efficiency (percent collected)	43%	68%	85%	98%
Cost of Collection and Disposal (US$/tonne)				
Collection[2]	20-50	30-75	40-90	85-250
Sanitary Landfill	10-30	15-40	25-65	40-100
Open Dumping	2-8	3-10	NA	NA
Composting[3]	5-30	10-40	20-75	35-90
Waste -to-Energy Incineration[4]	NA	40-100	60-150	70-200
Anaerobic Digestion[5]	NA	20-80	50-100	65-150

Estimated Solid Waste Management Costs 2010 and 2025

Country Income Group	2010 Cost[6]	2025 Cost
Low Income Countries[7]	$1.5 billion	$7.7 billion
Lower Middle Income Countries[8]	$20.1 billion	$84.1 billion
Upper Middle Income Countries[9]	$24.5 billion	$63.5 billion
High Income Countries[10]	$159.3 billion	$220.2 billion
Total Global Cost (US$)	**$205.4 billion**	**$375 billion**

Source: Hoornweg and Thomas, (1999)

APPENDIX E

SAMPLE SIZES FOR SMALL POPULATIONS

Estimating the required sample size for surveys measuring proportions					
	Enter data in green area below				
N (population size)	13,000		Required sample size =	21	
z (confidence level)	1.96				
E (+- error)	0.2				
p	0.7				
q	0.3				
Use the following values of z for different levels of confidence:				z	level of confidence
				2.58	99%
				1.96	95%
				1.645	90%
Formula used:					
n = Nz^2pq/(E^2(N-1)+ z^2pq)					

Source: Robert Hubrecht, (2010)