CHARACTERISTICS, DISPOSAL METHODS AND MANAGEMENT OF PLASTIC WASTE IN WATAMU, KILIFI COUNTY, KENYA

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A thesis submitted to the Graduate School in partial fulfilment for the requirements of the Master of Science Degree in Environmental Science of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been submitted or presented for examination in any other university, either in part or as a whole.

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Recommendation

This thesis has been submitted for examination with our recommendation and approval as University Supervisors.

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DEDICATION

I dedicate this thesis to my parents; Patrick Gwada and Jane Gwada, for their continued support and encouragement throughout my studies.

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ABSTRACT

Plastic waste has been and still is a major challenge and concern globally but more so in the developing countries. Plastic has been shown to impact negatively on marine life more specifically marine animals. Watamu ward, in Kilifi County, Kenya, is an important breeding ground for the critically endangered turtles and is being affected by plastic waste. The aim of this study was to assess the characteristics, disposal methods and management of plastic waste in Watamu, in order to contribute to an understanding of the plastic waste disposal practices in the country. The specific objectives were to characterize the plastic waste in Watamu, as well as their streams. Secondly, the study also assessed the factors influencing level of knowledge, attitude and perception among the general public with respect to plastic waste disposal. Thirdly, the study determined the factors that influence plastic waste disposal methods. Finally, the study assessed and described the existing plastic waste management methods in the study area. A social survey was conducted to characterize plastic waste and determine the existing plastic waste management methods in the study area. Stratified random sampling design was used to divide the population of Watamu into groups based on their sub-locations and simple random sampling was used to arrive at the sample for this study. Primary data were collected using observation, structured questionnaire and semi-structured interviews and secondary data from various sources. The data were analysed using descriptive and inferential statistics. The results show that 55.4% of the plastic waste discarded was low density polyethylene that was discarded by the public who were responsible for 69.3% of the plastic waste found discarded. According to the results, 50.7% of plastic wastes were disposed of at the open dumpsite at Timbotaka, in Watamu sub-location. Location of the respondents was a significant factor that influenced the level of knowledge, attitude and perception with respect to plastic waste disposal (FH = 25.729, $p = 0.002$; FH = 16.289, $p = 0.033$; FH = 24.145, $p = 0.009$). It also influenced the plastic waste disposal methods used by respondents (FH = 50.708, $p = 0.000$). Other factors that influenced plastic waste disposal methods include occupation FH = 30.082, $p = 0.038$), waste collection and presence of recycling centres. The existing plastic waste management methods are re-use and small-scale re-cycling done by locals and Eco-world respectively. In conclusion, the proximity of waste disposal sites determines the plastic waste disposal methods used by the locals. Therefore, for environmentally-sound management of plastic waste, disposal sites should be easily accessible. Further awareness campaigns and public education need also to be done on plastic waste management to facilitate proper disposal methods.

TABLE OF CONTENTS

DECLARATION AND RECOMMENDATION ..... **ii**
COPYRIGHT ..... **iii**
DEDICATION ..... **iv**
ACKNOWLEDGEMENT ..... **v**
ABSTRACT ..... **vi**
TABLE OF CONTENTS ..... **vii**
LIST OF TABLES ..... **x**
LIST OF FIGURES ..... **xi**
LIST OF PLATES ..... **xii**
ABBREVIATIONS AND ACRONYMS ..... **xiii**
CHAPTER ONE **1**
INTRODUCTION **1**
1.1 Background Information 1
1.2 Statement of the Problem 5
1.3 Objectives 6
1.3.1 Broad Objective 6
1.3.2 Specific Objectives 6
1.4 Research Questions 7
1.5 Significance and Justification of the Study 7
1.6 Scope and Limitations of the Study 8
1.7 Assumptions of the Study 9
1.8 Definition of Terms and Concepts 9
CHAPTER TWO **10**
LITERATURE REVIEW **10**
2.1 Characterization of Plastic Solid Waste 10
2.2 Quantities and Sources of Plastic Wastes 12
2.2.5 Plastics from Automotive industry 16
2.3 Factors Influencing the Level of Knowledge, Attitude and Perception on Plastic Waste Disposal 17
2.4 Plastic Waste Management Methods and Trends 18
2.5 Impacts of Plastic Waste on Human and the Environmental Health 21

2.6 Legal Framework on Plastic Waste Management 22
2.6.1 Global Environmental Policies 23
2.6.2 Local policies 25
2.7 Household and Institutional level factors influencing waste management 27
2.8 Theoretical Framework 29
2.9 Conceptual Framework 31
CHAPTER THREE 33
RESEARCH METHODOLOGY 33
3.1 Description of the Study Area 33
3.2 Research Design 35
3.3 Sampling Frame and Sample Size 35
3.4 Pilot Study 36
3.5 Data Collection Method 36
3.6 Data Analyses 37
3.7 Ethical Considerations 38
CHAPTER FOUR 39
RESULTS AND DISCUSSION 39
4.1 Demographic Characteristics of the Study Respondents 39
4.2 Characterization of the Plastic Waste and Waste Streams in the Watamu 40
4.2.1 Composition of Plastic Waste Discarded 40
4.2.2 Streams of Plastic Waste 42
4.3 Knowledge, Attitudes and Practice with respect to Plastic Waste Disposal 44
4.4 Factors that Influence Plastic Waste Disposal Methods 49
4.5 Existing Plastic Waste Management Methods in Watamu Ward 53
4.6 Legal Framework 57
CHAPTER FIVE 59
CONCLUSIONS AND RECOMMENDATIONS 59
5.1 Conclusion 59
5.2 Recommendations 59
REFERENCES 61
APPENDICES 72
APPENDIX 1: QUESTIONNAIRE 72

APPENDIX 2: SEMI-STRUCTURED INTERVIEW SCHEDULE..... 77
APPENDIX 3: OBSERVATION CHECKLIST..... 79
APPENDIX 4: NACOSTI RESEARCH PERMIT…….....81

LIST OF TABLES

Table 2.1: Types of plastics and their recycling and re-use potential 12
Table 3.1: Sample size of the population obtained concerning plastic waste from four sub-locations in Watamu at the Kenyan Coast. 36
Table 3.2: Summary of objectives, research questions and statistical tool used in data obtained from Watamu. 37
Table 4.1: Demographic characteristics of respondents in the study area 39
Table 4.2: Distribution of the type of plastic across the four sub-locations. 42
Table 4.3: Knowledge, Attitudes and Practice with respect to Plastic Waste Disposal. 45
Table 4.4: Parameter Estimates Showing How Different Factors Influenced The Education Levels of Respondents 46
Table 4.5: Parameter Estimates Showing How Different Factors Influence Awareness Levels of Respondents 48
Table 4.6: Predictors' Unique Contributions in the Multinomial Logistic Regression 50
Table 4.7: Significant Parameter Estimates Contrasting Those Who Disposed Their Plastic Waste At The Dumpsite Versus Those Who Used Other Means 50
Table 4.8: Level of Education in comparison with Origin 52
Table 4.9: Knowledge of the presence a recycling company or organisation in the area 54

LIST OF FIGURES

Figure 2.1: A modified DPSIR model showing the generation and potential impacts of plastics on the environment 30
Figure 2.2: Conceptual Framework. 32
Figure 3.1: Map of study area within Watamu ward 34
Figure 4.1: The proportion of different types of plastics discarded from households in Watamu. 40
Figure 4.2: The proportion of different types of plastics discarded from households in the four sub-locations of Watamu ward. 41
Figure 4.3: Proportion of plastic litter at different sites at Watamu 42
Figure 4.4: Contribution of various stakeholders to the plastic waste menace in the study area. 43
Figure 4.5: Plastic waste disposal methods used by households in the study area 44
Figure 4.6: Awareness levels of respondents on the effects of plastic waste in the environment. 47
Figure 4.7: Re-use methods of plastic items by households in the study area. 56

LIST OF PLATES

Plate 1.1: Plastic pieces recovered from hawksbill sea turtle at the Watamu Turtle Watch rehabilitation centre in Watamu, Kenya in December 2017 5
Plate 4.1: Plastic wastes discarded adjacent to residential areas (A) and in drainages causing blockage (B) at Watamu. 43
Plate 4.2: Bags made from old sacks. 54
Plate 4.3: Wall built with plastic bottles. 54
Plate 4.4: Crushed plastic that has been sorted into different colours. 55

ABBREVIATIONS AND ACRONYMS

B&C:	Building and Construction
DPSIR	Driving force, Pressure, State, Impact, Response
EEE:	Electrical and Electronic Equipment
ELV:	End-of-Life Vehicles
EAPRRO:	European Association of Plastics Recycling and Recovery Organisations
EPS:	Expanded Polystyrene
EuPC:	European Plastics Converters
EuPR:	European Plastics Recyclers
HDPE:	High Density Polyethylene
LDPE:	Low Density Polyethylene
LLDPE:	Linear Low-Density Polyethylene
MDPE:	Medium Density Polyethylene
MSW:	Municipal Solid Waste
Mt:	Megaton
NEMA:	National Environment Management Authority
PBT:	Polybutylene terephthalate
PET:	Polyethylene terephthalate
POPs:	Persistent Organic Pollutants
PP:	Polypropylene
PS:	Polystyrene
PUR:	Polyurethane
PVC:	Polyvinyl chloride
UNEP:	United Nations Environment Programme
UNESCO:	United Nations Educational, Scientific and Cultural Organisation

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Plastics consist of long chains of beads in which monomers such as ethylene, propylene, styrene and vinyl chloride are interconnected to form a chain referred to as a polymer (Wienaah, 2007). Polymerization process results in the formation of polymers such as polyethylene (PE), polystyrene (PS) and polyvinyl chloride (PVC). One or more types of monomers may be used to make a compound (Johnson, 2017).

Plastics have a variety of uses such as greenhouses, mulches, coating and wiring, packaging, covers, bags and containers. Therefore, it is quite realistic to find a substantial amount of plastic waste in the final stream of municipal solid waste (MSW) (Al-Salem, Lettieri, & Baeyens, 2009). Plastics (synthetic polymers) have attracted more public and media attention than any other component of the solid waste stream because of their durability and visibility in waste. Therefore, environmentally sound management of waste is necessary to prevent environmental pollution.

Plastic waste may come from a variety of sources including households, commercial areas, industries and agriculture. They can be broadly classified as thermoplastics or thermosets. Thermoplastics are plastics that are able to be repeatedly moulded such as PE, PS PVC (Hansen, Nilsson, Lithner, & Lassen, 2013). Thermosets, however, cannot be re-moulded as they undergo chemical changes such as melamine resin, silicone, vinyl (Al-Salem *et al.*, 2009). According to UNEP, plastic waste can be best classified on the basis of the type of polymer from which it has been made such as PS or PVC (UNEP, 2009a).

In East Africa, plastic waste is the third major component of MSW after organic waste and paper waste (UNEP, 2009a). Plastic waste has for a long time presented a challenge when it comes to waste management in Kenya. In Nairobi, for example, 20% of the total waste is said to be plastic waste (KNCPC, 2006). There is a wide variety of plastic materials available commercially in developed countries compared to developing countries where there are fewer types (Wienaah, 2007). In both, however, the most commonly recycled are polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC) which can be subdivided

based on their density, manufacturing process involved and the additives they have (Wienaah, 2007).

Countries with coastal borders dispose of plastics into the oceans with the largest quantities estimated to come from relatively small number of middle-income, rapidly developing countries (Jambeck, Geyer, Wilcox, Siegler, Perryman, Andrady, Narayan, & Law, 2015). This is attributed to the fact that these rapidly developing countries, which also have some of the lowest waste collection rates on the planet, do not have effective waste management systems, and if they do, these are at best informal waste recycling activities (Gugssa, 2012). There is going to be an increase in plastic debris entering the oceans if effective waste collection mechanisms are not implemented and more re-use and recycling initiatives encouraged (Jambeck *et al.*, 2015).

The waste management methods adopted depend on the waste stream, equipment capacity, finance, among others. Sustainable solid waste management is a major concern and the general attitude of individuals to waste as well as the adoption of specific policies that address waste streams is necessary to effectively manage the waste generated (Quartey, Tosefa, Danquah, & Obrsalova, 2015). Incineration as a method of plastic waste management releases carbon dioxide into the air, which is a greenhouse gas. It is therefore neither environmentally friendly nor sustainable to incinerate plastic waste. Similarly, landfilling of plastic waste is not recommended as plastic is non-biodegradable (Quartey *et al.*, 2015).

Plastic waste represents a valuable resource, which can be profitably ploughed back into the economy and the venture into plastic waste recovery has been ongoing since the 1990s by community based organizations that are in part propelled by a general lack of employment and high poverty levels (Republic of Kenya, 2010). In Watamu, recycling machines were donated to the Eco-world (formerly Watamu Community Solid Waste Management and Recycling Enterprises) to enable them to recycle plastic materials to deal with plastic waste menace and thereby promote a clean environment for both the locals and tourists. This would thereby not only enable the Eco-world to earn income from the recycling activity but also alleviate poverty through employment of locals.

Much of the plastic waste in East Africa is littered on public places, dumped at illegal sites and blocks drainage and sewer systems. As such plastic waste affects public health, water and

sewerage services and tourism, among others. Mismanagement of landfills could cause either the escape of plastic waste or the escape of landfill leachate containing the chemicals associated with plastic (European commission, 2011a). Moreover, informal recycling techniques especially in developing countries can lead to the release of dioxins into the environment for instance, the burning of plastic coated wires to obtain metal (European commission, 2011a). Short-term exposure to dioxins may result in skin lesions and patchy darkening of the skin and altered liver function. The worst and typical representative of dioxins is the 2,3,7,8-Tetrachlorodibenzo – p – dioxin (TCCD) that causes a condition in the skin called chloracne which resembles severe acne due to exposure to chlorinated chemicals (Ju & Zouboulis, 2013). Long-term exposure to dioxins impairs the immune system. It also affects the development of the nervous, the endocrine systems and reproductive organs especially development of sex organs in the foetus (Ithula, 2012).

Plastic waste often finds its way to the sea where it causes entanglement (such as when fishing nets and ropes are abandoned or lost in the sea) and ingestion when plastic items are confused for food by marine animals leading to digestive complications and ultimately death (Derraik, 2002; Gregory, 2009). The harm brought about by ingestion of plastic materials will vary from one animal to another depending on their digestive system, the quantity and type of plastic ingested as well as the developmental stage of the animal (European commission, 2011a). Juveniles will be more at risk because they cannot discriminate between suitable food items (Gerpe, Rodríguez, Moreno, Bastida, & Moreno, 2002), and sometimes parents will accidently feed plastic to offspring.

Plastics have been said to produce toxic substances (such as dioxins) that can be linked to cancer as well as medical complications in the reproductive system as they are hormone disruptors (Soffar, 2015; Verma, Vinoda, Papireddy, & Gowda, 2016). They contain chemicals or additives to give it certain properties (Hansen *et al*., 2013) that make them ideal for various applications, for example bisphenol A is used to make polycarbonate plastics such as refillable plastic water bottles, cell phones, CDs and DVDs (Global Industry Group, 2002). Phthalates are mainly used as plasticizers to make plastics more flexible such as in detergents, raincoats, personal-care products like shampoos, hair sprays, and nail polishes (Centers for Disease Control and Prevention, 2017). Brominated flame retardants are used in plastic applications such as electronics, carpets, paints and kitchen appliances and are highly fat-soluble (Janssen,

2005). Bisphenol A (4,4'-(propane-2,2-diyl)diphenol), phthalates and brominated flame retardants have been linked to various health problems in human beings such as prostate cancer, breast cancer, sperm count decreases, miscarriage, obesity, allergies, impairments in the development of the reproductive and nervous system and type 2 diabetes (European commission, 2011a).

In Kenya, most people are not able to access waste collection services and it is common to find plastic waste at disposal sites and open areas (Oyake-Ombis, 2016). In addition, the throw-away culture has thrived in the Kenyan society due to the fact that most plastic items are relatively cheaper than items made from other materials (Aurah, 2013a). As a result, the plastic waste menace has become a problem in all counties in Kenya. In Watamu, Kilifi county, data collected from the annual international beach clean-ups have indicated that in Watamu beaches, the most common types of plastic waste found along the beach constituting marine debris are small plastic pieces, polystyrene, plastic bottle caps, plastic bottles and flip flops (Trott, 2015b). As a result, out of the turtles brought to Watamu Turtle Watch Conservation for rehabilitation each year, 15% are harmed by plastic (Jena, 2017) leading to death arising from digestive complications (Plate 1.1). Although most of the waste in Watamu beaches is washed ashore from other countries in the Southwest Indian Ocean due to the nature of ocean currents, there is still a considerable amount that is as a result of poor waste collection and disposal (Trott, 2015a). Watamu being a peri-urban centre, has a lot of economic activities occurring such as businesses, fishing, and tourism that are likely to generate plastic wastes that end up in the beaches. However, there are still a number of informal actors and formal industrial actors have come up to handle waste collection and recycling (Oyake-Ombis, 2016).

Plate 1.1: Plastic pieces recovered from hawksbill sea turtle at the Watamu Turtle Watch rehabilitation centre in Watamu, Kenya in December 2017 (Source: Thomson Reuters Foundation/Manipadma Jena).

1.2 Statement of the Problem

Marine debris is a problem along the Kenyan coast. Non-biodegradable wastes such as plastics often find their way into the oceans, polluting the beaches and threatening vulnerable marine life. Along the beaches and in the streets of Watamu it is common to find plastic bottles, sweet wrappers, broken glass and plastic bags. There has been growth of plastic use in Kenya, which has resulted to more plastic waste. Plastic waste is no longer an urban problem confined to urban towns but an environmental problem throughout the country. Watamu, being an important breeding ground for the critically endangered green, hawksbill, olive ridleys, loggerheads and leatherbacks turtles, is affected by plastic waste. There have been cases of plastic ingestion (which causes digestive complications) and entanglement by domestic

animals, turtles and other marine animals such as humpback whales, which in most cases has led to their death. In addition, the coral formations in Watamu, which are said to be the best in East Africa, are also affected by poor plastic waste management. Moreover, the burning of plastic waste is linked to heart diseases, respiratory problems such as asthma and emphysema and causes rashes, nausea or headaches, and damages the nervous system. While most plastics are regarded as nontoxic (Polyvinyl chloride, PVC, being an important exception), they are unstable, and may decompose and release hazardous substances under the influence of light, heat or mechanical pressure. The monomers, from which polymers are made, may be released and may affect human health such as styrene, used in the manufacture of polystyrene (PS), which affects the central nervous system and has been linked to cancer. The huge quantities of plastic waste that are usually collected are not only an eyesore but also pose a problem to tourism in the area by reducing the aesthetic value. This affects the locals who are heavily reliant on the tourism sector. Most of the studies on waste management have focussed generally on solid waste and hazardous waste. There is little information available on studies done in Kenya on plastic waste, especially looking at the social aspect of plastics in terms of usage by households and management. Moreover, studies that have looked at plastic waste usage and disposal have been in major cities and have concentrated on plastic bags and not looked at the disposal of other types of plastics as well. Research has been done for micro plastics in seawater and sediments in Gazi Bay, South Coast of Kenya, which showed that there is a high degree of pollution. Coastal waters in Kenya are therefore polluted with plastic debris and it is important to examine the possible sources of these plastic waste, amongst which are disposal by households. There was therefore need for this research to be done to assess the characteristics, disposal methods and management of plastic waste in Watamu, Kilifi County, Kenya.

1.3 Objectives

1.3.1 Broad Objective

The main objective of the study was to contribute towards an understanding of the plastic waste disposal practices by assessing the characteristics, disposal methods and management of plastic waste in Watamu, Kilifi County, Kenya.

1.3.2 Specific Objectives

i. To characterize the plastic waste in Watamu, Kilifi county, as well as their streams.
ii. To assess the factors influencing level of knowledge, attitude and perception among the

general public with respect to plastic waste disposal.

iii. To determine the factors that influence plastic waste disposal methods.

iv. To assess and describe the existing plastic waste management methods in the study area.

1.4 Research Questions

i. How can plastic waste produced in the study area be characterised?

ii. What factors influence the level of knowledge, attitude and perception of locals on plastic waste disposal and the management?

iii. What factors influence plastic waste disposal methods?

iv. What are the existing plastic waste management methods in the study area?

1.5 Significance and Justification of the Study

This project was significant as it contributed to ongoing activities aimed at ensuring that all people's right to a clean and healthy environment is protected as stated in Article 42 of the Constitution of Kenya, 2010. This is essentially through proper management of plastic waste. The National Environmental Management Authority through the Kenyan Parliament, passed a bill on 28th February 2017 that banned the manufacture, use and importation of all plastic carrier bags in Kenya (NEMA, 2017). The study, however, was carried out before the Act came into force on 28th August 2017. However, the ban only covers plastic carrier bags which are represented by 25% of the plastics manufactured in the country (KNCPC, 2006). Hence, the Kenyan population still have to deal with the problem of plastic waste, which also constitutes other forms of plastics other than plastic carrier bags such as plastic bottles, food wrappings, and sweet wrappings. Therefore, before the ban of plastic carrier bags, the study contributed to Vision 2030 under the social pillar in the environmental sector (Government of Kenya, 2007). This ban covers only the manufacture, use and importation of plastic carrier bags and not all plastic items. One of the flagship projects that were rolled out in 2012 was the Plastic Bags Initiative which sought to tighten the regulations to limit production and usage of environmentally-detrimental plastic bags (Government of Kenya, 2007). However, with the current ban, the study was significant in justifying the reasons for banning plastic carrier bags as well as highlighting other types of plastics that are also a cause of concern.

The study contributed to activities aimed at attaining Sustainable Development Goals (SDGs) for 2030 adopted by the United Nations such as goal 12, which aims at ensuring sustainable

consumption and production patterns. The study findings helped in activities aimed at achieving one of the specific targets of goal 12 that is substantially reducing waste generation by prevention, reduction, recycling and re-use by the year 2030. The project contributed towards ongoing activities targeting the protection of marine and coastal ecosystems by contributing to the reduction of plastic litter that gets to the oceans through proper plastic waste management. It therefore helped activities aimed at attaining goal 14, which protects life below water.

The study findings are of benefit to investors and other entrepreneurs as it provides them with information on the opportunities available in terms of plastic recycling which will contribute to economic growth in the country and help achieve goal 8 of the SDGs that is to promote inclusive and sustainable economic growth and decent work for all. This will in turn help in reducing poverty, which is a current problem in Kilifi county, and worse in Watamu. The academia will also benefit from the study, as they will be able to get information on the status of plastic waste in Kenya, as well as get insight for further research in areas of plastic waste management.

1.6 Scope and Limitations of the Study

The study area covered Watamu ward and focused on the characteristics, disposal methods and management of plastic waste in Watamu, Kilifi County, Kenya. The scope involved the landscape of plastic waste in Watamu (location of the plastic waste), the players in plastic waste production and management, as well as the opportunities in plastic waste recycling. This is necessary because there has been a problem of solid waste management in Kenya, and more so plastic waste which is non-biodegradable. The study took place between June 2017 and August 2017.

Limitations

i. Illiteracy was a limiting factor as some of the respondents were not be able to fill in the questionnaires. This was mitigated by the use of a local educated research assistant who assisted in the collection of data from the study area.
ii. There was also language barrier, which affected communication between the researcher and the respondents. The local educated research assistant assisted in translation.

1.7 Assumptions of the Study

i. The households selected was a true representation of the plastic waste disposal and management practices in Watamu.
ii. Responses from respondents in Watamu ward were true, honest and transparent.
iii. There was a relationship between the independent variables and the dependent variable.

1.8 Definition of Terms and Concepts

Characteristics: This term has been operationalized to encompass the disposers of plastic waste as well as the locations of plastic waste

Composition: In this study, this term has been operationalized to mean the types of plastic waste that are discarded by households

Culture: In this study, this term has been operationalized to mean the social characteristics of the respondents such as beliefs and customs

Disposal methods: This term has been used in the study to reefer to how individuals discarded their plastics after its initial use

Disposer: This term has been operationalized to encompass people or institutions that pollute the environment through improper plastic waste disposal methods

Knowledge, Attitude and Perception: In this study, these three terms were operationalized to refer to the education and awareness of respondents on matters to do with plastic waste disposal

Location: This term has been operationalized to encompass the area in which respondents were stationed, in terms of urban and rural areas

Management of Plastic Waste: In this study, this term has been operationalized to encompass the means used by households to manage their plastic waste such as by taking for recycling or by re-using.

Plastic waste: In this study plastic waste was operationalized to mean the most commonly disposed synthetic polymers that were being discarded by households

Segregation: This referred to the separation of plastics from other types of solid wastes generated at the households

CHAPTER TWO
LITERATURE REVIEW

2.1 Characterization of Plastic Solid Waste

There are two types of plastics: thermoplastics and thermosetting polymers. Thermoplastics do not undergo chemical change in their composition when heated and can be moulded repeatedly (Hansen *et al.*, 2013). Examples of thermoplastics include polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), polyamides (PA), polycarbonate (PC), polyvinyl chloride (PVC), polystyrene (PS) and polytetrafluoroethylene (PTFE), among others (Hansen *et al.*, 2013; Thakur, 2012). Thermosets are assumed to have infinite molecular weight. That is, they are made up of many repeating molecular units derived from monomers; each polymer chain will therefore have several thousand repeating monomers (Thakur, 2012). They can melt and be moulded into various shapes but are not suitable for repeat heat treatments (UNEP, 2009a). Thermosets remain solid after they have been solidified and the chemical reaction which takes place in the thermosetting process is irreversible. For example, vulcanization of rubber is a thermosetting process (Thakur, 2012). Examples of thermosets include polyurethane (PUR), melamine resin, silicone, vinyl ester, unsaturated polyester, among others (UNEP, 2009a).

It is important to note that thermoplastics contribute to the total plastic consumption by about 80%, and are used for typical plastics applications such as packaging but also in non-plastic applications such as textile fibres and coatings (Brems, Baeyens, & Dewil, 2012). Plastics are classified on the basis of the polymer from which they are made (UNEP, 2009b). There are seven classes of plastics namely Polyethylene terephthalate (PET), high density polyethylene (HDPE), polyvinyl chloride (PVC), low density polyethylene (LDPE), polypropylene (PP), polystyrene (PS) and others.

Table 2.1: Types of plastics and their recycling and re-use potential (Source: Seaman, 2012)

Plastic Type	**Example of applications**	**Assigned number and recycling and re-use potential**
Polyethylene terephthalate (PET)	Salad dressing containers, processed meat packages, plastic soft drink and water bottles.	1 – recycled but not re-used
High density polyethylene (HDPE)	Milk bottles, shampoo bottles, detergent bottles, oil jerry cans, and toys	2 – Re-usable and recyclable
Polyvinyl chloride (PVC)	Fruit plastic packing, sweet trays and blister packaging.	3 – not recyclable nor re-usable*
Low density polyethylene (LDPE):	Bread bags, frozen food bags, squeezable bottles, fibre, bottles, clothing, furniture, carpet, shrink-wraps and garment bags.	4 – re-usable but rarely recyclable
Polypropylene (PP)	Margarine and yogurt containers, caps for containers, and wrapping to replace cellophane.	5 – reusable but rarely recyclable
Polystyrene (PS)	Egg cartons, fast food trays, and disposable plastic silverware.	6 – reusable but rarely recyclable
Other	This includes.an item which is made with a resin other than the six listed above, or a combination of different resins	7/none – not recyclable nor re-usable except those with polylactic acid (PLA) coding underneath

* Although it isn't recommended to re-use PVC, it can be repurposed for other functions excluding food and children use (Seaman, 2012)

Globally, polyethylene (PE) has the highest share (29.1%) of total production of any polymer type followed by polyethylene terephthalate (PET), which accounts for 20% of thermoplastic resin capacity (European commission, 2011b). Polypropylene (PP) accounts for 18%, followed by polyvinyl chloride (PVC) that accounts for 15.3%, and polystyrene/expanded polystyrene (PS/EPS) that accounts for 7.8%. Other polymer types account for 9.8% (European commission, 2011b). In terms of plastic conversion demand by industries, PE accounts for 28%, including low density, linear low density and high-density polyethylene (LDPE, LLDPE and HDPE, respectively).

Other than their chemical resins, plastics can also be classified based on physical properties. Colour for example, can be used in identifying different types of plastics using Visible (VIS) Reflectance Spectroscopy or Near Infrared (NIR) Reflectance techniques (Safavi, Masoumi, Mirian, & Tabrizchi, 2010; Tachwali, Al-Assaf, & Al-Ali, 2007). In the study area, however, there is no data on the kinds of plastic waste being disposed of. In order to manage plastic wastes more appropriately, there is need to know the kinds of plastic that are produced so as to know the treatment options that are best suited.

2.2 Quantities and Sources of Plastic Wastes

The EU accounts for about 25% of the world's plastic production while China produces the largest amount of plastic as a country at 15% of global production (European commission, 2011b). In Europe, Germany is the largest producer accounting for about 8% of global production while the Middle East and Africa combined produces 8% of global production (European commission, 2011b).

The major sources of plastic waste are naturally the sectors which have the highest plastic utilization. In 2008, in the European Union, including in Norway and Switzerland, packaging was found to be the largest contributor to plastic waste at 63%, while "others" which includes furniture and medical waste contributed 13%. The remaining sectors include: automotive (5%), electrical and electronic equipment (EEE- 5%), building and construction (B&C- 6%) and agriculture (5%) (European commission, 2011b).

About 80% of plastic entering the sea comes from land-based sources such as drinks bottles and plastic packaging (Eunomia Research and Consulting Ltd., 2016). The rest of the trash sources from ships and platforms that are offshore (Andrews, 2016) as well as lost or discarded

fishing gear (Eunomia Research and Consulting Ltd., 2016). The most awful thing is that these plastics are not biodegradable and hence breakdown into tiny pieces that are consumed by fish and sea mammals. Moreover, plastic is estimated to be killing more than 100,000 sea turtles and birds each year from ingestion and entanglement (Andrews, 2016).

In Ghana, 270 tonnes of plastic waste are disposed each day in the country's capital, Accra, and it is estimated that plastic water sachets account for about 85% of that refuse (IRIN, 2004). In South Africa 1,084,400 tonnes of plastic waste were sent to South African landfills in 2014 (Motsoai, 2015). In addition, 22.5% of plastic waste disposed in 2014 was recovered and recycled compared to 20% of the previous year (Motsoai, 2015).

In Kenya, over 48 million plastic bags are produced each year (Bashir, 2013). In 2004, the plastic manufacturing sub-sector grew by 2.9%. To this end, manufacture of plastic crates, bottles and plates increased by about 20%, 6.8% and 12.7%, respectively (Kenya National Bureau of Statistics, 2005). Over 70 plastic industries exist in Kenya with capacities ranging from 725.7 – 907.2 tonnes per annum (Muchane & Muchane, 2006). Kenya used to produce about 3628.739 tonnes of plastic waste per month before the plastic ban (Horvath, Mallinguh, & Fogarassy, 2018).

2.2.1 Plastics in Municipal Solid Waste

Municipal solid waste (MSW) comprises of waste collected by municipalities or local authorities such as household waste, garden and park waste and institutional (Pipatti, Sharma,Yamada, Alves, Gao, Guendehou, Koch, Cabrera, Mareckova, Oonk, Scheehle, Smith, Svardal, Vieira, 2006). Municipal solid waste accounts for approximately 40-50% of plastic waste in the EU-27 (Villanueva, Delgado, Luo, Eder, Catarino, Litten, 2009). In MSW, all plastics are found mixed with other types of waste.

The plastics fraction of MSW can differ from one country to another and is also dependent on the season. In 2007, MSW plastic generation in central Europe ranged from 9.6% in the winter to 10.5% in the summer. In Eastern Europe, plastic waste accounted for 5% of MSW in winter and 13% in summer (European commission, 2011b). Hence, the general trend is that there are more plastic wastes being generated during summer. A large share (70%) of MSW plastics consists of packaging items but house ware items (toys, leisure and sports goods) or small EEE are also discarded by households (Delgado, Barruetabeña, & Salas, 2007). According to data

for the 1990s, HDPE, LDPE and PP together account for 60% of plastics in MSW while PET and PS are also noteworthy and the share of the remaining resins represent approximately 10% (Delgado *et al.*, 2007).

Several studies indicate that much of the MSW from developing countries are generated from households (55-80%), followed by commercial or market areas (10-30%) with varying quantities from streets, industries, institutions among others (Nabegu, 2010; Nagabooshnam, 2011; Okot-Okumu, 2012). Waste plastics in MSW in developing countries constitute the third largest component, after food and paper (UNEP, 2009a). In Ghana, considerable amounts of plastic waste can be found within the MSW stream due to the littering habit of the population (Wienaah, 2007). On an average, the rate of waste generation in ten regional capitals of Ghana is 0.51/person/day while in the whole of Ghana it is averaged to 0.47 kg/person/day (Miezah *et al.*, 2015). In Eastern Africa, 5.5% of MSW comprises of plastics (Pipatti *et al.*, 2006). In Nairobi, food waste (51.5%) constitutes the major portion of MSW, followed by plastic waste (11.8%) which is the main problem facing Kenya and other countries because they are non-biodegradable (ILO, 2001).

2.2.2 Plastics in Packaging Applications

Approximately 30% of plastics are used worldwide for packaging applications such as food, pharmaceuticals, cosmetics, detergents and chemicals (Thakur, 2012). The most commonly used plastics used for packaging are polyethylene (LDPE, MDPE, HDPE, and LLDPE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), polyurethane (PUR), polybutylene terephthalate (PBT), and nylons (Thakur, 2012).

The utilization of plastics is still growing at a high rate of 12% per annum (Shimao, 2001). Plastic packaging accounts for a huge portion of total plastic waste in most Europe Member States. Germany was the largest contributor to plastic packaging waste disposed in the European Union in 2007, having generated 2,358,680.3 tonnes, with Italy at 2,086,524.9 tonnes and the UK and France, with 2.1 Mt each (European commission, 2011b). Most packaging is collected from the commercial and industrial sectors. Mainly PET and HDPE bottles are recovered from MSW.

In the developing world, 42% of plastic used in India is in packaging (Mutha, Patel, & Premnath, 2006). The general increase in per *capita* income, in South Africa, Kenya and

Nigeria, has led to the rise in consumption of packaged foods (Wood, 2016). South Africa is the most self-dependent market in plastic production, with raw materials being produced locally, while Kenya is to a huge extent dependent on imports, and Nigeria obtains half its supplies from international distributors (Wood, 2016). In South Africa, the majority of the plastic that was recycled in 2011 was from packaging (76.7% of total plastic recycled) and there was an increase in the amount of packaging plastic recycled from 182,032 tonnes in 2010 to 188,466 tonnes in 2011 (Botes, 2012). Moreover, a recovery of 32.9% of all plastic packaging material was achieved in 2014 (Motsoai, 2015).

2.2.3 Plastics from Construction and Demolition Sector

The construction sector accounts for only 6% of the plastic waste generated each year despite the fact that it is the second largest consumer of plastics in Europe (EuPR, 2010). This is because plastics used in the construction sector are designed to be durable. However, plastic building materials are often contaminated, making recycling difficult.

In developing countries, there might not be a significant amount of waste plastics in construction and demolition waste, nonetheless it might be present in the form of packaging materials or parts of equipment or materials itself (e.g. pipes) (UNEP, 2009a). Segregation of the plastics from other streams of waste is therefore recommended. In addition to it PVC should also be segregated from other plastics as a separate stream (UNEP, 2009a).

2.2.4 Plastics from Electrical and electronic equipment (EEE)

Plastic waste amounting to about 1.4 Mt was generated from EEE in Europe in 2008 (Association for Plastics Manufacturers, 2009). The service life of EEE is estimated to be around 3-12 years, with larger objects having a longer service life. In South Africa EEE consume 6% of plastics (Hanekom, 2014). More plastic waste is being produced today than in previous years due to the nature of products that use plastic which have an increasingly short lifespan such as the mobile phone whose plastic components contain several toxic substances (Nnorom & Osibanjo, 2009). In developing countries there is potential for environmental pollution and human health impacts when open burning of these substances is done (European commission, 2011a).

Kenya usually receives plenty of containers carrying EEE through port of Mombasa. These go to their various destinations and unlike in developed countries, where personal computers

become obsolete after 3 years, in Kenya, computers are used even after 7 years whereby they are re-sold at reduced prices before finally ending up in landfills, being burned or getting dumped (WEEE Centre, 2017). NEMA established some e-waste guidelines to rationalize procedures for handling and disposing e-waste. The draft Environmental Management and Co-ordination (E-Waste Management) Regulations 2013 provides the applicable legal and institutional framework as well as the structures for managing e-waste handling, collection, transportation, recycling and safe disposal.

2.2.5 Plastics from Automotive industry

Despite a relatively high recycling rate for End-of-Life Vehicles (ELVs), there is extremely low recycling of plastics from ELVs being done. This is because of the wide range of polymer types used. Generation of plastic waste is increasing at a slower rate than packaging plastic. At European level, 1,270,058 tonnes of plastic waste were generated from ELVs in 2008 (Association for Plastics Manufacturers, 2009). Data from the Department of Trade and Industry in South Africa revealed that automotive sector consumes about 7% of plastics, which is third after packaging which is the largest consumer and consumes 53% (about 820,000 tonnes) and construction which consumes 11% (Hanekom, 2014). In addition, there is high growth potential of this sector due to the increased use of plastic to increase fuel efficiency (Hanekom, 2014) which could increase the quantities of plastic waste generated if not managed in an environmentally sound manner.

In Kenya, the automotive industry is involved in the assembly, retail and distribution of motor vehicles. Plastic is usually used in packaging items such as detergents for washing screen, car shampoos, oil and greases. This is because of its qualities such as being light, shatterproof, durable and easy to clean.

2.2.6 Plastics from Agricultural sector

Agricultural sector produces about 362,873 tonnes of plastic waste per annum in the EU (Bos, Makishi, & Fischer, 2007; Delgado *et al.*, 2007). The most substantial source of plastic waste is pipes and fittings at 181,436.9 tonnes, with agricultural packaging (bags, liners and containers), collectively, accounting for 71,667.6 tonnes. In the UK, non-packaging plastic film in this sector accounts for around 77,110.7 tonnes of the plastic disposed of each year (European commission, 2011b).

In Uganda, 3,000 tonnes of plastic bags are dumped into soils annually, which have led to a decline in soil and agricultural productivity, the backbone of the national economy (Kabasa, 2010). In addition, 60% of stray cattle death has been as a result of polythene bags consumption (Kabasa, 2010). Approximately 27,000 hectares (ha.) of the land in Africa is covered by greenhouses and large plastic tunnels (Brown, 2004) and there is therefore need to properly manage their disposal to avoid pollution.

The composition of plastics in MSW is estimated to be about 15.8% in highly populated areas and 13.8% in lowly populated areas of Nairobi in Kenya (Khamala, 2011). In 2011 in Watamu, Kilifi County, approximately 18 tonnes of waste was removed from the beaches during a clean-up of which about 6 tonnes were plastic (Heuër, Kloibhofer, Marquard, & Zürker, 2015). However, the streams of these plastic wastes were not documented. This study intends to use Watamu to establish the streams of plastic waste being generated in the study area.

2.3 Factors Influencing the Level of Knowledge, Attitude and Perception on Plastic Waste Disposal

A fourth of diseases facing mankind today are said to occur due to continued exposure to environmental pollution (Kimani, 2007; Prüss-Üstün & Corvalán, 2006). Dumpsites are a common occurrence in African cities (Rotich, Yongsheng, & Jun, 2006). These generate environmental and health hazards due to the unregulated and indiscriminate dumping of waste materials.

When waste materials in the sites decompose, methane is produced, and this may cause fire and explosions, as well as pollute surface and ground water (Njagi, Ireri, Akunga, Afullo, Ngugi, Mwanzo, & Njagi, 2013). Since most dumpsites are in an open area, waste may be blown away by the wind, making it an eyesore as plastics litter the area around the dump (Mangizvo, 2010; Oyelola, Babatunde, & Odunlade, 2009). When there are more individuals in a household, more people are at risk and the longer people live in a contaminated area, the more likely it is that they suffer the related health risks (Olorunfemi, 2009).

The education level attained affects knowledge of individuals, attitude and perceptions of several issues (Njagi *et al.*, 2013). From demographic and health survey of 2008-2009, at least 53% of the population have secondary education and above in Kenya (KNBS & ICF Macro, 2010). There is a significant relationship between the level of education of participants and

their knowledge on the health risks posed by a dumpsite as more knowledgeable participants perceived themselves at a high risk of health issues compared to the less knowledgeable ones (Njagi *et al.*, 2013). High level of literacy is deemed advantageous for its role in impact studies (Olorunfemi, 2009).

For waste minimisation programs by local authorities to be effective, there is need to involve the public (Suttibak & Nitivattananon, 2008; Tonglet, Phillips, & Bates, 2004; Troschinetz & Mihelcic, 2009). Programs that create public awareness as well as public willingness are among the factors that influence the success of waste recycling. The attitude of the public is positively influenced by the presence of appropriate facilities, being educated about recycling and general concern for the community's wellbeing (Tonglet *et al.*, 2004).

Environmental education plays an important role in waste management efforts (Idowu, 2017). Moreover, responsibility is created among different communities and there is an increase in environmental accountability. It also encourages the sensible use of environmental resources. There is need to create a means for stakeholder involvement and dialogue so as to empower and enable the public to participate in sound environmental management practices (Njagi *et al.*, 2013). In a study conducted by Mukama, Ndejjo, Musoke, Musinguzi, Halage, Carpenter, & Ssempebwa (2016), residents in slum areas showed more concern for high vector populations and high burden of diseases related to poor solid waste management than that for the presence of wastes in their neighbourhood. This indicates that community members lacked knowledge on the relationship between poor solid waste management and its consequences. There is therefore need for awareness campaigns on proper solid waste management with emphasis on the most significant impacts on public health (Mukama *et al.*, 2016).

There is a study gap in terms of the local understanding of the relationship between poor solid waste management and environmental and health effects in Watamu. The study filled this gap by assessing whether the locals had confidence in their understanding of what plastic waste was and the impacts of plastic waste on the environment.

2.4 Plastic Waste Management Methods and Trends

2.4.1 Plastic Waste Management in Developed Countries

In 2007, plastic production in the world rose to around 260 million tonnes (PlasticsEurope Market Research Group (PEMRG), 2008). In Europe, this brought about the generation of 24.6

million tonnes of post-consumer plastic waste that were mainly in the packaging, construction, automotive and electrical and electronic equipment sectors (PlasticsEurope Market Research Group (PEMRG), 2008). Half of this waste was disposed of in landfills, while 20% was recycled and 30% was recovered as energy (Jan-Erik Johansson, 2008). In US, plastic solid waste found in MSW increased from 11% in 2002 (USEPA, 2002) to 12.1% in 2007 (USEPA, 2008).

The treatment option for plastics largely preferred environmentally is mechanical recycling. In order to achieve the most environmental benefits from recycling, focus is placed on recycling high quality plastic waste (Lazarevic, Aoustin, Buclet, & Brandt, 2010). Mechanical recycling is however, not the only recycling option. Feedstock recycling (also called chemical recycling) represented 63,502.9 tonnes in 2008 (European commission, 2011b). However, mechanical recycling is the main cause of the increase of the recycling rate from 19.5% in 2006 to 21.3% in 2008 contrasted to feedstock recycling which did not affect the recycling rate but remained at 0.3% (European commission, 2011b).

The use of a lot of plastics in packaging, however, can have important repercussions on the plastics recycling industry, affecting collection systems and quality owing to contamination and use of mixed plastics (European commission, 2011b). Packaging is largely mechanically recycled and is normally the first type of waste to be recovered. However, depending on the type of plastics, the recycling rates are very diverse (Jan-Erik Johansson, 2008). The overall recycling rate of packaging waste (household and commercial) across the EU in 2008 was 29% (28.5% mechanical recycling and 0.5% feedstock) and the recovery rate was estimated at 58%. Energy recovery in MSW incinerators was achieved for 6,168,856 tonnes of plastic waste (27.3% of post-consumer waste) and through other processes (power plants, cement kilns, waste derived fuel) for 612,349.7 tonnes of plastic material (2.7% of post-consumer waste) (European commission, 2011b).

2.4.2 Plastic Waste Management in Developing Countries

As applications for plastics increase as well as the growth in plastic use in developing and emerging economies, plastic production may increase in future. There is therefore need for proper waste management so as to prevent plastic waste increase that will enhance the ‘back log’ of plastic waste already in existence (Kershaw, Katsuhiko, & Lee, 2011).

There has been a perpetual increase in the use of plastic products over the years, which has resulted in an equal increase in plastic waste in solid waste streams in sub-Saharan Africa (Quartey *et al.*, 2015). Over the last few decades, there has been a steady increase in the use of plastic products resulting in a proportionate rise in plastic waste in solid waste streams in large cities in sub-Sahara Africa (Fobil & Hogarh, 2006).

In Africa, waste management in most countries is handled by municipal authorities who have often failed because this is beyond their capacity. Waste management problems in Africa often face infrastructural, political, technical, social/economic, organizational, regulatory and legal issues which need to be dealt with (Mwesigye, Mbogoma, Nyakang'o, Idan, Kapindula, Hassan, & Berkel, 2009). Waste collection trucks are in most cases unable to access rural areas because of poor roads. This has led to the accumulation of wastes in drains and open grounds which is a health hazard and has a negative impact on the air and water quality (Rotich *et al.*, 2006). As a result of low economic development, developing and least developing countries have an informal waste recycling activity (Gugssa, 2012) which is often carried out by scavengers without considering the health risks they are exposing themselves to (Abu Qdais, 2007). Therefore, there is need to regulate waste picking activities for purposes of employment, effective waste collection and occupational safety (Zhang, Keat, & Gersberg, 2010).

There are at least four major types of informal sachet waste recovery and recycling activities, namely itinerant waste buyers, street waste picking, municipal waste collection crew and waste picking from dumps. Itinerant waste buyers comprise of waste collectors who are involved in collecting (usually door to door) and marketing sorted dry recyclable materials (Gugssa, 2012; Wilson, Velis, & Cheeseman, 2006). This type of informal waste collection is universal. Street waste picking involves the recovery of recyclables from mixed waste on the streets or from communal bins while municipal waste collection crew involves the recovery of recyclables from trucks carrying MSW to the dumpsite. Waste picking from dumps comprise of waste collectors who recover recyclables from dumpsites before being covered (Gugssa, 2012; Wilson *et al.*, 2006). Plastics collection and disposal practices such as those in slum areas may make it challenging for recollection, recycling, and profitable reuse by recycling companies and individuals. To ease their collection, incentives for separation and collection of plastics can be given (Mukama *et al.*, 2016).

There is however a study gap in terms of the documentation of the plastic waste management methods adopted by coastal residents in Africa and their effectiveness. There is need to document these so as to know which strategies should be used to improve on the management methods in place. This study therefore looked at how Watamu residents manage their plastic waste and who is responsible for plastic waste management.

2.5 Impacts of Plastic Waste on Human and the Environmental Health

More than two thirds of plastic litter ends up on the sea bed with half of the remainder washed up on beaches and the other half floating on or under the surface (UNEP, 2005). In Gazi Bay in the South Coast of Kenya, for example, there was a high degree of pollution as a result of the presence of micro plastics in seawater and sediments (Janssen, Rycke, & Cauwenberghe, 2014). Poorly-disposed of plastics play significant role in potentially harming life by causing environmental pollution. In addition to this, the burning of polyvinylchloride (PVC) plastics produces persistent organic pollutants (POPs) known as furans and dioxins (Jayasekara, Harding, Bowater, & Lorne, 2005).

Plastics are resistant to microbial attack, because their short time of presence in nature evolution could not design new enzyme structures capable of degrading synthetic polymers (Mueller, 2006). Some additives in the manufacture of plastics are also human health hazard such as the potential leaching of bisphenol A from plastic containers into the food it contains (UNEP, 2014). The use of plastic containers for hot foods may expose individuals to phthalates (Swan, 2008). Some of these phthalates have been associated with a shorter time to pregnancy (V'elez, 2015).

Inappropriate disposal of plastics may clog drainage channels causing water to remain stagnant, creating a suitable breeding ground for mosquitoes to breed and also generating bad odour (Mukama *et al.*, 2016). Studies in humans and mussels (Browne, Dissanayake, Galloway, Lowe, & Thompson, 2008) have revealed that ingested and inhaled micro plastic gets into cells and tissues where it can cause harm. Replacement of knee or hip joints with plastics implants in patients disrupts cellular processes and degrades tissues. Laboratory tests have revealed that, monomers and other ingredients of PVC, polystyrene, polyurethane and polycarbonate can be carcinogenic and can affect organisms in a similar way to the hormone oestrogen (Teuten, Saquing, Knappe, Barlaz, Jonsson, Bjorn, Rowland, Thompson, Galloway, Yamashita, Ochi,

Watanuki, Moore, Viet,Tana, Prudente, Boonyatumanond, Zakaria, Akkhavong, Ogata, Hirai, Iwasa, Mizukawa, Hagino, Imamura, Saha, & Takada, 2009; vom Saal & Hughes, 2005).

Although the monomers constituting some plastics, such as polyethylene (used to make carrier bags), are thought to be more benign, these materials can still become toxic by picking up other pollutants (Teuten *et al.*, 2009; Rochman, Hoh, Hentschel, & Kaye, 2013). Pesticides and organic pollutants such as polychlorinated biphenyls are regularly found on plastic waste at harmful concentrations 100 times those found in sediments and 1 million times those occurring in sea water (Teuten *et al.*, 2009). Many of these are 'priority pollutants': chemicals that are controlled by government agencies due to their toxicity or persistence in organisms and food webs. These chemicals can disrupt key physiological processes, such as cell division and immunity, causing disease or reducing organisms' ability to escape from predators or reproduce (Rochman, Chelsea M. Browne, Mark Anthony Halpern, Benjamin S. Hentschel, Hoh, & Karapanagioti, Hrissi K.; Thompson, 2013). Some chemical additives used in manufacture of plastic items can leach out of plastic into the environment, affecting the health of wildlife (Thompson, Moore, vom Saal, & Swan, 2009). Plastic debris may kill or injure ecologically and commercially important species, including mussels, salt-marsh grasses and corals (Uhrin & Schellinger, 2011; Browne *et al.*, 2008).

Furthermore, flame retardants may migrate from plastic computer enclosures into dust that humans breathe posing a health hazard (UNEP, 2014). There may also be exposure of workers to additive leachate during the manufacturing stage. For example, *trimethlytin chloride* due to the use of *methlytin* stabilising agents in PVC products is connected to the increased chance of developing kidney stones in workers in the United States and China (Tang, Li, Kang, Dubois, Gong, Wu, & Gao, 2013). In a study conducted in Nairobi, respiratory and stomach problems among children were found common in the nearby clinics in houses near the Dandora dumpsite. School children passing through the dumpsite also often picked objects, which posed risks to their health (Aurah, 2013b).

2.6 Legal Framework on Plastic Waste Management

Adequate legal framework plays a critical role in the development of the integrated waste management system (Asase, Yanful, Mensah, Stanford, & Amponsah, 2009) whereas the lack of satisfactory policies (Mrayyan & Hamdi, 2006) and weak regulations (Seng, Kaneko,

Hirayama, & Katayama-Hirayama, 2010) are detrimental to it. In 2005 the European Commission's Thematic Strategy on the prevention and recycling of waste established new aims and objectives for EU waste policy. Furthermore, it put forward a vision of an EU "recycling society" as its long term goal (European Commission, 2005).

Since 1994, aims for plastic waste recycling and recovery have been set at the EU level. The latest Waste Framework Directive (WFD) 2008/98/EC (Council Directive, 2008) has established a 50% recycling target for household waste and a 70% recycling target for construction and demolition waste. However, the directive does not specify if the 50% recycling target pertains to the municipal waste stream entirely or specific material fractions within this stream (Lazarevic *et al.*, 2010). It also establishes prevention, preparing for reuse, recycling, other recovery, for example, energy recovery, and disposal to be applied as a "priority order". In Kenya, the Environmental Management and Coordination Act (EMCA, 1999 amended, 2015) provides a policy framework for environmental protection and management. It also establishes the National Environment Management Authority (NEMA) as the body responsible for implementing this Act.

2.6.1 Global Environmental Policies

a) Stockholm Convention

Kenya signed the Stockholm Convention on persistent organic pollutants on 17th May, 2004 and ratified it on 23rd December, 2004. The objective of this convention is to protect human health and the environment from persistent organic pollutants. The convention was established to regulate the use of organic chemicals known to cause toxic reaction, persist for long periods in the environment, travel many kilometres and cause long-term consequences both to humans and environment which were never intended. The most popular of these chemicals are those popularly referred to as persistent organic pollutants include polychlorinated biphenyls (PCBs), dioxins and furans (polychlorinated dibenzo-p-dioxins or PCDDs, and polychlorinated dibenzofurans or PCDFs) and nine pesticides (Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Mirex, Hexachlorobenzene, and Toxaphene) Plastics usually contain additives such as brominated flame retardants, phthalates and lead compounds that act as heat stabilizers of plastics. Some of these brominated flame retardants, such as PBDEs, have nearly the same molecular structure as polychlorinated bisphenyls (PCBs) (University of California - Riverside, 2007) which is one of the most notorious persistent organic pollutants (POPs).

b) Basel Convention

This was a treaty that entered into force on 5th May 1992 and was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries (LDCs) (Peiry, 2010). The main goal of this convention was to protect human health and the environment against the adverse effects of hazardous wastes and "other wastes", namely household waste and incinerator ash (UNEP, 2011). Some plastics are listed as "hazardous wastes" under the Convention, and a lot of household wastes contain plastics. The provisions of the Basel Convention pertaining to the minimization of the generation of wastes, their environmentally sound management as well as the control of their trans boundary movement may therefore apply to plastics wastes (UNEP, 2011). The regional and coordinating centres of the Basel and Stockholm conventions were encouraged to work on the impact of plastic waste, marine plastic litter, micro plastic, and measures for prevention and environmentally sound management (UNEP, 2011).

c) The United Nations Convention on the Law of the Sea

The United Nations Convention on the Law of the Sea (UNCLOS) also called the Law of the Sea Convention or the Law of the Sea treaty is the international agreement that resulted from the third United Nations Conference on the Law of the Sea (UNCLOS III), which took place between 1973 and 1982. The Law of the Sea Convention defines the rights and responsibilities of nations with respect to their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources. The Convention, concluded in 1982, replaced four 1958 treaties. UNCLOS came into force in 1994 and as of June 2016, 167 countries and the European Union have joined in the Convention.

The convention has a number of articles that make provisions that protect the marine environment from harmful effects that may arise from activities carried out in the sea such as those that may result in disposal and dumping of waste in the marine environment. The convention also gives contingency plans against pollution and gives States the responsibility of monitoring the risks and effects of pollution.

d) Convention for the Protection, Management and Development of the Marine and Coastal Environment of the East African Region, 1985

This convention applies to the Eastern African region, comprising of the marine and coastal environment of that part of the Indian Ocean situated within the Eastern African region and falling within the jurisdiction of the Contracting Parties to this convention. The extent of the coastal environment to be included within the convention area is indicated in each protocol to this convention considering the objectives of the protocol concerned. Article 6 of this convention deals with pollution caused by dumping. The Contracting Parties are to take all appropriate measures to prevent, reduce and combat pollution of the convention area caused by dumping of wastes and other matter at sea from ships, aircraft, or man-made structures at sea, considering applicable international rules and standards and recommended practices and procedures. The convection also deals with pollution from land-based sources (article 7); from sea-bed activities (article 8) as well as airborne pollution (article 9). This convention and its protocols shall be subject to ratification, acceptance or approval by the states and organizations referred to in article 26. Instruments of ratification, acceptance or approval shall be deposited with the Government of the Republic of Kenya which will assume the functions of depositary.

2.6.2 Local policies

a) Environmental Management and Coordination Act (EMCA, 2015)

Section 3 of this Act provides every Kenyan with the right to a clean and healthy environment as well as a duty to safeguard the environment. Section 87 stresses that every person whose activities generate waste must make sure that the waste is minimised through treatment, reclamation, and recycling. In addition, sub-section 6 of section 87 provides measures to be taken against anyone who breaches these provisions. Section 142 (1) stipulates that any person who pollutes the environment by discharging dangerous materials into land, water, air or the aquatic environment is guilty of an offence; it also lays down penalty provisions, in which the court may demand the person in question to pay 'the full cost of cleaning up the polluted environment'; in addition, the court may order the polluter to pay any third party who has incurred damages due to the pollution. Part V, Section 57, sub-section 1 makes provisions for the use of, taxes and other fiscal incentives, disincentives or fees "to induce or promote the proper management of the environment and natural resources or the prevention or abatement of environmental degradation."

Waste Management Regulations, 2006

EMCA also has the Environmental Management and Co-ordination (Waste Management) Regulations, 2006 which has provisions for the responsibility of the waste generator, cleaner production methods, segregation of waste by the generator, waste transportation licence, responsibility of waste transporter, transportation of waste by licensed transporter, licence for disposal facility, waste treatment by operators of disposal sites, requirement for environmental audit and re-use and recycling plants. In the fourth schedule of these regulations, wastes generated from the production and import of plasticizers as well as wastes resulting from the surface treatment of plastics are classified as hazardous. The regulations prohibit incineration of chlorinated plastics. However, incineration of anti-neoplastic drugs is allowed.

b) County By-Laws

The only counties in Kenya that have enacted legislations dealing with plastics are Nairobi and Baringo counties. The Nairobi City County Plastic Carry Bags Control Act (2014) provides for the control on the manufacture, usage and disposal of plastic carry bags and other plastic products so as to restore and maintain a clean environment in Nairobi County and for connected purposes. Baringo County Polythene Materials Control and Management Act (2014) provides for the control, management and regulation of the manufacture, importation, sale, use and disposal of plastic and polythene materials and products in Baringo County and for matters related and incidental thereto.

c) The Public Health Act

Sections 116 and 117 of this Act stipulate that local authorities are responsible to maintain cleanliness and prevent health risks from 'unsustainable dwellings'. Section 126A requires every council to make by-laws that control, among other things, the construction of buildings and sanitary amenities for drainage and sewer. Moreover, another section (129) gives every local authority the responsibility of preventing pollution of drinking water sources and the prosecution of polluters.

d) Others

The Land Act which is of relevance to MSW management requires the setting aside of suitable areas for garbage disposal and hazardous industries (Land Act, 2012).

The Building Code is also significant to MSW management as it demands the provision of refuse receptacles/cubicles in residential areas.

There is however a policy gap in that, there are no specific policies nationally targeting plastic wastes. This is despite the fact that plastic waste presents a menace in Kenya, more so at the coast. In addition, although waste management in Kenya has been devolved to county governments; only two counties have succeeded in formulating policies that target plastic wastes, namely, Nairobi and Baringo counties.

2.7 Household and Institutional level factors influencing waste management

a) Knowledge and Awareness

Knowledge on recycling activities influences positively recycling practice. Therefore, the more people are aware of recycling activities and the impact of the items being recycled on the environment, the more likely they will take these items for recycling such as plastics (Eeda, Ali, & Siong, 2016).

There will be more people getting involved in waste management activities when they observe others in their locale doing the same. Environmental awareness and knowledge about environmental conservation have a positive influence on recycling attitude. However, the opposite is not true as having a positive attitude will not necessarily result in waste management activities such as recycling, especially when knowledge about it was poor (McAllister, 2015).

b) Behaviour and Attitude

Behaviour, such as practising proper waste management can be predicted from attitude and awareness (Eeda *et al.*, 2016). People who are highly motivated by something to act in a specific way will probably do so (Eeda *et al.*, 2016). Hence people who have a positive attitude towards waste management are likely to engage in waste management practices. Despite having a positive attitude towards waste management, in most instances in developing countries, there is often a gap between attitudes and behaviour (McAllister, 2015). Attitude does not often reflect the behaviours on waste management in most of these countries (McAllister, 2015).

Factors influence public littering include a lack of social pressure to prevent littering, absence of realistic penalties or consistent enforcement, and lack of knowledge of the environmental effects of littering (Al-khatib, Arafat, Daoud, & Shwahneh, 2009). The amount of litter already present at a particular site and the number and/or placement and appearance (if any) of waste

collection bins at the site may also influence public littering (McAllister, 2015; Rotich *et al.*, 2006).

The throw-away culture whereby people become used to throwing waste in the streets and other inappropriate places because of the lack of formal systems of sorting and disposing waste (McAllister, 2015). As a result, this has further facilitated public littering. Moreover, it also presents a problem when changes are implemented but people do not change their disposal behaviours because of pure habit and custom (Yousif & Scott, 2007). Individuals may also be prone to litter because of the region they are in and their culture (Al-khatib *et al.*, 2009).

c) Availability of Solid Waste Equipment and Facilities

The availability of dustbins that provides people and households with a place to dispose their solid wastes such as plastic waste is important in waste management. According to a study on the factors influencing house hold functional solid waste management in Meru town, in Kenya, dustbins enhanced the cleanness of the town (Mugambi & Gichuki, 2017). Therefore, increasing the number as well as proper distribution of these dustbins in public spaces is important in ensuring that litter is not carelessly thrown in the streets (Al-Khatib, Kontogianni, Nabaa, Alshami, & Al-sari, 2015).

According to Mugambi & Gichuki, 2017, the availability of composting plants boosts waste recycling while the availability of waste-handling equipment encourages waste collection. In most developing countries, however, waste collection and management has often faced a challenge. This has been because of limited expansion of the recyclable products market, financial constraints as well as a deficiency in the number of skilled technical personnel capable of managing these systems (Al-Khatib et al., 2015; McDougall, White, Franke, & Hindle, 2001).

d) Waste Management Laws and Polices

Laws and policies have a positive influence on solid waste management in households (Mugambi & Gichuki, 2017). This is because laws and regulations usually specify the responsibilities of different actors in waste management (Aini, Fakhru'l-Razi, Lad, & Hashim, 2002). Most developing countries have not been able to move from waste management to environmental planning as seen in the current trend in developing countries. This has been associated with the failure to tackle waste-related issues that have hindered the

effective implementation of waste management processes downstream to citizens (Al-Khatib *et al*., 2015).

2.8 Theoretical Framework

The Drivers, Pressure, State, Impact and Response (DPSIR) model (Figure 2.1) was applied in this study as the theoretical framework in order to understand the issues on plastic waste management and assess the factors that contribute to its improvement (GESAMP, 2015). In this framework, food security, energy supply, housing and leisure are the main driving forces, which put pressure on fisheries, aquaculture, tourism, and waste generation. As a result, the state of the environment is affected in that plastics are found littered on the shore and chemical contamination occurs. This has an impact on the ecosystem whereby entanglement and ingestion of plastics occurs on marine animals and birds which ultimately leads to their death resulting in loss of species. Corals may also be smothered by plastics and die which will seriously affect the ecosystem as they are breeding grounds for fish. Another impact may be on human health such as reproductive problems and cancer as a result of exposure to hazardous substances when plastics decompose under the influence of light, heat or mechanical pressure. Response factor refers to treatment technologies such as recycling of plastics as well as rehabilitation centres for injured animals such as turtles that are implemented to reduce the impact of plastic waste on the environment. The Response may include various formal and informal methods as well as policies put in place that will lessen the impact.

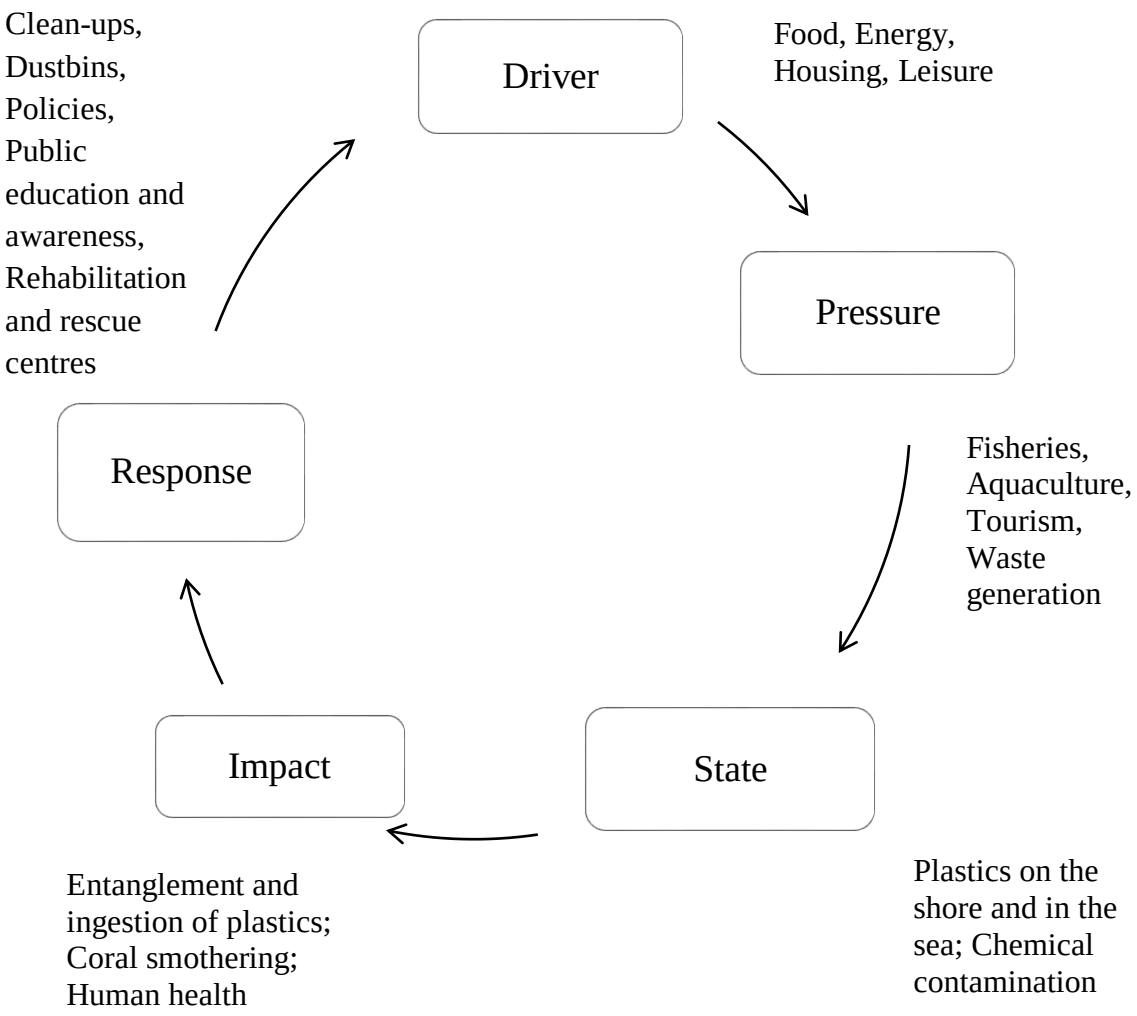

Figure 2.1: A modified DPSIR model showing the generation and potential impacts of plastics on the environment.

Source: adapted from GESAMP (2015).

2.9 Conceptual Framework

The characteristic of plastic waste generated and its streams, the factors influencing the level of knowledge, attitude and perception among the general public, the factors influencing plastic waste disposal methods are the independent variables that have an impact on the plastic waste disposal and management in Watamu, Kilifi County, Kenya (Figure 2.3). The characteristics of plastic waste generated and its streams encompasses the composition of plastic generated, the disposers of the plastic waste as well as the location of the plastic waste in terms of rural and urban areas. The composition of plastic waste that is being generated, such as HDPE, PETE or LDPE influences whether the plastic waste will be re-used, recycled or discarded as litter. It will also affect the management of plastic waste by either simplifying it or making it more complex to recycle or re-use and thereby making it easier or harder to protect the environment from the impacts of plastic waste. Where there are more streams of plastic wastes that will lead in most cases to more plastic wastes being generated, there will be more quantities of plastic waste in the environment which will affect the management of plastic waste by making it harder to control the plastic waste component of the solid waste stream. The factors influencing the level of knowledge, attitude and perception among the general public with respect to plastic waste disposal, may influence plastic waste disposal behaviour by either encouraging or discouraging people from properly disposing of their plastic waste. The perception of the general public on plastic wastes also needs to be pro-environment to reduce the quantities of plastic waste in the environment. Factors such as location, education, occupation, waste collection services and existence and enforcement of policies may also influence plastic waste disposal methods and need to be studied. Moreover, plastic waste management methods employed is an important variable in terms of effectiveness and efficiency of the methods employed to manage and deal with plastic wastes affecting environmental health. Culture and hygiene were intervening variables that may have influenced how respondents disposed their plastic waste but were not studied at depth in this study.

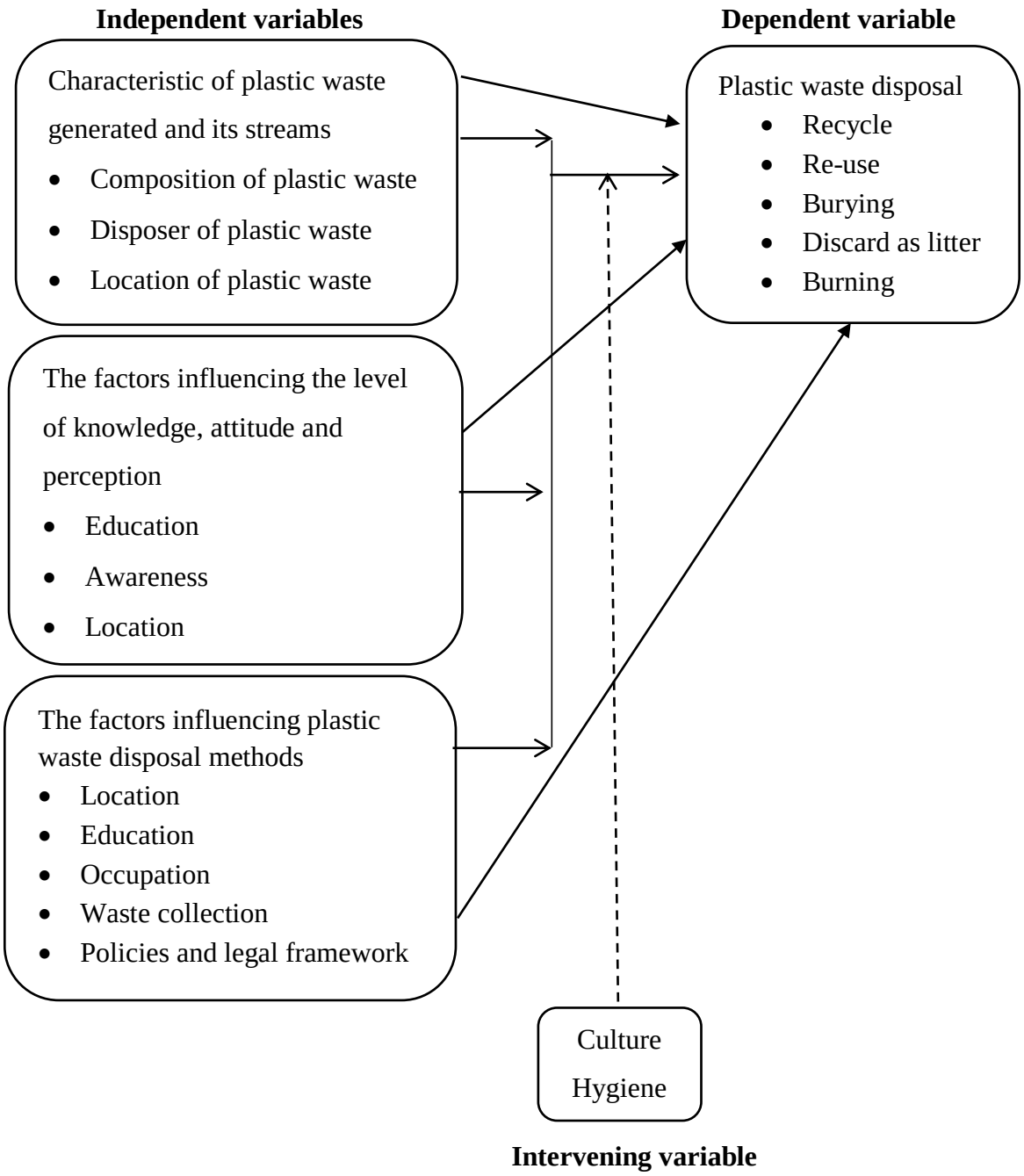

Figure 2.2: Conceptual Framework

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study area was Watamu ward which is located in Kilifi North Constituency in Kilifi County, 105 km north of Mombasa and about 15 km south of Malindi on the Indian Ocean coast of Kenya. It is approximately 59.20 km^2 and has four sub-locations namely; Jimba, Mbaraka Chembe, Watamu and Chembe Kibabamuche (Figure 3.1). Watamu has a population of 25,982 people with 5,449 households (KNBS, 2010). The coordinates for Watamu are latitude 3.3425°S and longitude 40.0274° E (Figure 3.1). It is situated between the Blue Lagoon and Watamu Bay and has gently sloping beaches sheltered behind a fringing reef. The sand is white calcareous sand of marine origin (coral sand).

a) Climate Characteristics of the Study Area

The climate and oceanographic conditions of the Kenyan coast follow a monsoonal cycle driven by the north-south migration of the Inter-Tropical Convergence Zone (ITCZ). Watamu experiences long rains between March and early June with the rainfall decreasing from August. Short rains are experienced between October and November but from December rainfall decreases rapidly once again to a minimum during January and February. Mean annual total rainfall ranges from 508 mm in the drier northern hinterland to over 1,016 mm in the year round reaching its peak during the wet months of April to July. The windiest time of the year is during Southeast Monsoon from May to September while the calmest months are March and November when the winds are also more variable in direction. Sea surface temperature and salinity vary with the monsoon season. The highest temperatures of 28- 29^oC have been recorded following the Northeast Monsoon in the months of March and April. The lowest sea surface temperature is recorded in August and September with a minimum of 24^oC.

b) Economic activities in the Study Area

Tourism is the most important economic activity of Watamu and it employs most of its population. This is followed by small businesses such as shop keeping, selling groceries and small restaurants (Carter & Garaway, 2014). Fishing is also a major source of income in the area. Other sources of income in the area include casual jobs and employment in the county government (Carter & Garaway, 2014). Kilifi county has the third highest poverty severity

(severity of poverty as percent of the poverty line is 21%) (Njonjo, 2013) and therefore poor people in this county are really poor.

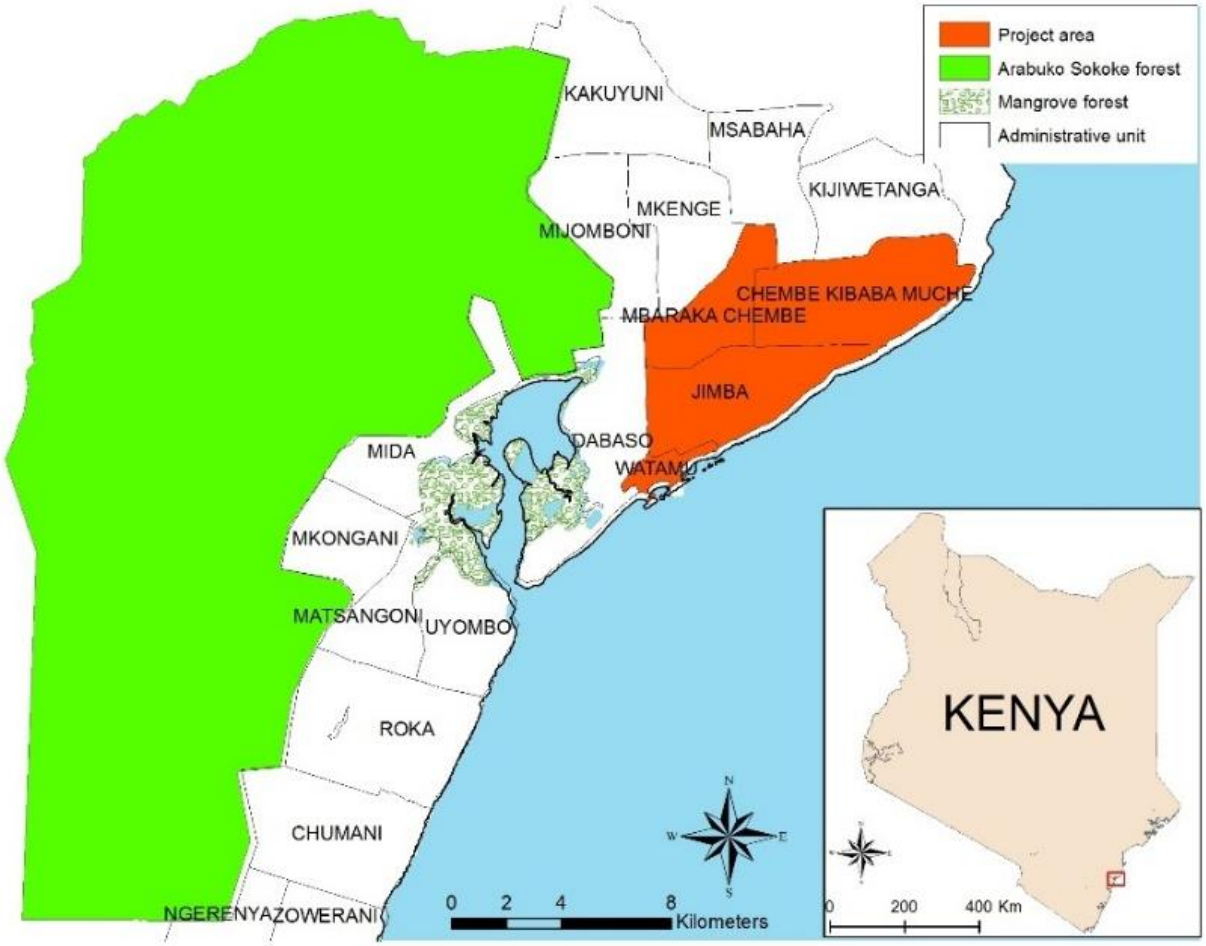

Figure 3.1: Map of study area within Watamu ward

c) Current solid waste disposal system in the area

The main disposal site in Watamu ward is located at an area called Timbotaka in Watamu sub-location which is a Swahili word meaning garbage point. In this disposal site, plastic waste is found mixed together with other types of solid wastes. The local authority in Watamu ward is charged with the responsibility of collecting the solid waste at Timbotaka and taking it to the open dumpsite in Malindi for further treatment. The local authority also has the responsibility of ensuring the municipal lorries ferrying the solid wastes are maintained and serviced.

3.2 Research Design

The research design used for this study was a social survey. This design was appropriate to assess the impacts of plastic waste in the study area. The design was also suitable as there was a need to describe the management of plastic waste in the study area.

3.3 Sampling Frame and Sample Size

The target population of the study comprised of residents of Watamu ward. The sampling frame consisted of the four sub-locations within Watamu ward from which data were collected, namely Jimba, Mbaraka Chembe, Watamu and Chembe Kibabamuche (Table 3.1). The respondents included tourism stakeholders (hotels and travel industry), fishermen, boat operators, Department of Environment (Watamu), farmers and other businessmen.

Stratified random sampling was used in the study because the population size in the four sub-locations was different (Table 3.1). The population was divided into various strata of interest that were identified (that is, their sub-location). This ensured that the entire Watamu population was well represented to facilitate a generalisation of the results as there were urban-like areas and rural-like areas. Simple random sampling was then used to obtain data from each stratum in order to constitute a sample.

The sample size for the study was determined using the following formula (Mugenda & Mugenda, 2003):-

$$N_0 = \frac{Z^2 \times P(1-P)}{d^2}$$

where:

Z = the standard normal deviation at the required confidence level (1.96 for 95% confidence level),

p = the proportion in the target population estimated to have characteristics being measured,

d^2 = the level of statistical significance test.

The value of *N* according to this formula, assuming the value of *p* is 0.9 (since variability is expected to be low), and the confidence level is 95%, was calculated as:

$$N_0 = \frac{1.96^2 \times\ 0.9(1-0.9)}{0.05^2} = \frac{0.3457}{0.0025} = 138.30$$

$$\approx 140\ respondents$$

The sample size was rounded off to 140 because of the logistics of administering questionnaires. This is because it would not be possible to have 0.3 of a person answering the questionnaires. The sample size was further increased by 10% to 154 respondents to take care of incidences of non-response.

Table 3.1: Sample size of the population obtained concerning plastic waste from four sub-locations in Watamu at the Kenyan Coast.

Sub-location	Household population	Sample size (hp/thp × 154)
Watamu	2795	78.99 ≈ **79**
Jimba	1270	35.89 ≈ **36**
Chembe Kibabamuche	590	16.67 ≈ **17**
Mbaraka Chembe	794	22.44 ≈ **22**

hp – household population; **thp –** total household population

3.4 Pilot Study

A pilot study was done in the neighbouring Dabaso ward to ensure validity of the research instruments whereby 10% of the main study (Trinity College Dublin, 2010), 15 subjects, were chosen in the same way as the main study to give the researcher the opportunity of verifying whether the respondents understood the questions in the same manner, whether all the instructions were clear, and, whether all questions were relevant. The participants of the pilot study were questioned to establish whether the questionnaire had any setbacks or issues. Subsequently, the structure and subject matter of the questionnaire was edited appropriately. The researcher then used data collected in the pilot study to generate dummy data for 154 participants in order to run a trial test on the selected methods of data analyses.

3.5 Data Collection Method

Primary data was collected using structured questionnaires with open-ended and closed questions which were distributed and filled by selected respondents in the study area (Appendix 1). This was because such a questionnaire would enable collection of data from a large population. A semi-structured interview guide (Appendix 2) was also used to interview some of the respondents, namely, hoteliers, boat operators, Kenya Wildlife Service (KWS) and fishermen. This technique enabled the assessment of people's knowledge, attitude and perception with respect to impacts of plastics on environmental health. An observation schedule (Appendix 3) was also adopted where the researcher noted down issues on plastic

waste management. Secondary data were obtained from referenced books, sessional papers, journals, newspapers and the internet.

3.6 Data Analyses

The data was analysed using descriptive and inferential statistics. Descriptive statistics included measures of central tendency and was used to explain the variables under study such as in characterizing the plastic waste produced in the study area and describing their sources (Table 3.2). Descriptive statistics was also used to evaluate the factors influencing level of knowledge, attitude and perception among the general public with respect to plastic waste disposal as well as in describing the existing plastic waste management methods in the study area (Table 3.2). Inferential statistics was also used to make inferences from the data obtained, such as establishing the relationship between the respondent's level of knowledge on the effects of plastic wastes and their level of education (Freeman-Halton extension of the *Fisher's* Exact test) (Table 3.2).

Table 3.2: Summary of objectives, research questions and statistical tool used in data obtained from Watamu.

	Objective	**Research variables**	**Statistical tool**
a)	To characterize the plastic waste in the study area as well as their streams;	Independent variables: • Type of plastic discarded • Location of plastic waste • Disposer of plastic waste Dependent variable: Discard area	• Descriptive statistics (Percentages) • Freeman-Halton extension of the *Fisher's* Exact test
b)	To assess the factors influencing level of knowledge, attitude and perception among the general public with respect to plastic waste disposal;	Independent variables: • Level of education • Level of awareness • Location of respondents Dependent variable: Discard area	• Descriptive statistics (Percentages) • Multi-variate analysis (Logit regression)

Table 3.2 continued

c)	To determine the factors influencing plastic waste disposal methods;	Independent variables: • Location of respondents • Level of education • Occupation • Waste collection service Dependent variable: Discard area	• Descriptive statistics (Percentages) • Multi-variate analysis (Logit regression)
d)	To assess and describe the existing plastic waste management methods in the study area;	Independent variables: • Recycling of plastics • Re-use of plastics Dependent variable: Location of respondents	• Descriptive statistics (Percentages) • Freeman-Halton extension of the *Fisher's* Exact test

3.7 Ethical Considerations

The researcher sought permission from relevant authorities like the local authorities as well as the National Commission on Science and Technology and Innovation (NACOSTI). The researcher also explained to these authorities and the participants the objective of the research, ensured confidentiality was maintained and then requested for voluntary participation. Professionalism was ensured through the training of the research assistant on how to administer the questionnaires. The consent of the respondents was also requested before administering the questionnaires

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Demographic Characteristics of the Study Respondents

There was 100% response rate by all the respondents from households who participated in the study whereby 32.9% of the respondents were in the age group 26 – 35 years (Table 4.1). A majority of the respondents were therefore young people similar to a study in Ongata Rongai where 46.7% of the respondents were aged between the ages of 21 to 30 years (Wachira, Wairire, & Mwangi, 2014). This is in line with the fact that 80% of the Kenyan population is below 35 years (Awiti & Scott, 2016). The results showed that 60.7% of the respondents had attended primary school education and 85.8% had lived in the area for more than 10 years showing that most respondents were in a position to give accurate information on management of plastic waste and practices in the area as well as impacts of plastic waste on the environment in Watamu (Table 4.1). In addition, 50% of the households interviewed had 1 – 5 members (Table 4.1). According to the United Nations Database on Household Size and Composition, household size declined in Kenya from 5 persons per household in 1969 to 4 in 2014 (United Nations Department of Economic and Social Affairs, 2017). There were more female respondents compared to male respondents because of the fact that in most of the households in the study area, waste management was regarded as the responsibility of women.

Table 4.1: Demographic characteristics of respondents in the study area (n = total number in column).

Demographic profile	**Category**	**Females (n=109)**	**Males (n=45)**	**Total (n=154)**
Age	18 – 25 years	19 (17.4%)	11 (24.4%)	30 (19.3%)
	26 – 35 years	36 (33.0%)	14 (31.1%)	50 (32.9%)
	36 – 45 years	34 (31.2%)	8 (17.8%)	43 (27.9%)
	Above 45 years	19(17.4%)	12 (26.7%)	30 (20.0%)
Education	None	28 (25.7%)	4 (8.8%)	32 (20.7%)
	Primary	67 (61.5%)	26 (57.8%)	94 (60.7%)
	Secondary	13 (11.9%)	14 (31.1%)	26 (17.2%)
	Tertiary	1 (1.0%)	1 (2.2%)	2 (1.4%)

Duration of	1 – 5 years	5 (4.6%)	6 (13.3%)	11 (7.1%)
residence	5 – 10 years	8 (7.3%)	4 (8.8%)	11 (7.1%)
	More than 10 years	96 (88.1%)	35 (77.8%)	132 (85.8%)
Number in	1 – 5	55 (50.5%)	22 (48.9%)	77 (50.0%)
household	6 – 10	50 (45.9%)	18 (40%)	68 (44.3%)
	11 – 15	4 (3.7%)	4 (8.8%)	8 (5.0%)
	16+	0 (0.0%)	1 (2.2%)	1 (0.7%)

4.2 Characterization of the Plastic Waste and Waste Streams in the Watamu

4.2.1 Composition of Plastic Waste Discarded

The results show that 55.4% of the plastics used and discarded by the respondents is low-density polyethylene (LDPE), while 41% of the plastics consist of polyethylene terephthalate (PETE) mixed with LDPE. High-density polyethylene (HDPE) mixed with LDPE accounted for 2.9% of the plastic waste. Polypropylene (PP) mixed with LDPEs account for 0.7% (Figure 4.1).

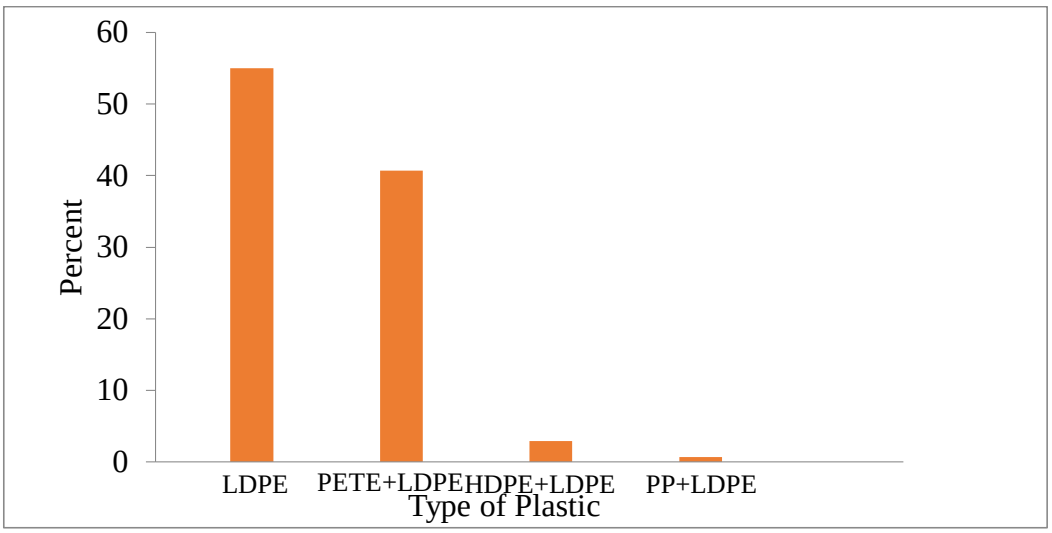

Figure 4.1: The proportion of different types of plastics discarded from households in Watamu.

The composition of plastic waste commonly found in the area were similar to those reported in sub-Saharan Africa and Ghana where the major plastics were LDPE, HDPE and other plastics such as PP, polystyrene (PS), polyvinyl chloride (PVC) and PETE (Quartey *et al.*, 2015; Miezah *et al.*, 2015). These studies showed that LDPEs constituted the largest quantities in waste because they are usually thrown together with other types of waste such as food waste.

According to the results, 49.4% of LDPEs, 50.9% PETE combined with LDPEs in Watamu ward came from Watamu sub-location (Figure 4.2). This could be related to the fact that Watamu sub-location had the greatest number of people with more economic activities than any other sub-location. In Watamu sub-location, LDPEs accounted for 53.5% of the type of plastic waste discarded compared to Mbaraka Chembe and Chembe Kibabamuche where it accounted for 75% and 60%, respectively (Table 4.2). In Jimba, 51.5% of the type of plastic waste discarded was PETE combined with LDPEs in contrast to Watamu where it was 40.8% (Table 4.2). Although Watamu sub-location produces the most LDPE and PETE waste, these types of plastic waste seem to represent a smaller proportion of the total plastic waste discarded in this sub-location. This could be because Watamu sub-location is the most developed sub-location, hence residents are likely to use a wider variety of plastics than the other sub-locations and hence result in less proportions of LDPE and PETE waste being discarded compared to other types of plastic waste. In examining the factors influencing MSW generation and management, affluent societies disposed more waste compared to their less affluent counterparts (Matsunaga & Themelis, 2002). This is because affluent societies have higher incomes, and are able to purchase more goods which translates to more waste being disposed (Matsunaga & Themelis, 2002).

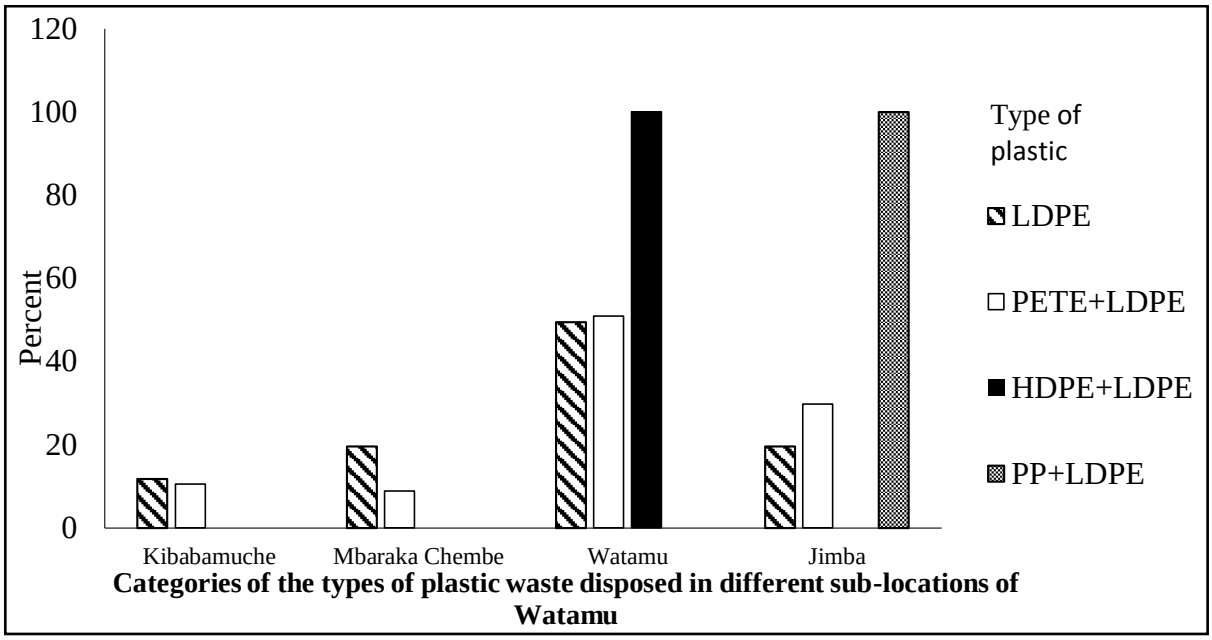

Figure 4.2: The proportion of different types of plastics discarded from households in the four sub-locations of Watamu ward.

Table 4.2: Distribution of the type of plastic across the four sub-locations.

Sub-location	Type of Plastic			
	LDPE	PETE+LDPE	HDPE+LDPE	PP+LDPE
Kibabamuche	60%	40%	0%	0%
Mbaraka Chembe	75%	25%	0%	0%
Watamu	53.5%	40.8%	5.6%	0%
Jimba	45.5%	51.5%	0%	3%

4.2.2 Streams of Plastic Waste

A study carried out at Ongata Rongai, Kenya, revealed that 44.7% of the respondents indicated that most plastic wastes were found at the dumpsites (Wachira et al., 2014).

In this study the respondents from Watamu ward indicated that 50.7% of the plastic waste in the area is found in an open waste dumpsite (Timbotaka) located in Watamu sub-location at Timboni. With regard to solid waste management in developing countries such as Kenya, Ethiopia, Tanzania, Bangladesh, Indonesia, Costa Rica and Peru, most of the disposal sites are open dumps that received different types of waste (Abarca, Maas, & Hogland, 2013). These observations are consistent with the current study findings in which most of the plastic waste ends up in open dumpsites such the one located at Timbotaka. The results indicated that 17.9% of the waste in Watamu ward can be found in any open dumpsites (Plate 4.1) while 12.9% was found along the beaches. Similarly, 9.3% of plastic waste was collected from roadsides whereas 8.6% was found in the marketplaces (Figure 4.3).

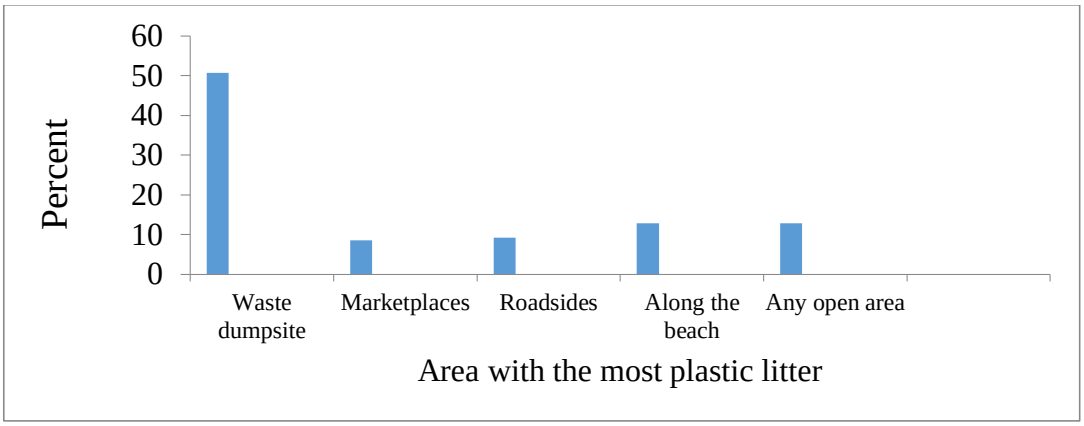

Figure 4.3: Proportion of plastic litter at different sites at Watamu

A. B.

Plate 4.1: Plastic wastes discarded adjacent to residential areas (A) and in drainages causing blockage (B) at Watamu.

This study revealed that 69.3% of respondents blamed the general public for discarding the most plastic waste in the ward while 22.9% blamed businessmen. In addition, 5% of the respondents were of the opinion that tourists and tourism stakeholders are responsible for most of the plastic waste littering in Watamu (Figure 4.4). A majority of residents of all the four sub-locations admitted that they were partly responsible for the plastic menace in the study area.

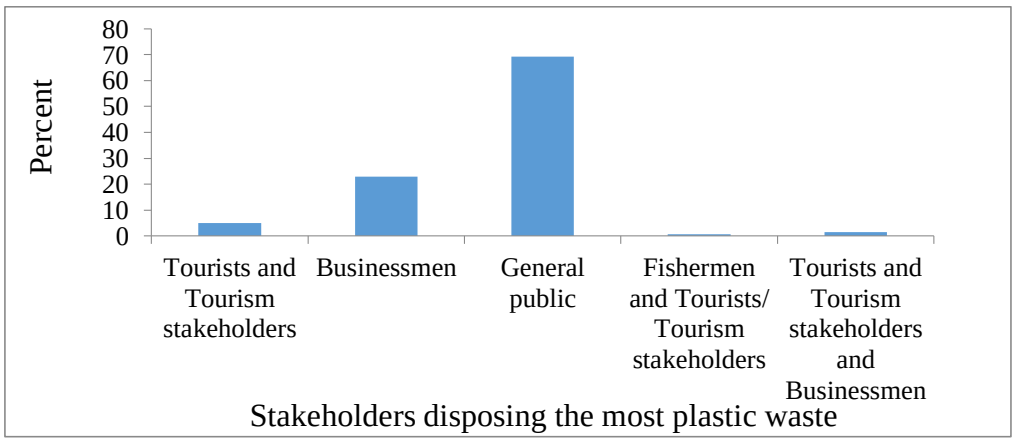

Figure 4.4: Contribution of various stakeholders to the plastic waste menace in the study area.

The results also showed that 61.4% of the respondents discarded their plastic waste at the dumpsite, while 6.4% stated that they discarded indiscriminately in undesignated dumpsites. There were also some 12.9% who stated that they not only discarded plastic waste openly as

litter but also burned it to reduce its sheer volume and likelihood of attracting pests. In addition, 12.9% of the respondents burned all their plastic wastes (Figure 4.5).

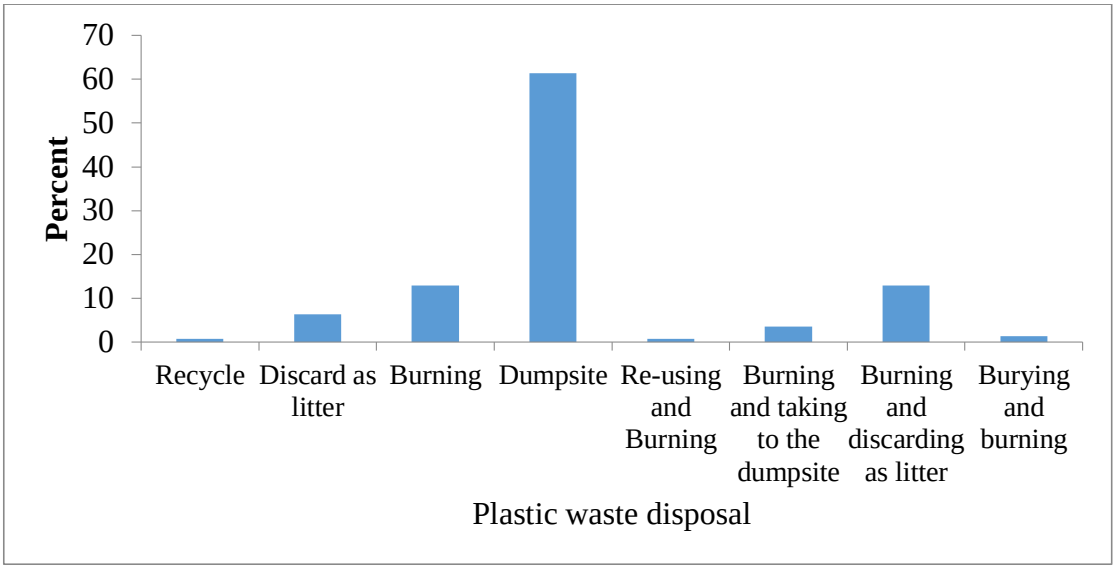

Figure 4.5: Plastic waste disposal methods used by households in the study area

In a related study in Shambu town in Oromia, Ethiopia, dumping of solid waste and burning in open disposal sites were used as the major methods of waste disposal (Tsega, 2013). Open burning is the most unacceptable method because of the dioxins and nitrous oxides gaseous that tend to be released when plastics are burnt (Tsega, 2013). In Watamu sub-location, 84.7% of the respondents dumped their plastic waste at the dumpsite, while 33.3% of the respondents from Jimba did the same. Thirty-five percent (35%) of the respondents from Mbaraka Chembe dumped their plastic waste at open dumpsites while plastic waste dumping at the dumpsite was done by 46.7% of the respondents from Chembe Kibabamuche. This suggests that a large population of Watamu sub location residents dispose of plastic waste at designated open dumpsites. The difference in the disposal habits and trends of respondents may be due to the fact that Watamu sub-location is nearest to Timbotaka dumpsite.

4.3 Knowledge, Attitudes and Practice with respect to Plastic Waste Disposal

The respondents were asked to show their level of agreement with the following statements that revealed their knowledge, attitude and perception on plastic waste disposal. The results are shown in Table 4.3.

From the descriptive statistics presented on Table 4.3, the majority of the respondents agreed with all the statements in the following order of the mean (*M*): Poor disposal and management

of plastic waste pollutes the environment ($M = 4.02 \pm 0.055$), Plastics clog drainages, creating breeding grounds for mosquitoes and bad odour ($M = 4.00 \pm 0.034$), Plastic waste management is a responsibility of each and every individual ($M = 3.87 \pm 0.047$), Some additives in the manufacture of plastics are a health hazard ($M = 3.82 \pm 0.074$), Plastic wastes finds their way to water bodies and pollute water ($M = 3.70 \pm 0.69$), and, Marine animals are killed when they ingest plastic waste that finds its way to the water ($M = 3.62 \pm 0.081$).

Table 4.3: Knowledge, Attitudes and Practice with respect to Plastic Waste Disposal.

Description of Criteria	**SA**	**A**	**IDK**	**D**	**SD**	**Mean**
Plastic waste management is a responsibility of each and every individual.	5	121	5	9	0	3.87
Poor disposal and management of plastic waste pollutes the environment.	24	101	10	4	1	4.02
Plastic waste finds their way to water bodies and pollute water.	11	96	13	20	0	3.70
Marine animals are killed when they ingest plastic waste that finds its way to the water.	23	65	29	22	1	3.62
Some additives in the manufacture of plastics are a health hazard.	32	62	35	11	0	3.82
Plastics clog drainages, creating breeding grounds for mosquitoes and bad odour	9	123	5	2	0	4.00

5 = Strongly Agree **(SA)**, 4 = Agree **(A)**, 3 = I don't know **(IDK)**, 2 = Disagree **(D)**, 1 = Strongly Disagree **(SD)**

An ordinal logistic regression was done to determine whether sublocation, origin of respondents and gender influence their education levels that would thereby influence their

knowledge on plastic waste. Together, the predictors accounted for a significant amount of variance in the outcome, likelihood ratio $\chi^2(5) = 17.504$, $p < 0.05$. However, these predictors explained little (13.6%) of the variance in level of education among respondents. Among all the predictors, only gender $b = -1.307$, SE = .414, OR = 9.946, $p < 0.05$, significantly influenced the education levels (Table 4.4). There was therefore a relationship between gender and the level of education attained, whereby the males were 3.7 times more likely to have attended formal schooling compared to their female counterparts. The reason why this was the trend in the study area was the fact that girls got married while they were still young and they therefore had other priorities, namely, takin care of their families as opposed to going to school. This may have hindered them from gaining useful information in schools, particularly secondary and tertiary, that would have expanded their knowledge concerning plastics.

Table 4.4: Parameter Estimates Showing How Different Factors Influenced the Education Levels of Respondents ($N = 154$)

		Estimate	Std. Error	Wald	df	Sig.
Threshold	[Education = 1]	-2.212	.453	23.848	1	.000
	[Education = 2]	.918	.410	5.016	1	.025
	[Education = 3]	3.778	.776	23.728	1	.000
Location	[Sublocation=1]	.576	.584	.974	1	.324
	[Sublocation=2]	-.482	.563	.733	1	.392
	[Sublocation=3]	.801	.525	2.324	1	.127
	[Sublocation=4]	0*	.	.	0	.
	[Origin=1]	.946	.584	2.625	1	.105
	[Origin=2]	0**	.	.	0	.
	[Gender=1]	-1.307	.414	9.946	1	.002
	[Gender=2]	0***	.	.	0	.

*Reference category for sub-location: Watamu sub-location

**Reference category for origin: Those from Watamu

***Reference category for gender: males

According to the results, 44.3% of the respondents rated themselves as having moderate knowledge on the effects of poor plastic waste management on the environment while 31.4% and 7.9% rated themselves as high and very high, respectively (Figure 4.7). However, this seems to conflict with their means of managing plastic waste as 61.4% take their plastic waste to the dumpsite which is an open dumpsite, 12.9% burn some of their plastic waste while 6.4% discard their plastic waste in any area. In addition 18.6% discard using a combination of two different methods such as discarding as litter and burning or burying when they become too much in the compound. Only 0.7% stated that they recycled their plastic waste. A similar scenario was found in a different study in Ireland where most respondents rated themselves as good or excellent waste managers yet there were very low rates of recycling (Davies *et al.*, 2006). This could be attributed to the fact that most respondents tend to associate waste management as simply leaving their homes or areas surrounding their homes clean or tidy. This perspective is however disadvantageous as it demotivates respondents from undertaking further waste management actions (Davies *et al*., 2006).

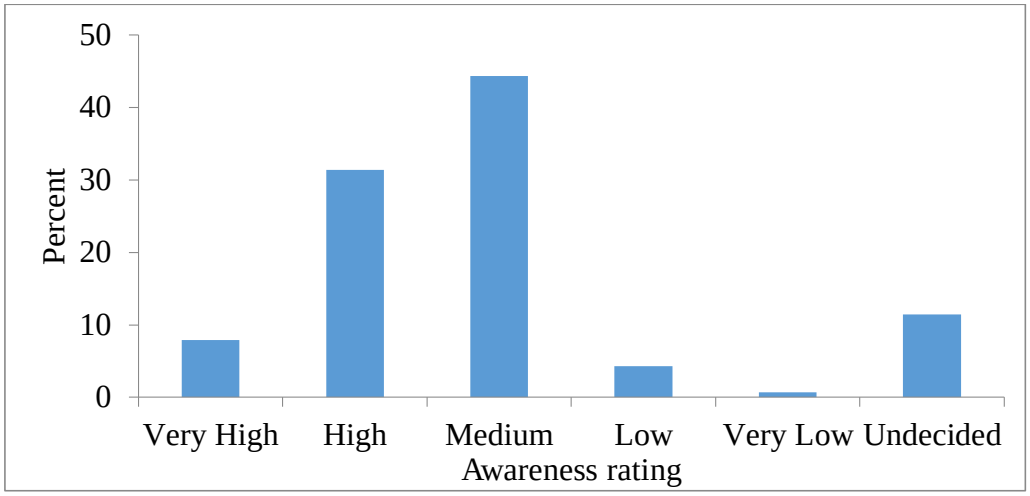

Figure 4.6: Awareness levels of respondents on the effects of plastic waste in the environment.

An ordinal logistic regression was also done to determine whether sublocation, origin of respondents, duration of stay in the study area, age, education and gender of the respondents influence their awareness levels. Together, the predictors accounted for a significant amount of variance in the outcome, likelihood ratio $\chi^2(13) = 28.292$, $p < 0.05$. However, these predictors explained little (19.6%) of the variance in awareness levels among respondents.

Table 4.5: Parameter Estimates Showing How Different Factors Influence Awareness Levels of Respondents

		Estimate	Std. Error	Wald	df	Sig.
Threshold	[Awareness = 1]	-2.080	1.525	1.862	1	.172
	[Awareness = 2]	.104	1.509	.005	1	.945
	[Awareness = 3]	2.476	1.526	2.634	1	.105
	[Awareness = 4]	2.885	1.532	3.548	1	.060
	[Awareness = 5]	2.967	1.533	3.746	1	.053
Location	[Sublocation=1]	2.174	.589	13.604	1	.000
	[Sublocation=2]	1.903	.594	10.267	1	.001
	[Sublocation=3]	.880	.505	3.035	1	.081
	[Sublocation=4]	0*	.	.	0	.
	[Origin=1]	.132	.737	.032	1	.858
	[Origin=2]	0*	.	.	0	.
	[Gender=1]	.205	.396	.268	1	.604
	[Gender=2]	0*	.	.	0	.
	[Education=1]	-.097	1.499	.004	1	.948
	[Education=2]	.814	1.423	.327	1	.568
	[Education=3]	1.078	1.463	.542	1	.461
	[Education=4]	0*	.	.	0	.
	[Age=1.0]	-1.301	.584	4.954	1	.026
	[Age=2.0]	-1.239	.507	5.967	1	.015
	[Age=3.0]	-.884	.496	3.175	1	.075
	[Age=4.0]	0*	.	.	0	.
	[Time=2]	-.983	.871	1.273	1	.259
	[Time=3]	-.526	.860	.374	1	.541
	[Time=4]	0*	.	.	0	.

*Reference categories for sub-location, origin, gender, education, age, and time

Among all the predictors, only Chembe Kibabamuche sub-location $b = 2.174$, SE = .589, OR = 13.604, $p < 0.001$, Jimba sub-location $b = 1.903$, SE = .594, OR = 10.267, $p < 0.05$, age group

18-25 *b* = -1.301, SE = .584, OR = 4.954, p < 0.05 and age group 26-35 *b* = -1.239, SE = .507, OR = 5.967, p < 0.05, predicted a significant variance in awareness levels (Table 4.5). Therefore, respondents from Chembe Kibabamuche and Jimba sub-locations were 8.8 and 6.7 more times more likely to rate themselves highly in terms of their awareness levels compared to respondents from Watamu. In addition, respondents over 45years were 3.7 times and 3.5 times more likely to rate themselves highly in their awareness levels of the effects of plastic waste compared to people in the age groups 18-25 and 26-35 years respectively. This may be because of the fact that respondents in the age group of over 45years had lived long enough to see for themselves the effects of plastic waste, having also lived in an era when paper bags before the introduction of plastic bags, and were therefore more confident in rating themselves more highly.

There was nonetheless evidence to suggest a significant relationship between the respondents' sub-locations and their knowledge on effects of plastic waste in especially the marine environment when a Freeman-Halton extension of the *Fisher's* Exact test was done. When sub-locations of the respondents were compared with their opinion on whether poor disposal and management of plastic waste pollutes the environment and is a health hazard, there was a significant difference (FH = 25.729, p = 0.002) between the respondents' sub-locations. Opinions of respondents on the possibility of plastic wastes finding their way into the water bodies thus polluting the water differed significantly (FH = 16.289, p = 0.033) in the sub-locations. Furthermore, a comparison with their opinion on the possibility of marine animals getting killed by plastic waste that finds their way in water bodies as they mistakenly eat plastics as food also differed significantly (FH = 24.145, p = 0.009) in the sub-locations.

4.4 Factors that Influence Plastic Waste Disposal Methods

A multinomial logistic regression was calculated to predict the factors that influence plastic waste disposal methods, based on gender, sublocation, age, origin, education, occupation and the types of plastic waste usually disposed by respondents as waste. The traditional .05 criterion of statistical significance was employed for all tests. Addition of the predictors to a model that contained only the intercept significantly improved the fit between model and data, χ^2 (68, N = 154) = 128.108, Nagelkerke R^2 = .679, p < .001. As shown in Table 4.6, significant unique contributions were made by sub-location, origin, age, education and type of plastic being discarded by respondents.

Table 4.6: Predictors' Unique Contributions in the Multinomial Logistic Regression (*N* = 154)

Predictors	χ^2	**df**	***p***
Sub-location	1190.392	12	<0.001
Origin	822.521	4	<0.001
Gender	3.310	4	0.507
Age	29.073	12	<0.05
Education	95.013	12	<0.001
Occupation	12.947	12	0.373
Plastic Type	24.050	12	<0.05

The response group was those respondents who disposed their plastic waste at the dumpsite. Accordingly, each predictor had four parameters, recycling, discarding as litter, burning and a combination of more than one method. Recycling was not a significant parameter that was opted for in place of taking to the dumpsite amongst any of the predictor variables. Only three predictors had significant parameters within some of their sub-groups for comparing the response variable with the other parameters (Table 4.7). These were sub-location, place of origin and age.

Table 4.7: Significant Parameter Estimates Contrasting Those Who Disposed Their Plastic Waste At the Dumpsite Versus Those Who Used Other Means (*N* = 154)

Predictor	**Dumping vs.**	**B**	**Odds Ratio (OR)**	***p***
*Sub-location	Discard as litter	Chembe Kibabamuche: 4.849	127.619	<0.05
	Burning	Jimba: 5.158	173.845	<0.01
		Mbaraka Chembe: 2.823	16.822	<0.05
	Combination of methods	Chembe Kibabamuche: 2.675	14.519	<0.05
		Jimba: 2.731	15.349	<0.05
		Mbaraka Chembe 3.053	21.171	<0.05
**Origin	Burning	Not from Watamu: -2.805	0.60	<0.05
***Age	Burning	Age group 36-45: -3.368	0.34	<0.05

*Reference category for sub-location: Watamu sub-location

**Reference category for origin: Those from Watamu

***Reference category for age: above 45 years

Respondents from Chembe Kibabamuche sub-location were more likely to discard their plastic waste as litter as opposed to taking them to the dumpsite compared to Watamu sub-location. In addition, respondents from Jimba and Mbaraka Chembe sub-locations were more likely to burn their plastic waste as opposed to taking them to the dumpsite compared to Watamu sub-location. Respondents from Jimba, Chembe Kibabamuche and Mbaraka Chembe sub-locations were more likely to use a combination of different methods to dispose their plastic waste as opposed to taking them to the dumpsite compared to Watamu sub-location. The reason for this trend of other sub-locations using other means of disposing their plastic waste as opposed to taking them to the dumpsite could be because of the fact that the dumpsite was located in Watamu sub-location. It was therefore more expensive and time-consuming for respondents who lived further away to dispose their plastic waste at the designated dumpsite in Watamu sub-location. This result concurs with a chi-square test that revealed a significant relationship between the methods respondents used in disposal of their plastic waste and their sub-location ($FH = 50.708$, $p = 0.000$) whereby 40.5% of the plastic waste disposed at the dumpsite came from Watamu sub-location. In Ghana, it was found that the geographical area had an effect on household waste generation and plastic waste generation was highest in the forest zone, 0.07 kg/person/day followed by the northern zone, 0.06 kg/person/day and coastal zone, 0.05 kg/person/day (Miezah *et al.*, 2015).

Respondents that were not from the area but had migrated from other areas to Watamu ward were less likely to burn their plastic waste as opposed to taking them to the dumpsite compared to those that were born and grew up in the area. This might have been because of the fact that 34.4% of respondents that were not originally from Watamu had attended secondary or tertiary schooling compared to 17.2% of respondents that were born and grew up in Watamu (Table 4.8). Therefore because of the lack of importance associated with schooling beyond primary levels, respondents may have failed to obtain knowledge on the effects of burning plastic waste and therefore were more likely to burn them compared to those who were born and grew up in other areas.

Table 4.8: Level of Education in comparison with Origin

	Level of Education				Total
	Illiterate	Primary	Secondary	Tertiary	
Origin from other areas	7 (21.9%)	14 (43.7%)	9 (28.1%)	2 (6.3%)	32 (100%)
Originally from Watamu	26 (21.3%)	75 (61.5%)	19 (15.6%)	2 (1.6%)	122 (100%)

However, it is important to note that in general, education did not play a significant (FH = 27.466, $p = 0.248$) role in how respondents disposed their plastic wastes in the study area. The multinomial logistic regression also revealed that it does not significantly influence the decision to choose one disposal method over another. This was in contrast to a study on soiled diapers disposal practices among caregivers in poor and middle income urban settings, whereby the level of education influenced how caregivers disposed of diapers (Kimani *et al.*, 2015). This difference observed in the study could be as a result of some sensitization of locals in the area by local elders (locally known as '*wazee wa mtaa*') who were very strict when it came to maintaining cleanliness in the area. Hence, very few people discarded their plastic waste in the open irrespective of their education level.

People of the age group 36-45 years were less likely to burn their plastic waste as opposed to taking them to the dumpsite compared to those who were above 45 years. The reason for this could be because of the fact that people in the latter age group were likely to be less energetic. It would therefore be more convenient for them to burn their plastic waste as opposed to taking them to the dumpsite.

Other factors that may have influenced plastic waste disposal include: -

1. Waste collection

A field survey revealed that Watamu ward did not have an existing landfill just like Shambu town (Tsega, 2013) instead, there was an open dumpsite where most residents in Watamu ward threw their wastes. Waste was collected from homes by some youth who carried them to the open dumpsite at a fee by means of carts (locally called '*mikokoteni*'). In the more affluent areas, waste collection was done by privatised companies.

It was observed that there were very few equipment for waste management. For instance, according to key informants interview, there was only one lorry that was used in ferrying waste from the open dumpsite in Watamu to Malindi and this vehicle was prone to breakdowns. This led to the piling up of waste at the dumpsite as the rate at which the waste was being dumped was higher than the frequency of garbage collection. Plastic waste would also sometimes fly from the lorry during transportation and which is in contrast to the Waste Management Regulations of 2006. These regulations obligate waste transporters to ensure that the collection and transportation of waste does not cause any scattering, flowing out and emissions or noxious smell (NEMA, 2010).

2. Recycling centres

It was observed that there was only one plastic waste recycling centre in the area called Eco-world (formerly known as Watamu Waste Recycling Centre), and it dealt mostly with plastics made from high density polyethylene (HDPE). From the results, 2.9% of plastic waste that is usually discarded from households is HDPE combined with low density polyethylene (LDPE) (Figure 4.1). Most people in Watamu do not buy plastics made from HDPE and when they do, such as oil containers, they usually re-use them. Therefore, there is very little plastic made of HDPE being discarded in Watamu as waste. Instead, the type of plastics that are usually discarded in the area is LDPE (Figure 4.1). The amount of LDPE discarded was significantly higher than other types of plastic wastes (FH = 37.959, p = 0.000). LDPE is a type of plastic that is hard to recycle and has the potential of polluting the marine environment if not well-disposed of.

4.5 Existing Plastic Waste Management Methods in Watamu Ward

An analysis of the data provided by respondents revealed that only 0.7% of the respondents stated that they actually recycled their plastic waste. This could be attributed to the fact that 84.3% of the respondents did not know of any recycling organisation that takes the plastic waste (Table 4.9). Eco-world had employed some locals that would collect plastic waste and either recycle them into other products or artwork for display and sensitization purposes such as showing locals and tourists how to use discarded plastic bottles as building blocks or sacks to make bags (Plate 4.2 and 4.3). Some hard plastics such as jerry cans are usually crushed and re-sold to bigger recycling companies in other towns such as Mombasa (Plate 4.4) which generates revenue and helps to ensure the centre's sustainability. Other plastic wastes are

recycled into other products and artwork for sensitization purposes such as showing locals how they can generate revenue using plastic waste. Some plastic bottles were for example, being used as building materials and other plastic material were made into creative artwork for display and sale.

Table 4.9: Knowledge of the presence a recycling company or organisation in the area

	Number of people	Percent
No	125	84.3
Yes	29	15.7

Plate 4.2: Bags made from old sacks.

Plate 4.3: Wall built with plastic bottles.

However, most of the recycling is done on small scale owing to the limited resources of the organisation. Therefore, for recycling to be successful in the region, there is need to improve the efficiency of equipment and infrastructure (Abarca et al., 2013). This needs the participation of the government as well as stakeholders and investors to be successful.

Plate 4.4: Crushed plastic that has been sorted into different colours

There is limited recycling of plastic waste that is currently being undertaken by the locals could. Instead plastic waste is taken together with other wastes to the open dumpsite. Nonetheless, 93.6% of the respondents re-use their plastics in different ways. The results indicated that 42% re-used old oil jerry cans for water storage, while 35.9% of the respondents stated that they re-used plastic waste for both water and food storage (Figure 4.8), whereby they would use old paint buckets to store foods such as rice, or old detergent containers to store foods such as tea leaves, sugar, and salt. Some also used plastics to repair other broken plastics such as basins

while others converted broken plastics into dustpans. Most people re-used their plastic to store water according to this study. This was done by washing old oil containers with hot water and soap before using it to store water. A study investigating the co-leaching of brominated compounds and antimony from bottled water showed that polycarbonates (PC), HDPE, and polystyrene (PS) have significantly lower antimony (Sb) and bromine (Br) leaching than PET (Andra *et al.*, 2012). Therefore, while re-use should be encouraged, locals need to be more enlightened on what type of plastics should be re-used and for what purpose. Re-using of plastic water bottles for juice storage and oil storage is likely to lead to leaching of some compounds such as Sb and Br.

A Freeman-Halton extension of the *Fisher's* Exact test done revealed a significant difference in terms of how the respondents re-used their plastic waste in the four different sub-locations (FH = 36.437, p = 0.005). From this study, 66.7% and 70% of respondents from Chembe Kibabamuche and Mbaraka Chembe, respectively reused old plastics for both food storage and water storage. This is in contrast to Watamu and Jimba where 25.8% and 20% of respondents respectively, stated that they did the same. However, when it comes to purely water storage, 42.4% and 56.7% of Watamu and Jimba respondents respectively, re-used their old plastic containers for mainly water storage. In Chembe Kibabamuche and Mbaraka Chembe, reuse of plastics for mainly water storage was observed on 26.7% and 30% of respondents, respectively.

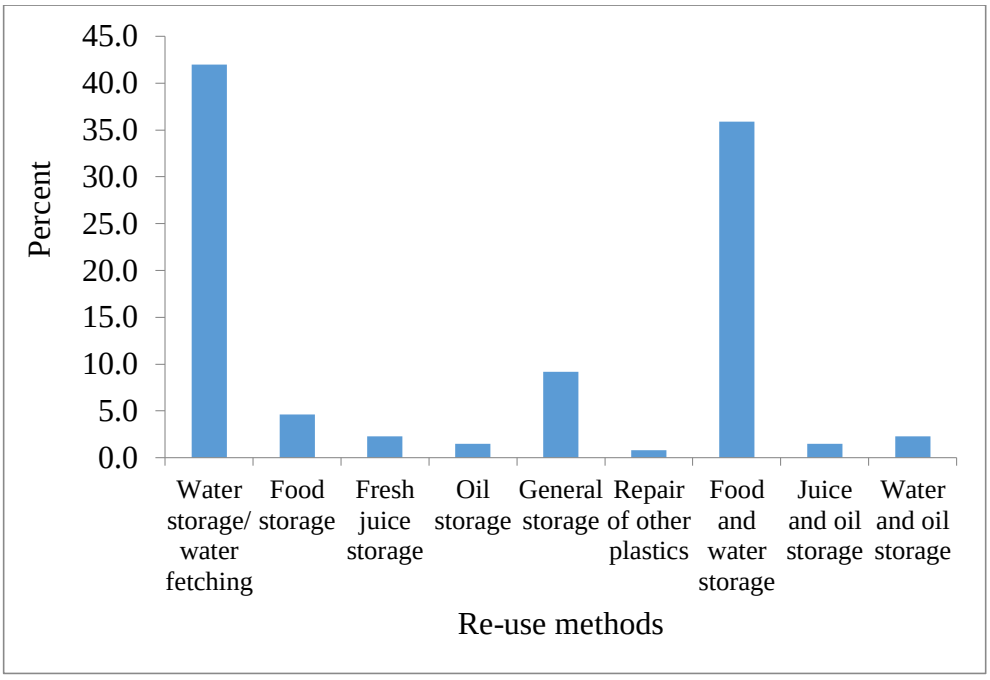

Figure 4.7: Re-use methods of plastic items by households in the study area.

4.6 Legal Framework

Waste Management in Watamu ward, like other wards in the county, is managed by the County Government of Kilifi. This follows the devolvement of most public services to the County Governments from the former management by the Central Government in Chapter 11 of the promulgated Kenyan constitution. The Constitution places the responsibility of financing waste collection services under the County Governments of Kilifi in Watamu ward, as well as purchasing the relevant infrastructure needed to carry out waste collection and management.
The County performs waste management through the Department of Water, Natural Resources, Environment, Forestry and Solid Waste Management. The mandate of this department is to ensure provision of safe water, clean and healthy environment for all. Therefore, this department has the responsibility of managing waste within the county such as in Watamu ward.

Some of the key issues that this department faces while performing its activities include: high recurrent costs associated with human resource wages, vehicle fuel and maintenance costs and waste management infrastructure acquisition and development including PPEs. This has come about because of the underfunding of this department that hinders it from effectively doing its work. In Watamu ward, for example, there is only one lorry available for collecting waste in the entire county, and this lorry is prone to break-downs. This is therefore a setback in the process of waste collection. Watamu ward also has improper ways of waste disposal and therefore there is need for more awareness to be done. This is especially because members of the community form an integral part of waste management as they are the primary generators of waste.

The Amended EMCA Act 2015, establishes NEMA, among other institutions, to develop regulations, recommend measures and standards and, issue guidelines conservation and management of natural resources and the environment. It also gives NEMA the power to implement all policies relating to the environment, and to exercise general supervision and coordination over all matters relating to the environment. In the County Government of Kilifi, NEMA performs its work through the Kilifi NEMA County Office that represents and acts on behalf of NEMA in the county. This includes implementation of policies and regulations as well as compliance such ensuring that waste generators properly dispose of their waste (section

87 of the EMCA Act 2015 and taking to court environmental polluters so that they may take responsibility for their actions as laid out in section 142(1) of the Act.

Within Watamu sub-location in Watamu ward, households also had systems for ensuring order. There were elders who were locally known as '*wazee wa mtaa*' present in Watamu sub-location. Apart from other duties, such as resolving minor issues in the community, they also ensured that households maintained some level of cleanliness near their homes. This helped to reduce the piling up of disposed plastics in the environment.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Plastic waste frequently discarded by households can be characterised as LDPE, HDPE, PETE and PP. LDPE such as plastic bags has fewer re-use options and is of lower recycling potentials. Therefore, it is common for them to be discarded as litter or found at the dumpsites compared to other types of plastics that can be re-used several times or have a higher recycling potential recycled. Knowledge, attitude and perception of plastic waste influences how plastic waste is disposed. These are influenced by campaigns and sensitization efforts done by government bodies and NGOs. People who are located in areas that are able to access information on plastic waste are more likely to dispose their plastic waste in environmentally friendly ways compared to those who are not. Location and accessibility to waste collection services influences plastic waste disposal methods used. Areas with facilities and more access to waste collection services are more likely to dispose their plastic waste in environmentally-friendly ways. Re-use and recycling are both methods of plastic waste management practiced in the study area though on a small scale. Re-use was the most feasible method of plastic waste management and thus the need to embrace and provide resources and information on how best to entrench it in this community.

5.2 Recommendations

Recommendations for the County Government and NGOs

(i) Dustbins need to be set up strategically (such as in the villages, towns and at the entrance of beaches) and labelled effectively to enable plastic waste separation from other waste streams.

(ii) There is need to create a landfill or fence the open dump site at Timbotaka to prevent plastic wastes from flying around.

(iii) Locals need to be sensitized more on proper waste management which will enable them to know how to handle their plastic wastes. They also need to be educated more on the opportunities available in terms of using plastics to create artwork for sale and in building houses.

(iv) Provision of more transport vehicles which are more suitable to carry wastes from Watamu ward. Currently there is only one Municipal Authority lorry carrying trash from Watamu to Malindi which is prone to breakdowns.

(v) Policies that encourage plastic waste recycling along the Kenyan coast should be formulated. There is a lot of marine debris which is usually deposited at the shorelines, most of which is plastic. Hence, there are a lot of raw materials that remain largely unexploited.

Recommendations for further studies

(i) Further research needs to be done on plastic waste generation among households along the Kenyan coast.

(ii) A study needs to be done on the socioeconomic and environmental impacts of the recent ban on plastic carrier bags on Kenyan coastal communities including marine life.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE

The researcher administers this questionnaire with the purpose of assessing the potential impacts of plastic waste and its management on environmental health in Watamu, Kenya. This questionnaire will help in carrying out a project whose report will be handed to Egerton University in partial fulfilment for the award of a Master degree in Environmental Science.

All information given will be treated with utmost confidentiality.

SECTION A: Background information

1. Sub-location …… Occupation ……

For the following questions tick where appropriate

2. Are you originally from this Sub-location?
   A. Yes [ ] B. No [ ]
3. How long have you been living in this Sub-location?
   A. Less than a year [ ]
   B. 1 – 5 years [ ]
   C. 5 – 10 years [ ]
   D. More than 10 years [ ]
4. Respondent's gender
   A. Male [ ] B. Female [ ]
5. Age bracket
   A. 18-25 years [ ] B. 26-35 years [ ] C. 36-45 years [ ] D. Above 45 years [ ]
6. Level of education
   A. None [ ] B. Primary [ ] C. Secondary [ ] D. Tertiary [ ]
7. How many are you in your household _____
8. Who are you in the family?
   A. Father [ ]
   B. Mother [ ]
   C. Son [ ]
   D. Daughter [ ]
   Other specify _____

SECTION B: Characterization and Quantifying of Plastic Wastes

9. List plastic items found in your household/establishment that are normally discarded as waste

   ……

   ……

   ……

   ……

   ……

   ……

   ……..

10. How frequently do you discard these plastic items?

    A. Once a week [ ]
    B. One – Two times a week [ ]
    C. 3 – 4 times a week [ ]
    D. Everyday [ ]

11. Do you practice sorting of plastic wastes that when discarding your solid wastes?

    A. YES [ ] B. NO [ ]

    If not, why?

    ……...

12. How do you discard these plastic wastes?

    A. Recycle [ ]
    B. Re-use [ ]
    C. Burying [ ]
    D. Discard as litter [ ]
    E. Burning [ ]
    F. Other (specify)…….

SECTION C: Streams of Plastic Waste

13. Where is plastic litter most commonly found in your sub-location?
    A. Waste dumpsites [ ]
    B. Marketplaces [ ]
    C. Roadsides [ ]
    D. Along the beach [ ]
    E. Any open area [ ]
14. In your opinion, who do you think is responsible for disposing most plastic wastes that are found in your sub-location?
    A. Fishermen [ ]
    B. Tourists and Tourism Stakeholders [ ]
    C. Businessmen [ ]
    D. General Public [ ]

SECTION D: Community's knowledge, attitude and perception on the impacts of plastics on environmental and human health

For questions 15 to 20, in the box provided insert the letter that best represents your choice

[A] Strongly Agree **[B]** Agree **[C]** I Don't Know **[D]** Disagree **[E]** Strongly Disagree

15. Plastic waste management is a responsibility of each and every individual. [ ]
16. Poor disposal and management of plastic waste pollutes the environment and is a health hazard. [ ]
17. Plastic wastes find their way into the water bodies thus polluting the water. [ ]
18. Marine animals are killed by plastic waste that finds their way in water bodies as they mistakenly eat plastics as food. [ ]
19. Some additives in the manufacture of plastics are human health hazard. [ ]
20. Plastics tend to clog up drainage areas creating suitable breeding ground for mosquitoes to breed and also generating bad odour. [ ]

For questions 21 to 26, tick where appropriate

21. Plastic waste is dumped and burned in open areas
    A. Yes [ ] B. No [ ]
22. Cancer cases and infertility problems have been on the rise over the years

A. Yes [ ] B. No [ ]

23. Animals frequently eat plastics as they graze

A. Yes [ ] B. No [ ]

24. Rating yourself, what is your awareness level on effects of poor plastic or solid waste management on the environment and human beings?

A. Very high [ ] B. High [ ] C. medium [ ] D. Low [ ] E. Very low [ ] E. None [ ]

25. Do you think there is need for more action / awareness campaigns on the impact of plastics on environmental and human health?

A. Yes [ ] B. No [ ]

26. Who are the people most affected by poor waste management?

A. The poor [ ] B. The rich [ ] C. The middle class [ ]

SECTION D: Factors Influencing Plastic Waste Disposal Methods

27. Where do you dispose plastic waste? ……

28. Why do you dispose plastic waste in the area named in question 28 above?

A. Near my home/ Convenience [ ]
B. Cheaper [ ]
C. Safeguard the environment [ ]
D. Other reasons

……
……
……

SECTION E: Existing Plastic Waste Management Methods

29. Is there a plastic item(s) that you do not discard?

A. YES [ ] B. NO [ ]

If yes, name the item(s) and state how you re-use it

……
……
……
……
……

……

……

30. Do you know of any recycling company or organisation near you?

A. YES [ ] B. NO [ ]

If yes, state if is the company benefiting you and how?

……

……

……

……

……

……

APPENDIX 2: SEMI-STRUCTURED INTERVIEW SCHEDULE

INTERVIEW QUESTIONS FOR MANAGERS/ BUSINESSMEN

1. What is your name and job description?
2. How long have you worked at the area?
3. What kinds of waste are produced by the facility?
4. Do you have a policy on waste management in your facility?
5. How do you manage plastic waste?
6. Has plastic waste posed a problem to your facility or to the environment surrounding your facility?
7. How do you rate your facility in terms of managing plastic waste on a scale of 1 – 5 (1 - very poor; 5 - excellent)?
8. What are some of the challenges of effectively managing plastic waste that you face?
9. Are there ways in which you could improve?
10. What barriers prevent you from doing more to manage plastic wastes?
11. Who do you feel is responsible for plastic waste?
12. What are some of the impacts that plastic waste on the environment and human health?

INTERVIEW QUESTIONS FOR THE LOCAL AUTHORITY AT WARD LEVEL

1. What is your name and job description?
2. How long have you worked at the area?
3. What kinds of waste are produced in Watamu?
4. Is there a problem of plastic waste in Watamu?
5. What is the role of the local authority in managing plastic wastes in Watamu?
6. What is the role of the public in managing plastic wastes in Watamu?
7. Have there been sensitization and awareness campaigns on locals in order to improve their perspective on plastic waste?
8. What are some of the challenges of effectively managing plastic waste that you face?
9. Are there ways in which you could improve?
10. What barriers prevent you from doing more to manage plastic wastes?
11. Who do you feel is responsible for plastic waste?
12. What are some of the impacts that plastic waste on the environment and human health?

INTERVEW QUESTIONS FOR TOURISM OPERATORS AND FISHERMEN AT THE BEACH

1. What is your name and job description?
2. How long have you worked in the area?
3. Are there plastic waste issues in your area of operation?
4. What are your opinions on them?
5. How do you manage your plastic waste?
6. Who do you feel is responsible for plastic waste?
7. What are some of the impacts that plastic waste on the environment and human health?

APPENDIX 3: OBSERVATION CHECKLIST

1. What are the main kinds of plastics that are found littered in the area?
   a) Plastic grocery bags/ paper bags ☐
   b) Plastic bottles ☐
   c) Discarded plastic parts (e.g. of basins, electric wires) ☐
   d) Sweet wrappers ☐

2. What type of plastic waste has been observed?
   a) Low density plastic ☐
   b) Medium density plastic ☐
   c) High density plastic ☐

3. Where was the above type of plastic waste been identified?
   a) Waste dumpsite ☐
   b) Marketplaces ☐
   c) Roadsides ☐
   d) Along the Beach ☐
   e) Open area ☐

4. What is the social status of the people living in the area?
   a) Rich ☐
   b) Average ☐
   c) Poor ☐

5. What plastic waste management methods are being used by residents?
   a) Recycling ☐
   b) Re-using ☐
   c) Burying ☐
   d) Burning ☐
   e) Discarding openly ☐
   f) Other ……

6. The following important notes were noted;

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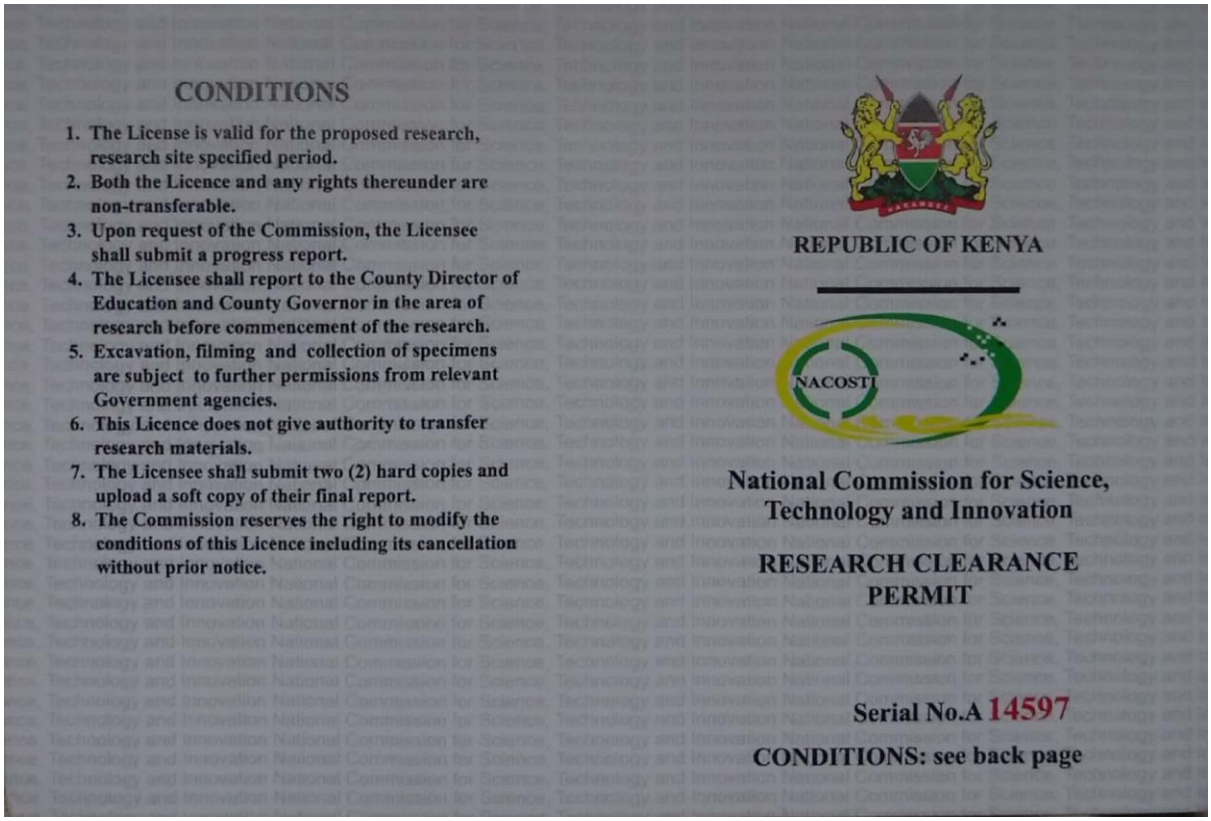
APPENDIX 4: NACOSTI RESEARCH PERMIT



CONDITIONS

1. The License is valid for the proposed research, research site specified period.
2. Both the Licence and any rights thereunder are non-transferable.
3. Upon request of the Commission, the Licensee shall submit a progress report.
4. The Licensee shall report to the County Director of Education and County Governor in the area of research before commencement of the research.
5. Excavation, filming and collection of specimens are subject to further permissions from relevant Government agencies.
6. This Licence does not give authority to transfer research materials.
7. The Licensee shall submit two (2) hard copies and upload a soft copy of their final report.
8. The Commission reserves the right to modify the conditions of this Licence including its cancellation without prior notice.

REPUBLIC OF KENYA

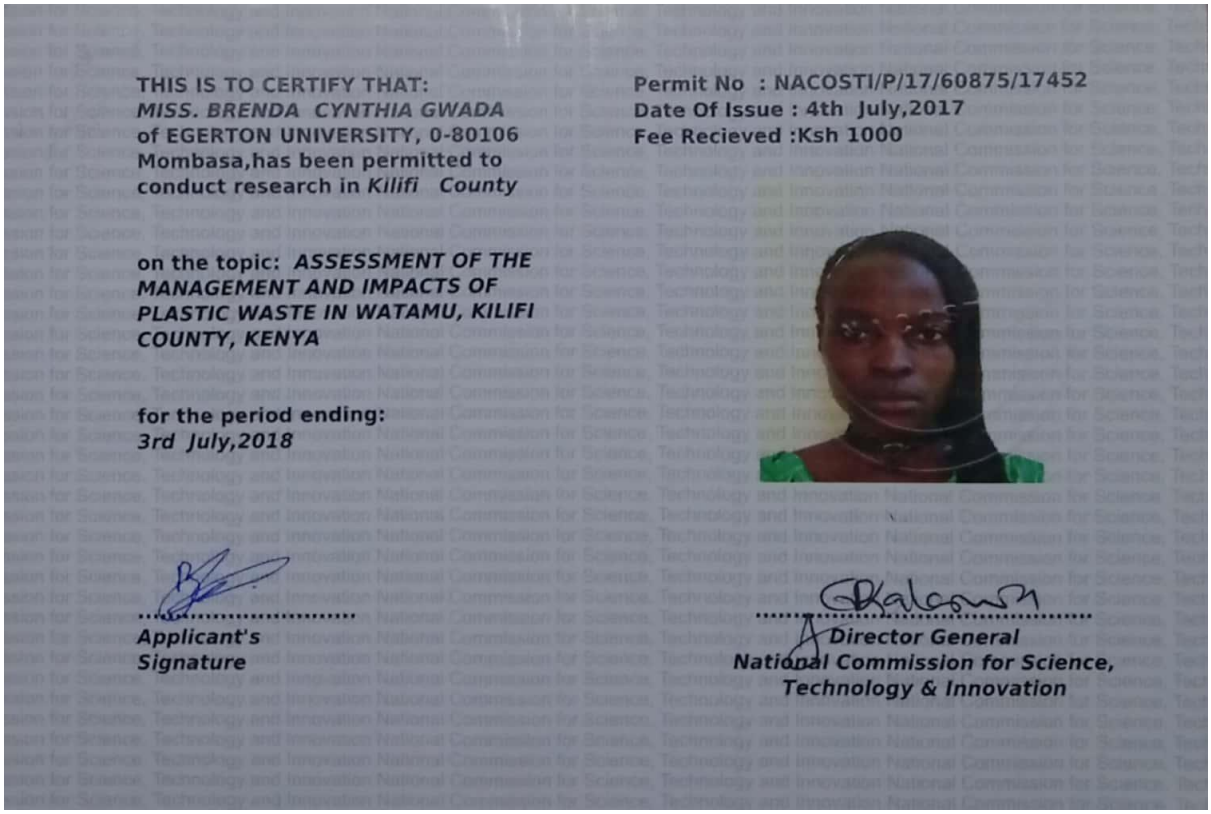
NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No.A 14597

CONDITIONS: see back page



THIS IS TO CERTIFY THAT:
MISS. BRENDA CYNTHIA GWADA
of EGERTON UNIVERSITY, 0-80106
Mombasa,has been permitted to
conduct research in *Kilifi County*

on the topic: *ASSESSMENT OF THE MANAGEMENT AND IMPACTS OF PLASTIC WASTE IN WATAMU, KILIFI COUNTY, KENYA*

for the period ending:
3rd July,2018

Permit No : NACOSTI/P/17/60875/17452
Date Of Issue : 4th July,2017
Fee Recieved :Ksh 1000

.....
Applicant's Signature

.....
Director General
National Commission for Science, Technology & Innovation