WASTE MANAGEMENT PRACTICES IN THE FRUIT VALUE CHAIN DEVELOPMENT: THE CASE OF MANGO FRUIT IN LOWER EASTERN AND NAIROBI COUNTIES OF KENYA

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A RESEARCH PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTERS OF ART DEGREE IN ENVIRONMENTAL PLANNING AND MANAGEMENT, SCHOOL OF BUSINESS, UNIVERSITY OF NAIROBI

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Student Declaration

This research project is my original work and has not been presented in any other institution of higher learning for an academic award.

Signature: ……………………………… Date: ………………………………..

Tabitha Njambi Runyora

C50/71849/08

Supervisors' Declaration

This project has been submitted for examination with my approval as University Supervisor.

Signature: ……………………………… Date: ……………………………….

Dr. John K. Musingi

Signature: ……………………………… Date: ……………………………….

Mr. Isaac J. Ndolo

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DEDICATION

I wish to dedicate this work to my dear family who were the source of motivation in my studies as well as in this research, especially for their care and sacrifice throughout my studies. Their love, care, concern, support, encouragement and enthusiasm inspired me to finally achieve this goal. May God bless and keep you well.

ABSTRACT

The study on waste management practices in the mango fruit value addition chain involved three kinds of population; the farmers, processors and the marketers. The target sites were based in countryside and urban areas where the fruits are produced and marketed respectively. The study objectives were meant to identify and analyze the type and quantities of waste generated during mango fruit production and value addition processes and investigate the influence of the mango fruit waste disposal methods on the environment.

The study utilized the interview guide as the methods of data collection from the targeted interviewees. The researcher managed to gather information from 86 interviewees which gave a response rate of 78% of the targeted population. The information was therefore adequate for analysis. The study revealed that the basic proportion of mango fruit that goes to waste is relatively between (30-50%). More waste is generated during production (26%) and distribution (24%) the mango fruits than when the fruit is in the hands of the processors.

The most applicable methods of waste disposal are decomposing the excess byproducts from the mango fruit, animal feeding, and planting back the mango seeds, use of garbage bins and land-filling. Wash-water is mainly recycled and the solid wastes disposed in the garbage sites.

However large population shows low satisfaction level with the current performance of the authority that should control the waste disposal in the fruit processing sector. This implies that more effort should be put to minimize the amount of waste generated, promote re-use of waste products and also enforce rules that should control the amount of waste products disposed into the environment. The study recommends that waste management should be considered not only as an individual issue but also as a corporate issue that should be put at everyone’s concern. There is need to create awareness to every intermediary involved in processing and consumption of mango fruits on the importance of managing and utilizing the waste generated from processing and consumption of the fruit. Waste disposal should be everyone’s concern at all times for the need to conserve the environment.

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LIST OF ACRONYMS

HCDA	:	Horticultural Crops Development Authority
KARI	:	Kenya Agricultural Research Institute
KENFAP	:	Kenya National Federation of Agricultural Producers
KICC	:	Kenya International Convention Centre
PRISMA	:	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSDA	:	Promotion of Private Sector Development in Agriculture Project
UNDP	:	United Nations Development Programme
USAID	:	United States Agency for International Development

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Waste management is a major challenge in Kenya and other countries in Africa. The increase in waste material generation has not been accompanied by an equivalent increase in the capacity of relevant authorities to deal with it, nor with a particularly evident expansion of the demand from industrial or agricultural value chains. In many areas of the world, especially the developing countries, environmental issues concerning waste disposal and processing are the same (Shittu *et al*., 2007). Human beings produce large quantities of wastes in their daily lives. From homes come wastes from food preparation, washing machines, baths, toilets, newspapers, junk mail, packaging, hobbies, auto and home maintenance projects, and the landscape. In addition, wastes are generated in producing the goods and services utilized.

Waste is defined as any material, which has not yet been fully utilized, (i.e. the leftovers) from production and consumption. However, waste is an expensive and sometimes unavoidable result of human activity. It includes plant materials; agricultural, industrial, and municipal wastes and residues. Waste also refers to liquid or solid discharged from residences, business premises, small scale industries, and institutions. In general, waste can be characterized based on its bulk or organic contents, physical characteristics, and specific contaminants. Each waste contains its unique quality and characteristics, which then suggests the type of treatment required. The two divisions of waste– Domestic and Industrial effluent have different make-ups and often require various treatment processes. Waste treatment is generally classified into four levels: primary, secondary, tertiary, and quaternary treatment with each treatment level aimed at removing a more specific class of contaminants (Mc Langhlin, 1992; Aririatu *et al*., 1999; Okonko *et al*., 2006).

In arid and semi-arid continent where soils are seriously depleted (i.e. exhausted or over-used in terms of minerals) due to excessively intense cultivation and inadequate soil management and countries like Kenya, industrial processing activities (aimed at reusing, recycling, or composting from waste) of organic waste in agricultural systems is astonishingly under-utilized. Managing organic waste separately is not yet part of the experience – or of the accepted work package – of most African city councils and waste officials, despite the fact that increasing the beneficial use of organic waste as animal feed, compost or energy would contribute to closing the rural–urban nutrient cycles in a sustainable manner. Understanding the problems and potentials of the organic waste stream is perhaps the single most important step that rural and urban authorities could take in moving towards sustainable, affordable, effective and efficient waste management.

1.1.1 Mango Production in Kenya

Although mango production and processing has gathered momentum in recent years throughout Kenya, there is no reliable documentation available on national level processing and waste generated during production and processing activities (Griesbach, 2003). According to the Horticultural Crops Directorate (HCD 2013), production increased from 452,944MTs in 2011 to 581,290MTs in 2013. However, several government agencies and development projects are working on mango and have produced useful reports which document their particular areas of interest.

The Ministry of Agriculture (MOA) produces the only available national database on mango production. This is inclusive of production in metric tons, area under production, yields and value of produce in Kenya shillings. Unfortunately, the reports contain many errors. In 2009, Horticultural Crops Development Authority (HCDA) coordinated a technical team to "validate" MOA horticultural production data for 2005-2007, which included mango. The team reviewed and corrected many of the obvious errors and omissions in the annual production tables for these three years (HCDA, 2009). According to the validated report, Mango is the third most produced fruit after bananas and pineapples The main threat to mango production is pests especially the mango weevil and the fruit fly. For better quality mangoes production, a coordinated IPM programme for pest control is essential. Other value addition initiatives like the frozen mango, which was reported to have a potential niche market, need to be explored (Kaminchia, 2007).

Kenya Agricultural Research Institute (KARI) researchers have worked on mango production for many years and produced a number of technical papers on mango production (HCDA, 2009). The first group of cultivars adapted for commercial purpose and introduced to farmers in Eastern and Central Provinces by KARI were Apple, Kent, Van Dyke, Tommy Atkins and Haden between 1986 and 1994. In the last 15 years, KARI has introduced the Glenn, Maya, Irwin, Chino and Zill varieties. They are currently testing more varieties on farms in Kibwezi and other areas.

National Mango Growers Association is a relatively new organization established under the umbrella of the Kenya National Federation of Agricultural Producers (KENFAP). Members have valuable qualitative information on the strengths and constraints of mango production. The Association is active in key mango growing areas, particularly in Ukambani. They have no data collected yet on production by members in the various regions (Mutunga, John. Feb 2010).

USAID/Kenya Horticultural Development Program (KHDP) has been working since 2005 to commercialize mango from the Tana River and Malindi Districts. The focus has been on post-harvest handling, processing and logistics management to reduce losses and increase utilization. In 2006, the program carried out a feasibility study for a proposed fruit juice processing factory in Malindi. The study reported that production of mangoes from Coast and Eastern Provinces accounted for around 150,000 tons and that there were several out-grower programs being implemented by donors and NGOs which can quickly increase volumes for these crops. This was a generic study prepared in response to enquiries from several potential investors in fruit processing to utilize mango, pineapple and passion fruit grown in Malindi, Tana River and other areas of Coast Province. Unfortunately, due to inadequate marketing outlets and problems of infrastructure, up to 75% of all the fruit production at the Coast goes to waste every year (USAID/HDC (2004).

GTZ/MOA Promotion of Private Sector Development in Agriculture Project (PSDA) pioneered mango value chain analysis in Kenya but has not attempted any large-scale production surveys. According to a report after a value chain study in 2006, mango production in Kenya is mainly concentrated in smallholder farms in regions with a high incidence of poverty (60%) (PSDA 2006). The producers are facing fierce international competition, not only in overseas markets but also in regional and domestic markets.

Widespread management failures from orchards to consumers' tables result in massive quality problems and high cost per fruit.

Overall losses along the Value Chain are estimated at 50% per year, representing approximately 90,000 tons. The current heavy post-harvest losses, the unstable annual production and short production season are mainly due to inadequate variety research and propagation of seedlings, inappropriate orchard management, pre and post-harvest handling, fragmented marketing systems, poor infrastructure as well as lack of marketing information and standards in marketing and processing. Fresh Mango supplies to the local market and exporters as well as raw material supplies to processing plants hence cannot satisfy quality requirements nor can they respond to requirements of rural or urban markets or the strict supply calendar necessary to utilize established processing capacities to the optimum or to meet overseas customers' requirements. DANIDA/MOA Agricultural Business Development Project (ABD) carried out a detailed and fairly accurate survey of mango production in Coast Province in 2009. The main objective of the study was to establish a reliable estimate of the total population of mango trees in the Coast province by age, variety and geographical areas of distribution. The major constraints highlighted in the study were; high post-harvest losses, inadequate processing capacity and poor infrastructure (Kaminchia, 2007).

1.2 Statement of the Problem

Mango production in Kenya has experienced significant growth in recent years. Volume produced between 2011 and 2013 increased from 452,944MTs to 581,290MTs (HCD 2013). This growth is not only in volume but also in the geographical location of commercial and homestead plantings increasing the area under production from 39,367Ha to 46,980Ha over the same period. Although mango production and processing has gathered momentum in recent years throughout Kenya, there is no reliable documentation available of national production, processing and the impacts that both production and processing have to the environment.

The principal areas of mango production include the Eastern and Coast regions (responsible for 85 percent of national mango production), followed by Central Region and other emerging producing areas such as Nyanza, Rift Valley, North, and Western

Region (HCDA, 2012). The two main varieties of mango produced in Kenya include Apple (50 percent of produce from Eastern Region) and Ngowe (49 percent of produce from Coast Region).

75% of all the fruit production at the Coast, (which is mainly mango) go to waste every year due to inadequate marketing outlets and problems of infrastructure (USAID/HDC (2004). Several government agencies and development projects are working on mango and have produced useful reports which document their particular areas of interest some citing high losses and others up to 40% waste. Losses due to pests and diseases are estimated at 30 – 40% per year (ABD/MOA 2006).

Kenyan mangoes are unable to compete internationally due to unreliable supplies, poor quality and inadequate infrastructure which increases prices of mangoes. According to a presentation by Technoserve during the February 2010 Mango Conference at KICC Nairobi, 50% of mangoes produced in Kenya do not reach end markets due to inefficiencies along the value addition chain. Negligible amounts of the fruit are currently processed (~1%) with processors importing concentrates from Brazil and South Africa. In addition, higher quality mangoes are exported as well as sold in high profile retail outlets, supermarkets and green grocers in the upper market areas while the lower quality remains in the domestic market. During the same conference, a presentation by a USAID funded program, Kenya Horticultural Development Program, indicated that high levels of black spot from fungal diseases and mango weevil (due to climate change**,** pests that were not able to survive previously are now able to do so); poor crop husbandry and harvesting practices are leading to wastage and low fruit quality. Bad roads, expensive logistics are also leading to high wastage (USAID/KHDP (2004)).

Stakeholders in the mango value addition chain have been advocating for the promotion of processing capacity in Kenya to decrease post-harvest losses and extend shelf life but unfortunately the fruit is bulky and has a short storage life span, thereby making it difficult to store for continuous processing. Mangoes can be processed into pulp and juices, dried mango confectionery products, dried mango chips as a food ingredient, green mango in brine or vinegar for processing, jams, preserves, chutneys and mango seed oil for cosmetics. All these products have bi-products which need to be followed up to find out if they finally turn into waste. It is therefore important to carry out a study on the entire mango value chain to find out the amount of waste generated in each node and how it is disposed-off so as to ensure sustainability in mango farming.

1.3 Research Questions

i) What type of solid waste do mango producers, processors and sellers release to the environment during the fruits production, processing and distribution?

ii) How do the mango value chain players dispose-off the mango waste?

iii) Are there alternative systems in which the waste generated can be re-used?

iv) Are there environmentally sound measures for management of mango waste?

1.4 Objective of the Study

The main objective of the study is to assess the processes involved in mango fruit production from harvesting, processing and distribution with emphasis on waste generation and management.

1.4.1 Specific Objectives

i) To identify and analyze the type and quantity of waste generated during mango fruit production and value chain development processes and how it is disposed;

ii) To assess the influence of the mango fruit waste disposal methods on the environment.

1.5 Justification of the Study

Mango production in Kenya has experienced significant growth in recent years. Volume produced between 2011 and 2013 increased from 452,944MTs to 581,290MTs (HCD 2013). The principal areas of mango production include the eastern and coast regions (responsible for 85 percent of national mango production), followed by Central Region and other emerging producing areas such as Nyanza, Rift Valley, North, and Western Region (HCDA, 2012). There are over 3 million mango trees in the Lower Eastern region, of which 1 million are young and not yet in production, signaling a potential 35% increase in production by 2015 (ABD 2010).

Approximately 64% of all mangos in Kenya are lost every year. The main reason for the huge losses is that only 7% of the mangos in Kenya are processed or exported (Kenya Investment Authority 2012). Due to inadequate marketing outlets and problems of infrastructure, up to 75% of all the fruit production at the Coast alone goes to waste every year USAID/HDC (2004).

According to Kehlenbeck et al., (2010) the market for fresh fruit currently constitutes the biggest market for mangoes accounting for almost 90% (165,000MT) in 2010. Within this market, the urban market is the biggest and most lucrative accounting for 75% of the total marketed production (14,200MT) valued at ks.5.3 billion annually, hence the choice for two big markets in Nairobi County for the study.

Processing of the fruit does not completely resolve the issue of waste from the product, in fact, the process also produces waste. This therefore means that a problem exist that may in future drive mango value chain players out of business due to resource degradation or depletion, thus the need for the study to review the current situation so as to come up with recommendations on what can be done

1.6 Scope of the Study

The study was carried out in two stages; the farm level/production and the post-harvest stage. Farm level/ production study was carried out in Kathonzweni and Kibwezi sub counties of Makueni County, emphasis being on commercial farmers due to availability of records. Marketing/trade focused on Rural Assemblers & Purchasing Agents whose names and contacts were obtained from farmers interviewed.

The information from Rural Assemblers & Purchasing Agents then directed us to the markets where they sold the fruits. The study also targeted two markets; Wakulima and Eastleigh markets in Nairobi and two processors; Kitui Microprocessors Company and Chuluni Horticultural Enterprises both in Kitui County.

1.7 Operational Definition

Rancidity: The process which causes a substance to become rotten, that is, having a rank, unpleasant smell or taste.

Stakeholders: A person, group or organization that has interest or concern in an organization or undertaking. Stakeholders can affect or be affected by the organization's actions, objectives and policies.

Value chain: This refers to a chain of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the market, with improvement in value at each level of the process.

Waste management: this refers to generation, prevention, characterization, monitoring, treatment, handling, reuse and residual disposition of solid wastes, which mango waste can be classified into. The term is used in this study in relation to materials produced by human activity, and the process generally undertaken to reduce their effect on health, the environment or aesthetics.

Waste Utilization: This refers to the process of applying wastes to beneficial use in an environmentally acceptable manner while maintaining or improving soil and plant resources.

Waste: This refers to unwanted or unusable materials. The term is often subjective because waste to one person is not necessarily waste to another. Mango waste in this study refers to what is lost as either unwanted or unusable along the typical mango value chain.

CHAPTER TWO: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

This chapter captures the review of some of the studies that have been carried out regarding solid waste management. The literature will cover both theoretical review and empirical evidence.

2.2 Waste Management

Waste management is the collection, transport, processing or disposal, managing and monitoring of waste materials (Okonko *et. al.,* 2006). The term usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is a distinct practice from resource recovery which focuses on delaying the rate of consumption of natural resources. The management of wastes treats all materials as a single class, whether solid, liquid, gaseous or radioactive substances, and tried to reduce the harmful environmental impacts of each through different methods. Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers (Okonko *et. al.,* 2006). Management for non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator.

According to Bilitewski et al. (1994) and Gilpin (1996) waste management encompasses collection, transporting, storage, treatment, recovery and disposal of waste, and is defined as a comprehensive, integrated, and rational system approach towards achievement and maintenance of acceptable environmental quality and support of sustainable development. In addition, Minks (1994) regarded waste management as a tool for controlling disposal costs of construction waste, as well as facilitating examination of other alternative disposal methods such as recycling and reusing in order to reduce waste that finally results in landfills.

The requisite conditions for the tackling waste management is the understanding of local conditions, full range of technological options available and factoring one of the traditional wisdom and systems that the local people have developed over time in handling waste. This is fundamental to availing a system that will become viable and sustainable. Several technical and commercial feasible options present themselves for exploration. These options would call upon the engagement of labor-intensive and decentralized strategies to map out ways of managing the waste (Minks, 1994).

In Kenya, the challenge of Solid Waste Management is real (Gakungu, 2011). Collection systems are inefficient and disposal systems are not environmentally friendly. The country has a growing human population and an increase in urbanization. The urban centers have attracted a large population of informal settlements dwellers and the middle class. This urbanization and increased affluence has led to increased waste generation and complexity of the waste streams. This trend is compounded by growing industrialization of the Kenyan economy. Despite the existence of laws and policies guiding waste management, weak implementation and poor practices have led to towns and cities being overwhelmed by their own waste, consequently affecting public health and the environment. Over the years' waste management has been the mandate of the local Authorities. However, most local authorities did not prioritize the establishment of proper waste management systems and hence allocated meager resources for its management. Further the councils lacked technical and institutional capacities to manage waste. This has led to the current poor state of waste management which includes indiscriminate dumping, uncollected waste and lack of waste segregation across the country (The National Solid Waste Management Strategy).

Most towns and cities have inefficient waste collection and disposal systems. For instance, a study done for Nairobi indicates that about 30-40% of the waste generated is not collected and less than 50% of the population is served (Otieno, 2010).

Waste transportation is largely rudimentary using open trucks, hand carts, donkey carts among others. These poor transportation modes have led to littering, making waste an eye-sore, particularly plastics in the environment. However, some counties have adopted appropriate transportation trucks as stipulated by the Waste Management Regulations. In addition, County Governments have privatized waste transportation through Private

Public Partnership arrangements. Disposal of waste in the country remains a major challenge as most of the counties lack proper and adequate disposal sites. The few towns that have designated sites practice open dumping of mixed waste as they lack appropriate technologies and disposal facilities. In an effort to address this situation NEMA directed all county governments to designate areas of waste disposal and undertake basic actions to manage the sites including fencing, manning and weighing of the waste.

2.3 Waste Management Options

Following the waste products generated in value addition chain of fruits and other agricultural products, the overall need is that a variety of options will be needed to achieve sustainable waste management. These highlight that:

Waste reduction- provides the greatest overall benefits (reducing financial and environmental costs) (Pap *et al.,* 2004). This should therefore be at the heart of any strategy for waste management. Incentives for farmers to reduce waste have been limited to date and there is clearly potential for reduction of some waste streams through improved farming practices. Many input manufacturers and distributors have already acted to reduce waste and, in the short-term, the scope for further reduction through design appears to be relatively small, but a complete 'rethink' of some inputs and processes could bring significant waste reduction in the longer term. However, even with extensive application of this option, it is unlikely that waste streams will be eliminated completely. The need for other options therefore remains.

Re-use- of waste can have significant financial and environmental benefits (although not always) and this option is potentially viable for a number of waste streams (Pongrácz, 2002). However, the scope for increased re-use of waste on farms (that is beyond current practice) appears to be limited. In this case mango seeds can be buried back into the ground to give back the seedlings that can be used to plant back mango trees.

On-farm incineration without energy recovery, for example in the 'drum incinerator', may be one of the most realistic options in the short term (particularly on small farms in remote areas). It is not a long-term option, since on implementation of the requirements for emission control and monitoring mean that it will no longer be viable. Small-scale incineration of non-hazardous waste (for example, secondary packaging) is likely to be exempt from waste management licensing, but the specific details have not been confirmed by either the Government or the Environment Agency (at the time of writing).

On-farm composting- is only potentially viable for a small proportion of the non-natural waste stream, principally secondary cardboard packaging (PSDA, 2006). It is not considered viable for other primary paper packaging (that is packaging used for seeds, feed and agrochemicals) due to the risk of soil contamination. In future, composting of biodegradable films may be a viable option, but this is uncertain at present. Overall, further research is needed before confirming the role of composting.

2.4 Waste Utilization

Wastes are produced by virtually all types of industries, although many cleanup and disposal options exist, no single process can be applied to all types of waste streams. The trend in the world today is to convert waste into useful products through the manipulation of microorganisms and to recycle waste product as much as possible and the role of microorganisms in waste utilization has been studied extensively by several authors (Pap *et al.*, 2004). Waste utilization is another approach in waste management practice. Waste utilization is an ecologically safe and economically efficient method of waste management since; the waste is not treated spending money or disposed-off in the landfill causing pollution Waste utilization could be brought about by the following methods (Okonko *et. al.*, 2006).:

Bioconversion

Biological processes for the conversion of wastes to fuels include ethanol fermentation by yeast or bacteria, and methane production by microbial consortia under anaerobic conditions. Bioconversion is referred to as the enzyme-mediated conversion of organic substrates, such as cellulose, to other more valuable substances, such as protein, by other organisms. The conversion of biomass to useable energy, as by burning solid fuel for heat, by fermenting plant matter to produce fuel, as ethanol, or by bacterial decomposition of organic waste to produce methanol is also referred to as bioconversion.

Bioremediation

One of the promising methods for toxic waste cleanup problems is bioremediation. Bioremediation is an environmental biotechnology process that use either naturally occurring or deliberately introduced microorganisms, to consume and breakdown environmental pollutants into harmless by-products such as water, CO_2 and salts, in order to cleanup a polluted site. Naturally occurring bacteria or fungi that degrade specific substances are isolated, cloned, and manufactured in large quantities and introduced as combinations of microorganisms into a hazardous waste site to eliminate specific contaminants. Under carefully controlled conditions, it is a practical and cost effective method to remove pollutants from contaminated surfaces and sub-surfaces.

Biotechnological Processes

In the industry the production processes are now being modified using biotechnology for reduction in pollution caused by the conventional methods. The biotechnological processes also prove to be very economical and also they provide products, which are better or at least equal in quality to the conventional methods. But in these processes the cost of pollution eradication is also saved as these processes generally give out very little or nil pollution and are more efficient than the conventional processes. Biotechnology serves as a solution to many problems in various fields ranging from fuels to many other cleaner and innovative clean up technologies. Some examples are: Biotechnological production of bio-surfactants; and Biochemical conversion of lignocelluloses substrates to cellulose, liquid glucose, and value added chemicals.

Biotechnological, bioremediation or bioconversion process is often successful and the most inexpensive method, it is only one of many techniques for dealing with hazardous wastes. This biological waste treatment or bioconversion is desirable because it is inexpensive, can be done at the site of pollution, and causes minimal physical disturbance to the surrounding area compared to other methods.

Bio-catalysis

To develop bio-catalytic methods for the conversion of crop derived carbohydrates to high value polysaccharides or oligosaccharides. The project composed of two major objectives. Develop bio-catalytic methods for the conversion of starch, corn co-products, beet sugar, or cane sugar to value-added oligosaccharides.

Biofilm reactors

Nicolella *et al*. (2000) reported that biofilm reactors are in operation at industrial scale throughout the world. Use of biofilm reactors is anticipated to be economical for the production of these industrial chemicals. It has been reported that the best biofilms were obtained with *Pseudomonas fragi*, *Streptomyces viridosporus*, and *Thermoactinomyces vulgaris* when used in combination with polypropylene composite chips.

2.5 Value addition

Value addition is the process of increasing the economic value and consumer appeal of an agricultural commodity (Griesbach, 2003). It is a production/marketing strategy driven by customer needs and preferences. "Value-added" is used to characterize food products converted from raw materials through processes that give the resulting product an "incremental value" in the market place either through higher price or expanded market. Examples of "value-added products" are: Jams, Ketchup, squashes, cheeses and pre-cooked meats are considered. Why value addition?

- Make more money: value added agricultural product has more market value than raw commodity.
- Meet changing tastes and preferences of consumers' -convenience, quality, safety, health, variety, and price, social and environmental consciousness.
- Compete by differentiating a product in a highly competitive market.

Food processing involves any type of value addition to the agricultural produce starting at the post-harvest level. The value of farm products can be increased through any of the route singly or in combination of extracting; drying; distributing; churning; culturing; smoking; labeling; grinding; hulling; or packaging.

2.6 Theory of Waste Management

Waste Management Theory (WMT) is a unified body of knowledge about waste and waste management. It is an effort to organize the diverse variables of the waste management system as it stands today. WMT is considered within the paradigm of

Industrial Ecology, and built side-by-side with other relevant theories, most notably Design Theory (Pongrácz, 2002). Design Theory is a relatively new discipline, still under development. Following its development offers valuable insights about evolving technical theories. According to Love (2002), it is crucial to theory development to integrate theories from other bodies of knowledge, as well as the clarification of the definitions of core concepts, and mapping out key issues, such as domains, epistemologies and ontologies. At the present stage of WMT development, scientific definitions of key concepts have been offered, and evolving of WMT under the paradigm of Industrial Ecology is in progress.

The function of science is to build up systems of explanatory techniques; a variety of representative devices, including models, diagrams and theories (Toulmin 1953). Theories can be considered milestones of scientific development. Theories are usually introduced when previous study of a class of phenomena has revealed a system of uniformities. The purpose of theory is then to explain systems of regularities that cannot be explained with scientific laws (Hempel 1966). Formally, a scientific theory may be considered as a set of sentences expressed in terms of a specific vocabulary. Theory will always be thought of as formulated within a linguistic framework of a clear specified logical structure, which determines, in particular, the rules of deductive inference (Hempel, 1966).

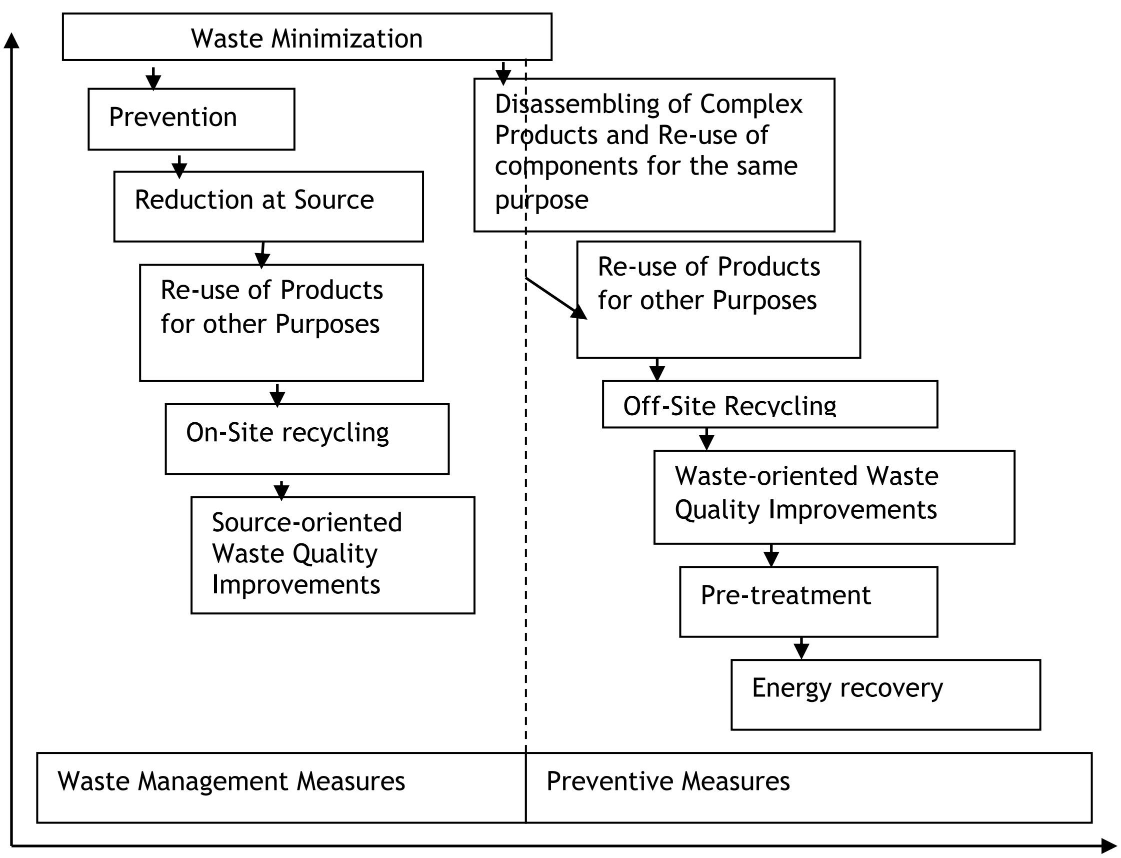
2.6.1 Waste Minimization – resources use optimization

According to Pongrácz (2002) Prevention of waste creation is the main priority of waste management, which corresponds to the principal goal of waste management: conservation of resources. Moving toward waste minimization requires that the firm commits itself to increasing the proportion of non-waste leaving the process. It has been argued that, it follows from the laws of thermodynamics, that producing by-products is concomitant of a main product. For this reason, industrial firms have to look beyond their factory walls, and seek for external utilization of their waste, in accordance with the principles of Industrial Ecology (IE). If we accept that waste minimization and resources us optimization is the most important objective of waste management (Pongrácz, 2002), it is essential that WMT is to be considered together with IE, as resource use optimization considerations reach beyond the tradition scope of waste management.

2.6.2 Waste Minimization in the Waste Management Hierarchy

The waste management hierarchy developed by El-Haggar (2007) is a useful framework and serves effectively as a guide while developing waste management plans. The framework works for providing an integrated approach in which options of waste management can be considered and thus serves as a systematic tool for those who generate and manage waste. There are five major steps in the structure: Reduce; Reuse; Recycle; Recover; and Disposal. More details on the framework are explained in the research documented by El-Haggar (2007) and Greenwood (2000). When waste management is properly implemented based on the framework, it can generate various benefits through the whole lifecycle of the waste from its generation to its final disposal. Apart from economic benefits, waste management may positively contribute to the following aspects (Cunningham, 2001; Tam et al., 2007):

Figure 2.1: The Waste Management Hierarchy



Source: Riemer & Kristoffersen

Minimizing the amount of waste sent to landfills for disposal can lead to less demand for landfill and reduction of negative environmental effects such as air pollution effects of landfill as well as emission and residues from incinerators. Waste management also involves planning and control of resources committed to projects in order to control the amount of waste generated (Riemer & Kristoffersen 1999). Therefore, better control of resources may be achieved with reduction in waste as well as improvement of entire resource management performance.

Waste prevention refers to three types of practical actions, i.e. strict avoidance, reduction at source, and product re-use. However, waste prevention does not only include the reduction of absolute waste amounts but also avoidance of hazards and risks because safety is also of major concern. Considering the waste management options, at the top of the hierarchy stands waste minimization that includes (Riemer & Kristoffersen 1999): Waste prevention i.e. reduction of waste by application of more efficient production technologies; Internal recycling of production waste; Source-oriented improvement of waste quality, e.g. substitution of hazardous substances; re-use of products or parts of products, for the same or other purpose.

Preservation of fruit juices also contributes to waste minimization by the means of avoiding the spoilage of the product. The traditional preservation methods are based the addition of chemicals or physical methods such as pasteurization, evaporation. Comparing to the evaporation, which is widely used for fruit juice concentrate production, energy efficiency is of great importance. The end- product is clean and of good quality, while the by-product of the final concentration step is a clear water that can be re-used in a process, e.g. for the first rinse of the berry fruits or for floor washing purposes (Pap *et al.,* 2003).

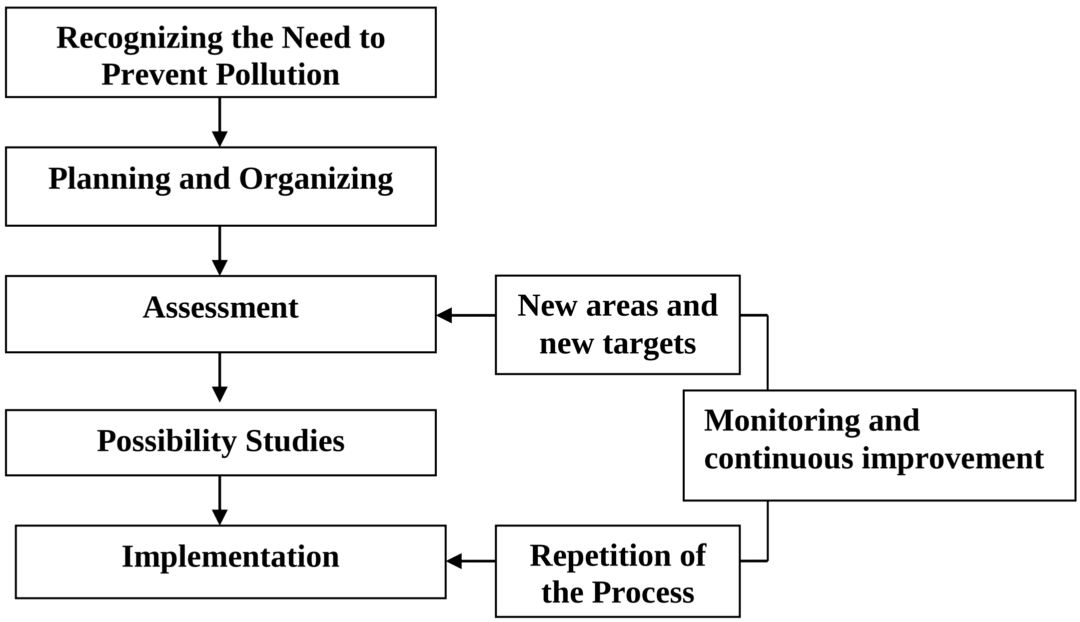
2.6.3 Theory of Cleaner Production

Cleaner production is a specific approach to reduce industrial environmental impact. The origin of the approach is to be found in the American company 3M. In 1975 3M initiated its 3P-program: "Pollution Prevention Pays" program. The philosophy of the program was that any waste produced during the production process is to be regarded as a misallocation of input materials. The 3M-3P-program was designed to work through the inputs of the employees. Employees were encouraged to report options that could reduce waste and emissions and could save money at the same time. The company promised that any option that would reduce costs would be implemented and the employee would receive a reward for reporting the option. In this way 3M was able to reduce considerable amounts of waste and considerable amounts of costs at the same time (Royston 1979).

Dieleman carried out a longitudinal in-depth study following 5 of the PRISMA-companies in the period of 1989 until 1996. He concluded that first of all, decisions are very much influenced by random events: a letter from a legislator, a talk with a colleague, reading an article in a journal and so on. He observed that when a stakeholder tells employees to handle a certain environmental situation and they are experienced in pollution control, the decision will often be to invest in a pollution control, even when pollution prevention is actually paying and pollution control is not. He advises to focus less on "convincing" and "demonstrating" the benefits of cleaner production and to focus more on making cleaner production a normal part of day-to-day activities (Dieleman 1999 and Dieleman and Cramer 2004).

The methodology used in cleaner production (CP) projects is centered on the identification and implementation of so-called cleaner production options or opportunities. The definition of cleaner production as used by UNEP reflects the essence of the methodology. The essence of the methodology is first of all to identify sources of the production of wastes and emissions inside the production process. Once such sources are identified the next step is to think about all possible ways to eliminate or reduce those sources. Once a variety of potential options is generated the methodology prescribes to engage in feasibility studies to assess the economic and environmental consequences of the options. Finally, those options that prove to be feasible from an economic and a financial point of view are put forward for implementation. These subsequent steps can be characterized as (1) a planning and organization phase, (2) an assessment phase to identify wastes and emissions and options for change, (3) a feasibility analysis phase and (4) an implementation and continuation phase. Various demonstration projects showed positive results and optimistic believe was to be found that Cleaner Production was soon to be applied on large scales in many industrial sectors.

Figure 2.2: Steps of Implementation of Cleaner Production



Adopted from Dielemann and de Hoo (1993)

Step1: Recognizing the need to prevent pollution

Pollution prevention is viewed as a responsibility that is shared among governments, communities, individuals, and the private sector. Recognizing the need to prevent pollution will outline the views on the definition of pollution prevention and will help on how keep the environment clean. It will also help in ensuring that the preventive measures are involved in the implementation process.

Step2: Planning and organizing

Develop indicative targets, goals and objectives of what you would like to achieve. For example, you may want to aim for a 10% reduction in waste, water, energy and/or labour costs. Identify the staff who will work on a resource efficiency team.

Step 3: Assessment

Use our checklist to conduct a site assessment. Start from where goods enter the factory, through to processing and finally where goods are packaged and stored for delivery.

Develop a flow diagram for the site to identify where materials are travelling throughout the site. This will help conduct a mass balance for the site.

Step 4: Possibility Studies

Record and review utility data against production output for the previous two years using our Utility Reporting Worksheet. This will help to identify your company's performance and develop a snapshot of the current processes for which to benchmark against these changes. How much does waste really cost you? (Include loss of raw materials, labour, energy, water and trade waste). Develop a Resource Management Action Plan making the plan outcome focused, simple and easy to follow. Assign timelines and responsibilities to key personnel and tackle the simplest, most cost-effective issues first and develop the plan from there.

Step 5: Implementation

When implementing your Action Plan prioritise actions from the most cost-effective with no capital costs to those that may require capital investment. Identify where the largest percentage of waste is being generated and target this area first. Start with opportunities that have direct financial benefits for no capital expenditure. Track and chart all actions and progress. Encourage continuous feedback and rewards for staff and Keep it simple.

Step 6: Monitoring and continuous improvement

Once actions have been implemented, it is important to monitor performance to look for opportunities for continuous improvement. Monitor and track results and get continuous feedback and rewards for staff. Look at justifying any capital expenditure with costs saved through the program. Also set new targets, goals and objectives. Start the process again and look for opportunities and this should become part of your company's daily operations.

2.7 Environmental Impacts of Waste from the Food Sector

While it is true that the principle of waste prevention is universally accepted, the practice has lagged far behind. Food industry will also have to concentrate on waste avoidance as well as utilization of process wastes (Blottnitz *et al*. 2006). Application of clean technologies enhances the safety and quality of the product as well as reducing the energy requirements and environmental impact of the food industry. The main environmental impacts of the food sector are aquatic, atmospheric and solid waste emissions. By choosing proper separation technology, wastewater treatment is usually carried out and is implemented in process installations. The atmospheric emissions are mainly caused by extensive energy use. The food industry consumes a great deal of energy for heating buildings, processes, and process water, for refrigeration and for the transportation of raw materials and products. The increased share of renewable energy sources could slowly reduce the amount of conventional fossil fuel utilization (Blottnitz *et al*. 2006).

Solid by-products and wastes are also generated in high amounts in the food industry. The main treatment method of solid wastes is, composting. Recovery and re-use of by-products and wastes as raw materials is another option. However, microbiological quality and safety is always of major concern. Solid waste management has become one of the main environmental concerns during recent years (Hartmann and Ahring, 2006). In South Africa, the Department of Water Affairs and Forestry (DWAF, 1998), refers to Municipal Solid Waste (MSW) as general waste that does not pose a significant threat to the public environment if properly managed (Blottnitz *et al*. 2006). Landfilling is generally considered the most practical waste management method in South Africa. However, the scarcity of available land in close proximity to areas of waste generation as well as the uncontrolled landfill gas (CH_4) and leachate emissions from organic waste have caused landfilling to become a less attractive option (Reuters, 2007).

Moving towards a sustainable waste management regime, the internationally accepted hierarchy of waste management has shifted the emphasis from disposal to minimization, recovery, recycling and treatment (Sakai *et al*. 1996, DEAT 1999). Anaerobic digestion as a biological treatment technology applied to the organic fraction of municipal solid waste has become an established treatment process worldwide. The products generated from this technology comprise biogas (methane), which is a potential energy source and a nutrient-rich sludge, which has beneficial value as a fertilizer.

Thus, the recovery of biogas as well as the recovery of nutrients makes anaerobic digestion of organic waste a sustainable waste treatment concept (Hartmann and Ahring, 2006). The anaerobic digestion technology for the treatment of organic fraction of municipal solid waste was developed in the 1980s and early 1990s and has been the major development within waste treatment facilities in Europe during the last few decades, resulting in more than 120 waste facilities presently in operation across European countries. A recent publication from Canada indicated that biogas production from waste has also been introduced in that country, where 1,000 – 2,000 tonnes of grape skin waste from a wine producing area, originally shipped to landfill sites, is now used to produce biogas, to generate electricity or to process it to natural gas (De Baere, 2006).

This study will be concentrated mainly on technical/operational aspects, namely improving current practices/techniques and innovating new ones. The authors believe that if sustainable waste management plans are to be devised, they have to be based on local conditions. A good way of identifying these conditions is by studying the 'drivers' (factors) in the planner's area of responsibility (Wilson *et al*. 2007).

Waste management techniques as applied in more developed countries are not always directly applicable on developing countries, due to social, economic and cultural differences. Waste management in developing countries has only been addressed since the mid to late 1980s (Thomas-Hope, 1998).

Kenya is no exception in that Environmental Management and Co-ordination (Waste Management Regulations, 2006) was the first Kenyan law that regulated waste disposal. According to the Act, any person whose activities generate waste shall collect, segregate and dispose or cause to be disposed-off such waste in the manner provided for under these Regulations. Without prejudice to the foregoing, any person whose activities generates waste has an obligation to ensure that such waste is transferred to a person who is licensed to transport and dispose-off such waste in a designated waste disposal facility.

In Kenya local authorities are charged with the responsibility of collecting and disposing of solid and liquid municipal wastes within their areas of jurisdiction (WMR, 2006).

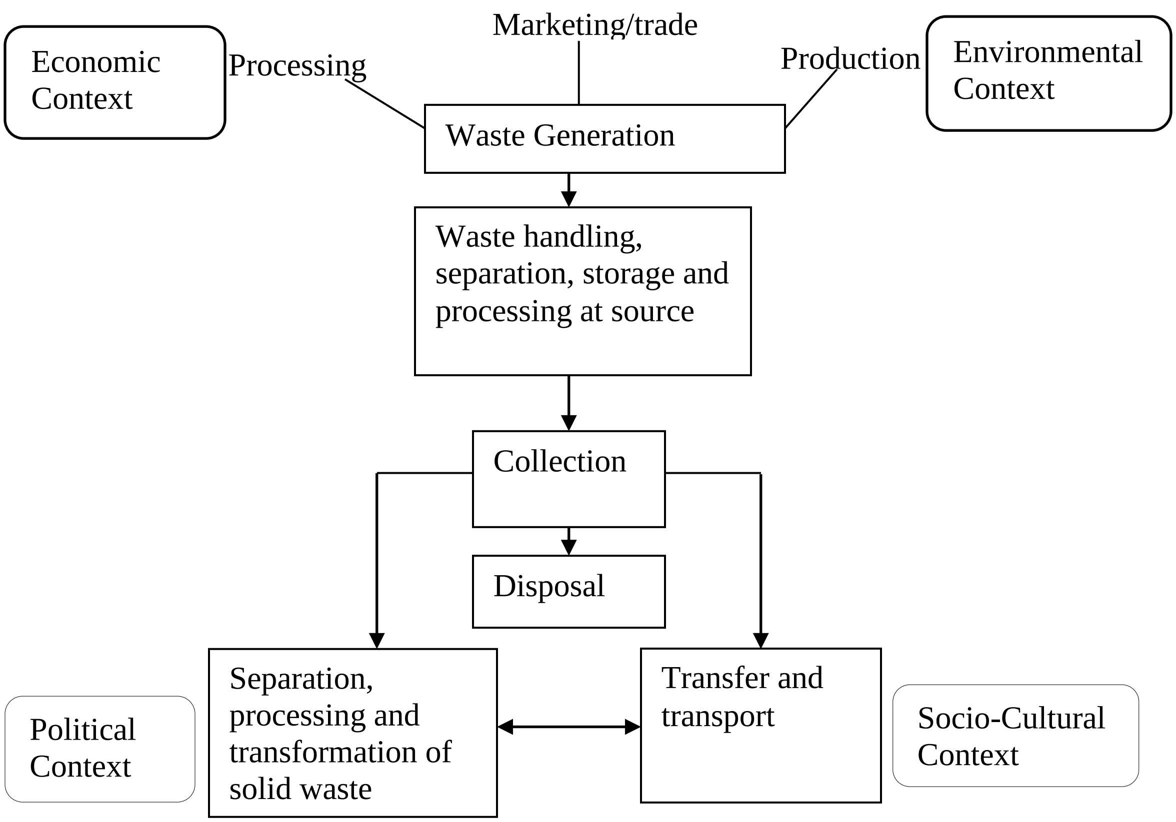
Centralized municipal solid waste management systems are used by most local authorities in Kenya. According to estimates from the World Resources Institute and

USAID, many local authorities in developing countries spend over 30% of their budgets on refuse collection and disposal but can only collect at most 50–70% municipal solid waste (Matrix, 1993). Most do not meet environmentally safe municipal solid waste disposal levels because of a lack of sanitary landfills. In Kenya plans are underway to shift towards sanitary landfilling.

2.7 Conceptual Framework

Figure 2.3 is a conceptual framework on waste management adopted and modified from Urban Management Program (UMP) working paper No. 9, 2006, to correspond to the various questions governing the scope, actors and strategic aspects in waste management. The effectiveness and sustainability of Municipal Solid Waste management (MSWM) systems depend upon their adaptation to the prevailing context of the city and/or country in which they operate. The most important aspects in this respect are outlined below at the political, socio-cultural, economic and environmental levels:

Figure 2.3: Conceptual framework on waste management



Source: Researcher (2011)

2.7.1 Political Context

Waste management is influenced in numerous ways by the political context. The existing relationship between local and central governments, the form and extent of citizens' participation in the public processes of policy making and the role of party politics in local government administration affect the character of management, governance and the type of waste management system which is possible and appropriate.

2.7.2 Socio-Cultural Context

The functioning of waste management systems is influenced by the waste handling patterns and underlying attitudes of the urban population. Programs to disseminate knowledge and skills, or to improve behavior patterns and attitudes regarding waste management, must be based on sound understanding of the social and cultural characteristics. Fast growing low-income residential communities may comprise a considerable diversity of social and ethnic groups. Social diversity strongly influences the capacity of communities to organize local waste management.

The effectiveness and sustainability of municipal waste management systems depends on the degree to which the served population identifies with and takes "ownership" of the systems and facilities. It is important that the people be involved from the outset in the planning of the local segments of waste management systems. Community involvement is particularly important regarding the siting of facilities such as waste transfer stations and landfill sites.

2.7.3 Economic Context

The character of waste management tasks and the technical and organizational nature of appropriate solutions depend a great deal on the economic context of the country and/or city in question and, in fact, on the economic situation in the particular area of the city. The level of economic development is an important determinant of the volume and composition of wastes generated by residential and other users, for example. At the same time, the effective demand for waste management services the willingness and ability to pay for a particular level of service is also influenced by the economic context of a particular city or area.

2.7.4 Environmental Context

Firstly, at the level of the built environment, the size and structure of a settlement has an important influence on the character and urgency of waste management needs. In quite low-density semi-urban settlements, for example, some form of local or even on-site solution to the management of organic solid wastes may be more appropriate than centralized collection and disposal. In urban areas, the physical characteristics of a settlement including such factors as density, width and condition of roads, topography, etc. need to be considered when selecting and/or designing waste collection procedures and equipment such as containers and vehicles.

Secondly, at the level of natural systems, the interaction between waste handling procedures and public health conditions is influenced by climatic conditions and characteristics of local natural and ecological systems. The degree to which uncontrolled waste dump sites become breeding ground for insects, rodents and other disease vectors and a gathering place for dogs, wild animals and poisonous reptiles depends largely on prevailing climatic and natural conditions. In practical terms, climate determines the frequency with which waste collection points must be serviced in order to limit negative environmental consequences.

Finally, environment health conditions may also be indirectly affected through the pollution of ground and surface water by leachate from disposal sites. Air pollution is often caused by open burning at dumps, and foul odors and wind-blown litter are common. Methane, an important greenhouse gas, is a by-product of the anaerobic decomposition of organic wastes in landfill sites. In addition, waste dumps may also be a source of airborne bacterial spores and aerosols. The suitability of a disposal site depends upon many factors, including specific characteristics of the subsoil, ground water conditions, topography, prevailing winds and the adjacent patterns of settlement and land-use.

2.8 Conclusion

The mango value chain involves a number of activities which include; supply of inputs, primary production, bulking, sorting, processing and trade, each of which have the potential to produce waste. At the farm level, inputs such as fertilizers and chemicals are used which are packaged in cans and paper bags/wrappers. There are some fruits that are spoilt and of poor quality which end up remaining in the farms. Some of the farmers sell their fruits at the farm gate to middlemen while others deliver their produce to the markets as well as roadside shops. Across the chain, sorting and grading is carried out to separate ripe fruits, unripe and spoilt/rejected fruits. It is in the interest of this study to find out how much waste is at each level and how this is disposed. The researcher will find out whether the rejected mangos are thrown away as waste or are a raw material for another product.

Before processing, the fruits are washed thoroughly to remove dirt, adhering latex and other foreign matter before peeling. The researcher will be interested in knowing the quality of water used and whether the used water is re-used or is waste. Contamination by peel constituents often results in unacceptable off-taste and discoloration in the mango pulp which may lead to waste. Peeling can be done either by hand or by steam/hot water which needs to be changed intermittently to avoid cross-contamination. A pulper is then used to disintegrate the fresh of the peeled mango while leaving the seed intact. Additional use of a finisher will help remove more fiber if required. Here the researcher will find out whether the peel, fiber and the seeds are useful or they are waste. The pulp is then heat treated and packed in drums with polyethylene liners then rapidly frozen and stored. In the case of dried mango, the peeled fruit is sliced, placed on trays and then dried up to below 10% final moisture. The dried pieces are then immediately packed in plastic bags to avoid re-hydration. If retail packaging is used, laminated bags are recommended with good moisture and oxygen barrier characteristics.

As the current trend in the world today is to utilize and convert waste into useful products as means of achieving sustainable development. As with any development, the sustainable re-use of waste resources would not be without difficulties, but it would open up the opportunity for biotechnological developments. The economic environment would need to foster the type of conditions in which the emergent food industry can thrive. Therefore to manage mango fruit wastes, the general pathways of industrial waste generation in the value addition chain should be reduced, recycled or reused and what is left must be treated and disposed of in an environmentally acceptable way. If a process is not environmentally friendly, it should be redesigned such that it becomes so and where a process cannot be redesigned, then it is necessary to reconsider whether it should be undertaken at all.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter explains the study area, data collection and analysis process that took place in an attempt to answer the research questions. This study utilized the research questions and objectives. The main objective of the study was to assess the processes involved in mango fruit production from harvesting, processing and distribution with emphasis on waste generation and management. The study was undertaken between December 2013 to April 2014. This was to capture all the activities in the mango value chain when the fruits are mature and harvesting is happening.

3.2 Study Area

The study was carried out in two stages; the farm level/production and the post-harvest stage. Farm level/ production study was carried out in Kathonzweni and Kibwezi sub counties of Makueni County, emphasis being on commercial farmers due to availability of records. Marketing/trade focused on Rural Assemblers & Purchasing Agents whose names and contacts were obtained from farmers interviewed. The information from Rural Assemblers & Purchasing Agents then directed us to the markets where they sold the fruits. This was mainly Wakulima and Eastleigh markets in Nairobi and two processors; Kitui Microprocessors Company, Chuluni Horticultural Enterprises both in Kitui County.

The study focused on the sources of different kinds of waste material, the methods of disposal and management and also the measures that can support reduction of waste generation in the value addition chain of the mango fruits. This information was largely useful in answering the research question of the research.

3.3 Research Design

The study focused on the entire mango value chain. Researcher adopted descriptive research design to understand the activities involved in the mango fruit value addition chain with the aim of pinpointing activities that produce waste and also find out how the waste generated is disposed and treated.

3.3.1 Sampling Technique

The stratified random sampling technique was applied in the selection of sample elements from the study population. The population was segregated into several mutually exclusive sub populations, or strata, the process by which the sample was constrained to include elements from each of the segments. This technique is referred to as stratified random sampling. Stratified random sampling has three main benefits: it increases a sample's statistical efficiency, provides adequate data for analyzing the various subpopulations, and enables different research methods and procedures to be used in different strata (Cooper & Schindler, 2001).

3.3.2 Target population

The study targeted three categories of respondents; the farmers, processors and the marketers. These involved commercial farmers in Kathonzweni and Kibwezi sub counties of Makueni County. Two markets, Wakulima and Eastleigh markets in Nairobi County, and two processors, Kitui Microprocessors Company and Chuluni Horticultural Enterprises in Kitui County were involved

3.3.3 Sampling Frame

Saunders, Lewis and Thornhill (2009) define the sampling frame as the complete list of all the cases in the population from which a probability sample is drawn. Sampling frame refers to the list of elements from which the sample is actually drawn, and is closely related to the population. According to Cooper and Schindler (2011) it is a complete and correct list of population members only. However, it is important to note that the sampling frame often differs from the theoretical population because of errors and omissions. The study targeted three categories of respondents; the farmers, processors and the marketers. The study adopted Yamane (1967) simplified formula for calculating sample size below;

$n=N/ (1+N (e^2))$ where n - the sample size, N - the population size, e - the acceptable sampling error. Therefore, for a population of 500 with 10% precision, a sample size of 83 was sufficient

Table 3.1: Sampling Frame

Strata	Population	Sample Percentage of Population	Sample size
Farmers	433	24%	104
Processors	26	15%	4
Markets	8	25%	2
Total	**467**	**21%**	**110**

3.4 Data Collection Procedures

The study employed non probability sampling procedure; convenience sampling. Primary data was collected using three sets of interview guides targeting the producers, processors and the marketers. Field visit was conducted where the researcher visited all the players in the mango value chain, interviewed them, face to face, and observed the activities. Observations were applied to give the real picture of the problems and help to answer the research questions clearly. The data collected was integrated to give the analysis of the exploratory research.

Secondary methods such as books, journals and Internet, were used as reference materials in order to get historical backgrounds of the challenges of waste management and solutions to the problem.

3.5 Data Analysis

Content analysis was utilized to integrate the information gathered from the field. Content analysis is a research tool used to determine the presence of certain words or concepts within texts or sets of texts. Researchers quantify and analyze the presence, meanings and relationships of such words and concepts, then make inferences about the messages within the texts, the writer(s), the audience, and even the culture and time of which these are a part. Texts can be defined broadly as books, book chapters, essays, interviews, discussions, newspaper headlines and articles, historical documents, speeches, conversations, advertising, theater, informal conversation, or really any occurrence of communicative language.

The information was presented in prose form. This method was preferred because the information collected was qualitative and therefore required analytical understanding. These approaches had been used before by Machuki (2005) and Ateng (2007) on such study to evaluate various phenomenon in a given industry.

3.6 Limitations of Study

Since most of the mango fruit waste products were mixed with other forms of waste in the disposal sites, it was difficult to determine their estimate tonnage in all the targeted areas of study. This would help to analyze the areas by the amount in tonnage of the disposed mango fruit waste products.

Time allocated for data collection was little and it was costly to reach all the respondents in the region. Thus the researcher did not get responses from all the respondents that were targeted.

Some respondents also gave wrong information and others were not co-operative to giving information fearing that the information sought would be used to intimidate them or print a negative image about their product.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

The study was carried out to investigate the waste management practices in the Kenyan mango fruit value chain. The information was gathered from the producers, processors and marketers operating in the study area.

4.2 The Study Response Rate

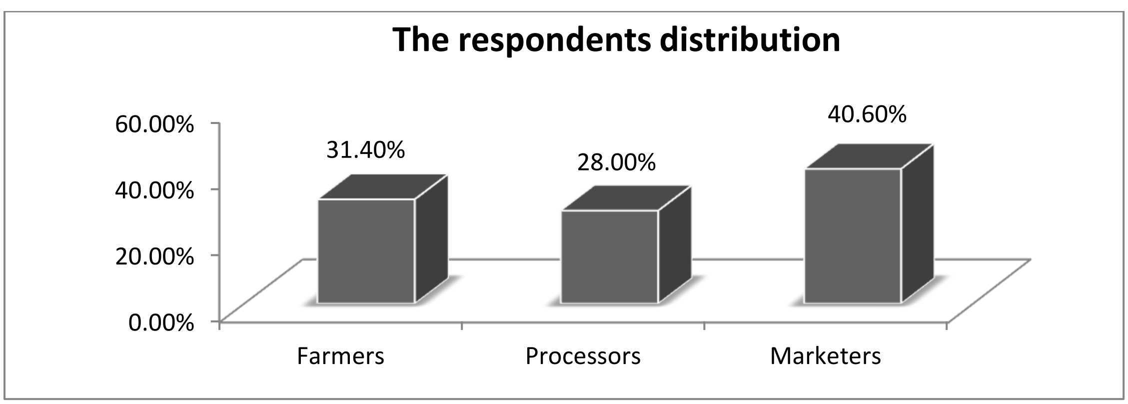
The study planned to collect primary data from a total of 110 respondents but only managed to collect data from 86 respondents. The target respondents were mainly farmers, processors and marketers who are actively involved within the mango value chain.

The researcher managed to interview 86 out the targeted 110 respondents from the different levels, a 78 percent response rate. This was a sufficient response rate able to inform the study objectives, meeting the sufficient threshold set by Mugenda and Mugenda (2003) of at least 70 percent response.

4.3 The Respondents distribution

The study also grouped the respondents depending on their position within the mango value chain and the following observations were made as presented in figure 4.1

Figure 4.1: Distribution of the study respondents by the Value chain node

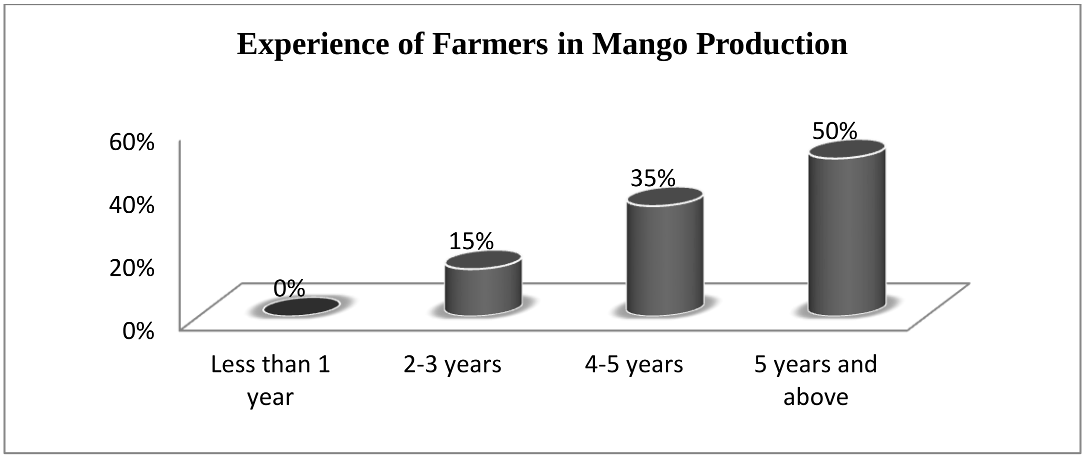


The study targeted various stages within the value chain to form its outcomes. From the total of 86 interviewed respondents, 27 were farmers (31.4 percent), 24 processors (28 percent) and 35 traders (40.6 percent). This is an indication that the mango value chain was well represented in the study.

4.4 Experience of the Respondents in mango fruit waste management

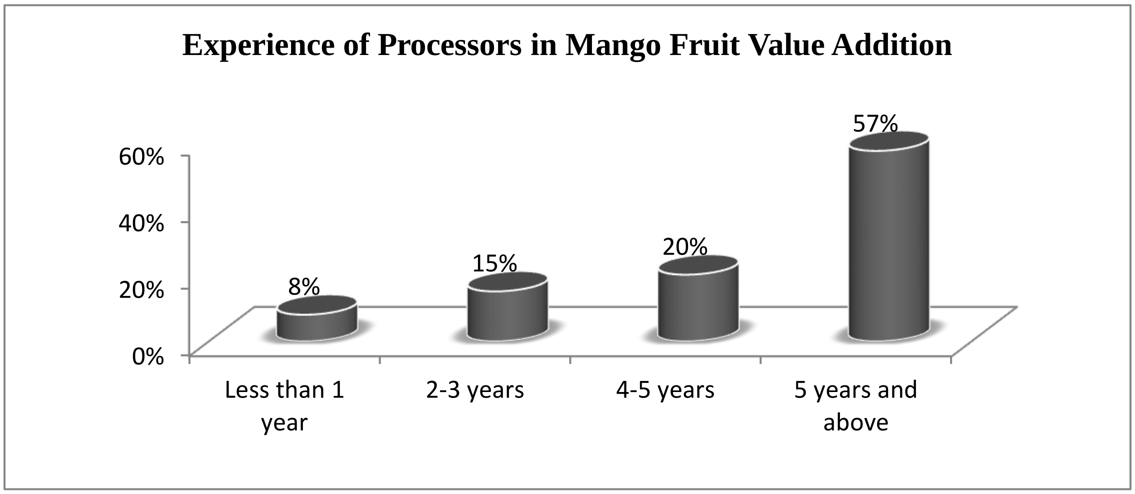
The researcher sought to know the period that each of the farmers, processors and the marketers were involved in the mango fruit value addition chain and trading. The study outcomes on the experience of mango farmers are as presented in figure 4.2.

Figure 4.2: Years of experience of farmers in Mango Production



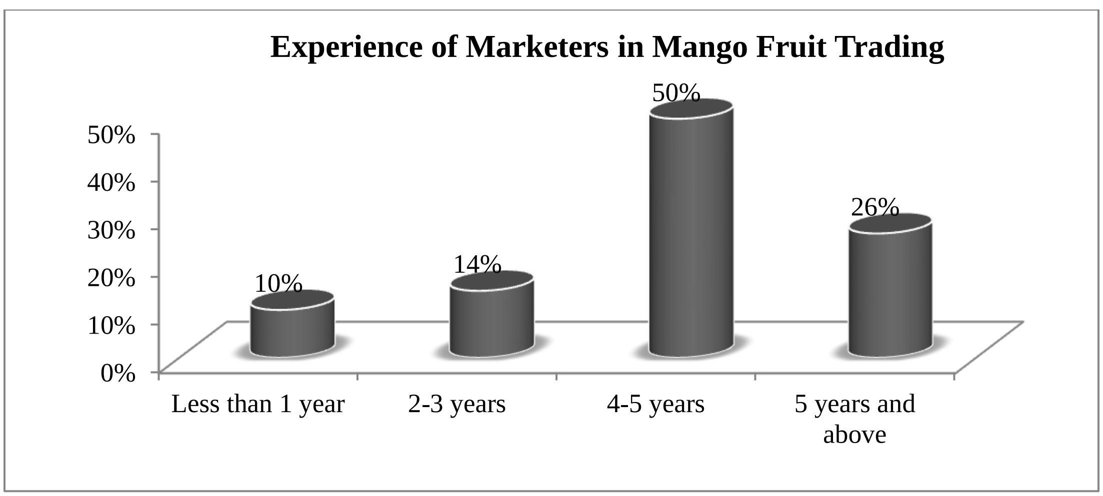
The response showed that majority of the mango commercial farmers (53 percent) had an experience of more than 5 years while 35 percent had an experience of 4-5 years, and 15 percent of the respondents had a 2-3 years experience. This implies that the respondents representing mango farmers were appropriate group to interview on the phenomenon under this study since their long experience in mango fruits value addition chain would help them know how to manage waste among other issues involved in the process. The study also considered the experiences of mango processors involved in the study and the following outcomes are as represented in figure 4.3.

Figure 4.3: Experience of Processors in Mango fruit Value Addition



The study found that most of the respondents representing the mango fruit processors had more than 5 years of experience, while 20 percent had an experience of between 4-5 years, 15 percent between 2-3 years and 8 percent less than 1 year. This is an indication that most of the respondents involved in the study have had adequate experience in providing the study requisite information. The study also looked into the experience of marketers of mango fruit, whose outcomes have been presented in figure 4.4.

Figure 4.4: Experience of Marketers in Mango Fruit Trading



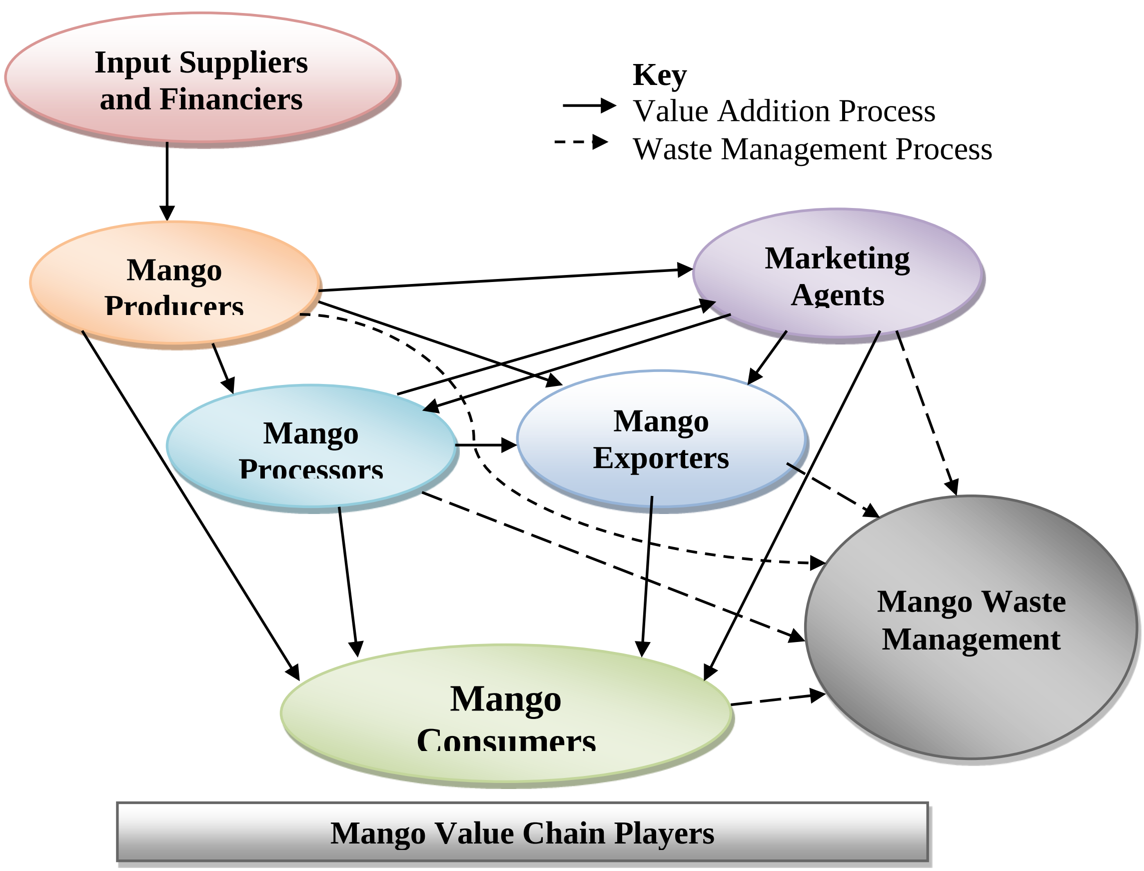
The study found that 50 percent of the study respondents representing the mango marketers had been providing the mango marketing services for 4-5 years, 26 percent for

5 years and above, 14 percent for 2-3 years and finally 10 percent for less than 1 year. This is an indication that the study respondents representing mango marketrs were well versed concerning the issues surrounding mango marketing in the Nairobi region. The study respondents were therefore able to provide information that was applicable and reliable to form the study observations.

4.5 The Kenyan Mango Value Chain

A review of available secondary data on the mango value chain provided some valuable information to the study which helped the study to form a pictorial representation of the mango value chain in the study area, which is applicvable to the whole of Kenya, providing a keen interest on the leakages along the value chain and the wastes generated along the way. The Kenyan Mango value chain can be presented as in figure 4.5.

Figure 4.5: Mango Value Chain Players



Source: Reasearcher 2014

Input Suppliers

Important input suppliers to the mango value chain include nursery operators and agro-chemical dealers. There are an estimated 200 certified nurseries and over 8,000 agro-chemical dealers in the country. Access to seedlings remains a major challenge for farmers. Likewise, long average distances to agro-chemical dealers limits the ability of farmers to buy appropriate inputs. Generally, farmers in the study area rarely used inputs on mango plants. Only 4 percent of the interviewed farmers used an agro chemical while 12 percent applied fertilizers.

Mango Producers (Farmers/ Farm Groups)

There are approximately 200,000 smallholder farmers, supplying approximately 65 percent of total national mango production. Farmers tend to have inadequate knowledge of orchard management, which is compounded by limited access to inputs, expertise and potentially useful public services or infrastructure—leading to low yields and low returns to their labor.

Image 4.1: Mango trees in Kibwezi, Makueni County

According to the National Horticulture Validated Report 2013, the leading counties in Mango fruit production, by quantity, in 2013 were Kilifi (18%), Kwale (16%), Machakos (9%) and Makueni (8%). Production has increased by an average of at least 13 percent since 2000, while exports have increased by an average of more than 18 percent in the same period. Kenyan yields (13.1MT/HA) compare favorably with global averages, however a number of quality and cost issues often prevent Kenyan producers from getting their product to market. Postharvest losses, estimated at up to 40 percent of total production, continue to weigh down the volume of produce available for domestic, export and processing markets. The main varieties grown include Sabine, Ngowe, Boribo, Apple, Kent, Haden, Dodo, Tommy Atkins and Van Dyke.

The study found that, for all the mango produced at the farm level, 20 percent are consumed at the farm, 45 percent are sold to the distributors and the remaining 25 percent are sold to the processing companies. The study estimated that about 11 percent of the mango is lost at the farm level as waste.

Marketing Agents:

These include village assemblers, brokers and wholesalers, who face numerous challenges ranging from poor infrastructure and unreliable transport, high post-harvest loss rates, to relatively expensive raw materials. A lack of appropriate transport and packaging technologies contribute to the high post-harvest losses. Inadequate organization of marketing agents substantially increases logistics times and costs, including those related to aggregation. Image 4.4 and 4.5 are a pictorial representation of mangoes packaged for the domestic and export markets from the Kenyan producers.

Image 4.2: Mango packed ready for distribution-local market

The study classified exporters as marketing agents too. Kenyan mangoes are relatively expensive in export markets because of the high cost of air freight. Despite high prices, Kenyan mangoes sell in Middle Eastern markets because they are available outside of Indian and Pakistani seasons.. In addition to high prices, exporters face difficulties in procuring high quality fruit due to poor postharvest practices, high local transport costs, and lack opf cold chain facilities in many production areas.

The study found out that 10 percent of the mangoes are lost at this section of the value chain in storage and during transportation.

Image 4.3: Mango packed ready for export

Mango Processors

There are four established mango processors, with a total installed capacity of 88,000 MT per year. More plants planned in Makueni, Kitui and other counties. Most processors specialize in pulp and juice, with only one currently producing concentrates. Processors operate at about 40 percent capacity, as a result of shortages of suitable raw material created by seasonality, shortage of varieties suitable for processing and competition from fresh produce buyers.

Mango processors acquire their fruits directly from the farmers or indirectly through the mango marketing agents who acquire them from local farmers or imported. After processing the mangoes into mango juice and other products, the processors either sell the products directly to the consumers, or access the consumers through the retailers. At this value chain level, losses of mangoes as waste is experienced comprising about 8 percent of the total products acquired into the processing plant

Image 4.4: Different steps in Mango processing

Image 4.5: Ngowe mangoes being unloaded and stored at a processor's premises in Mombasa

Mango Retailers

These include rural retail centres, open air retail markets, middle class and high end green grocers, supermarkets, hotels and international markets. The role of the mango retailers in the mango value chain is to bring the mango fruit and its products nearer the consumers. The retailers acquire the mangoes and/or their products from the farmers, processors and/or the marketing agents. The study found that 8 percent of these products spoil at this stage and are thrown off as waste. Image 4.8 below represents a typical mango retail within a market setup.

Image 4.6: Mangoes in Wakulima Market, Nairobi

Mango Consumers

Mango consumers are the main most important part of the mango value chain. Their role is the consumption of the mango fruits and the other products produced. they lead in guiding the quality control in the value chain. The mango consumers acquire the mangoes from locally sourced or imported from the farmers directly, from the processors directly, from the retailers or from the mango distributors. The study found out that 5 percent of all the mangoes and mango products acquired by consumers is lost as waste.

Image 4.7: Ready for consumption mango products

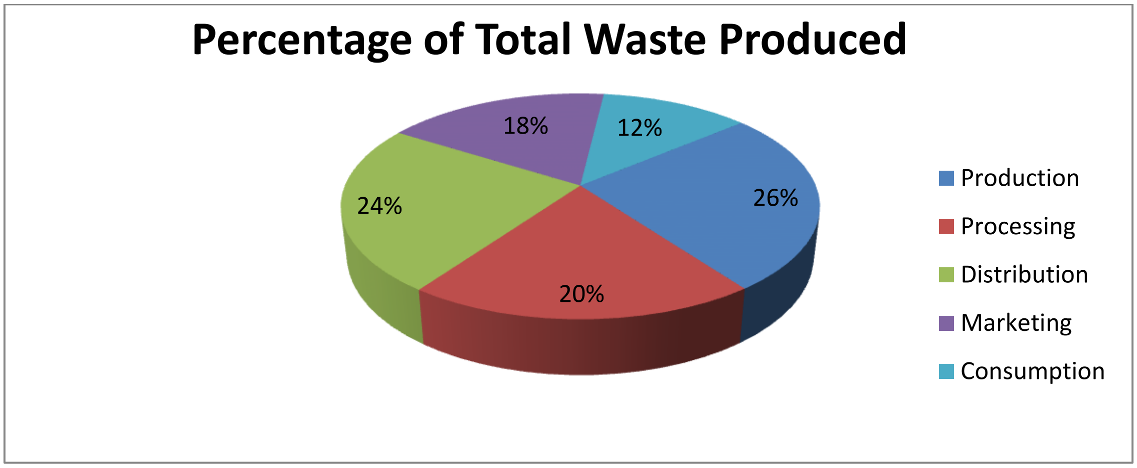
4.6 Types of Waste Materials Generated from Mango Fruits

It was observed that mango production and the preceding processes generate waste materials of different types at each and every level of mango value chain. This include solid waste for example stems, leaves and culled materials, the mango peel/skin, seeds/stones, and liquid waste (juice and wash-waters).

4.6.1 Amount of waste generated along the mango value chain

The study found that mango waste is produced at every point of the value chain in mango production and consumption process. Fresh mangoes spoil rapidly, and several methods for ensiling them have been proposed. The following scenario was observed in relation to waste production within each of the points along the value chain as presented in figure 4.6.

Figure 4.6: Mango Waste production within the value chain



The study found that 26 percent of the waste is realized at the farm level, 24 percent at the distribution level, 20 percent at the processing level, 18 percent at the retailing level and 12% at the consumers' level.

The mango value chain waste is accumulated through:

- Farm level losses: these arise due to mechanical damage during harvest or fruit picking and cull fruits after sorting.
- Processing losses: include losses due to spoilage and mango bi-products resulting from industrial or domestic processing.
- Distribution losses: they include losses due to spoilage and damage during handling, storage and transportation.
- Consumption losses: includes waste produced during consumption at the household level.

Image 4.8: Mango Waste at the Distribution and Processing level

According to the information and observations that were noted at the processing level, the amount of waste product generated from each mango fruit was 30-50 percent. This comprised of the mango peels and the seeds.

The bi-products of mango production often referred to as waste along the value chain include:

- Mango seed meal- this is made from ground mango seeds/stones. The mango seed represent 20 percent to 60 percent of the whole fruit weight, depending on the mango variety.
- Mango kernel meal- this is made from ground mango kernels. These are inside the seed and form 45-75 percent of the whole seed mango kernels (Maisuthisakul et al., 2009).
- De-oiled mango kernel meal (de-oiled mango seed kernel meal) is the by-product of the extraction of mango oil from the kernels. This product contains only residual oil, unlike mango kernels or seeds;
- Mango peels: the peels represent from 7 percent to 24 percent of the whole fruit weight (Berardini et al., 2005). They are a source of pectin, which is considered a high quality dietary fibre.

4.6.2 Mango Waste Impact on the Environment

The carbon footprint of the mango industry takes into consideration both its greenhouse gas emissions and its potential to remove carbon from the atmosphere. Therefore, its overall carbon footprint is lowered by its ability to sequester carbon which offsets the amount of greenhouse gas emitted.

Data collected from the Mexican Production to the U.S. retail distribution centres show that, greenhouse gas emissions from mangoes average 0.46 kg of CO_2 equivalent per kg of mango. Of this approximately 32 percent is emitted during transportation and a further 28.5 percent from agrochemical use. This is fairly low when compared to emissions from other fruits and vegetables. Tomatoes for example emits from 0.8 to 5.6 kg CO_2 equivalent /kg while emissions from carrots range between 0.3 to 0.6 kg CO_2 equivalent /kg. Beef on the other hand, has been shown to emit an average of 14 kg CO_2 equivalent /kg.

There are several sources of greenhouse emissions throughout its value chain, from the farm operations, packinghouses, exporters and retailers. Mango production contributes to slightly above 50 percent of the emissions while 42 percent is emitted during packaging.

The emissions emanate from the use of fossil fuels, agrochemicals, fertilizers, refrigerants and cooling equipment in pack houses, and emissions associated with transportation.

It can be estimated that mango processing yields between 150,000 and 400,000 tons of wastes worldwide, which may cause environmental problems in the vicinity of the processing plants. The use of mango wastes in livestock feeding is a way of reducing environmental concerns (Jedele *et al*., 2003; El-Kholy *et al.,* 2008).

Mango kernels are fairly rich in tannins, which progressively lead to reduced growth rates and less efficient feed utilization when included as a major component in diets for pigs and poultry (Moore, 2004). They also contain cyanogenic glucosides (64 mg/kg DM), oxalates (42 mg/kg DM) and trypsin inhibitors (20 TIU/g DM) (Ravindran *et al.,* 1996). Several treatments (soaking, boiling, HCl or NaOH treatment, autoclaving or HCl followed by Ca(OH)2) may remove tannins and HCN but the most effective method proved to be soaking as it removed 61 percent of the tannins and 84 percent of HCN (El Boushy *et al*., 2000).

The mangoes have an impact on the animals within the environment. Like other fruits of similar size, mango fruits can be dangerous to cattle when swallowed whole, as they may lodge in the oesophagus, causing obstruction and subsequent meteorism (choke bloat) and heart attack (da Silva, 2008; Vishwanatha, *et al.*, 2012). Similar problems have been reported with mango seeds in buffaloes (Kumar et al., 2010). Also, cattle fed mangoes in excess or consuming fallen mangoes at the time of harvest can experience difficulties in rumination and dizziness, due to possible ethanol intoxication due to ethanol intoxication (Assis *et al.*, 2010). The impact of mango waste on human being is also observed; Mango peels contain urushiol, a chemical that can cause contact dermatitis in susceptible people (Geller, 1989). Mango kernels contain oil and must be dried to prevent rancidity (de la Cruz Medina *et al.*, 2002).

4.7 Waste Management Practices

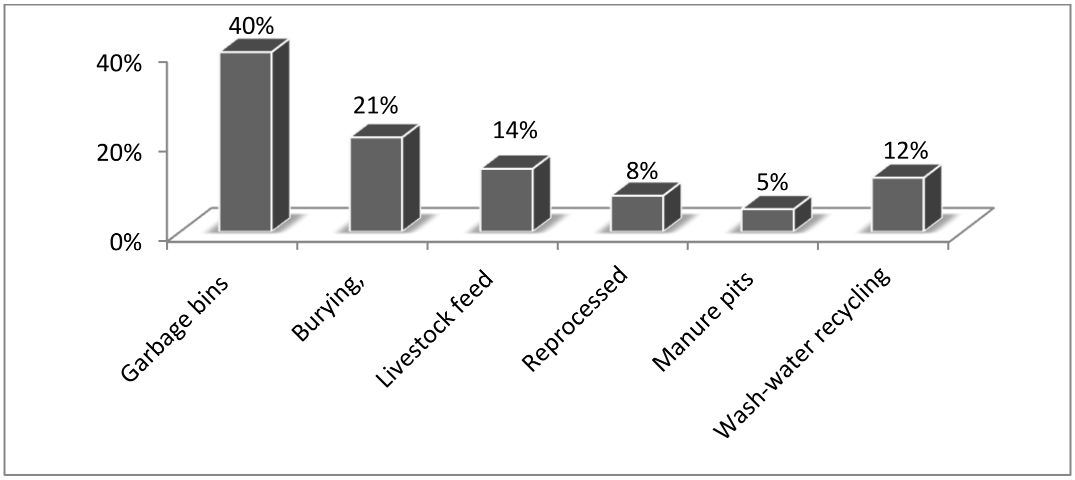
From the findings of the study, waste management was based on individual or organizational level. All the interviewees (100 percent) agreed that every stage of mango fruit value addition has a possible way to handle the waste products. Some farmers preferred to bury the mango seeds as a way of reusing the product. The mango peels if not consumed was fed to the livestock but those farmers without the livestock would utilize the peels to form manure and some disposed them as normal waste material. The observation made show that most of the farmers did not utilize the oil contained in the mango seed due to lack of machinery and know-how to do it.

From the processors, the amount of wastes products from the mango fruits appears lower (20 percent) than the rest of the intermediaries (See figure 4.6). The main sources of waste material are peels, seeds and the wash-waters. Most of the processors disposed the waste products into the waste bins and collected later by the garbage collectors. At the markets most the mango fruit waste products were unevenly discarded on the ground and most of them found in the garbage sites. Most of the mango fruit sellers stated that they gathered their waste from mango fruit and paid for collection by the garbage collectors.

4.7.1 Methods of Waste Disposal

The study assessed how the waste generated along the mango value chain is disposed-off and revealed the following;

Figure 4.7: Methods of Waste Disposal in the study areas



Majority of the respondents disposed their waste in garbage bins (40 percent) while 14 percent used it to make livestock feed. Only 12 percent of the respondents recycled the water they used during value addition.

4.7.2 Involvement of Waste Management Authority

From the study, it is clear that the authority has not played its role in controlling the disposal of waste products from the mango fruit processing industry. 83 percent of the respondent indicated that they do not involve the waste management authority in the disposal of the mango waste.

4.7.3 Waste Minimization Practices

The study looked at the various ways through which waste can be minimized in the mango value chain. Only 32 percent of the respondents from different sectors thought that waste generation could be minimized. It was further indicated that a considerable waste reduction can be achieved through simple activities such as sorting, which would ensure that stems, leaves and culled materials remain in the field during harvest. If fruit washing, grading and trimming can happen in the field, then additional soil and food residues will remain at the farm where they can be put into more use. Realistically, these wastes are being handled at the mango fruit processing plant sites. The primary waste-management strategies used by this industry are water conservation and waste-solids separation. It was also noted that water use by the mango fruit processing industry is essential to washing of the fruits and equipment. But the study was informed that the industry has adopted a number of practices, showing increased sensitivity to the need for water conservation:

It was suggested that wash-waters could be reduced in processing the mango fruits and also the consumers should be encouraged to utilize more parts of the fruit to ensure that only a smaller percentage of the fruit lower than 20 percent is wasted. Also clean processes, efficient, and complex method for mango fruit juice concentrate production and processing should be introduced to ensure the percentage of waste generated during the processing of the fruit is also minimized. This will enhance the safety and quality of the fruit as well as reducing the energy requirements and environmental impact of the whole industry.

The study found out that mango value chain can benefit very much if waste reuse processes are introduced into the mango waste management system. Parts of the mango value chain by-products can be reused in very beneficial ways. One such waste is the mango peel. Due to their high sugar content, they are palatable to ruminants and can be considered as an energy feed. In order to produce good silage, mango peels have to be mixed with dry materials (straw for example) and a nitrogen source (a legume for example) to increase moisture and protein content to facilitate fermentation (Sruamsiri *et al.,* 2009).

Mango seeds have a hard fibrous shell containing a kernel rich in oil (6-16 percent DM of the kernel) and starch (40-50 percent) (Medina *et al.,* 2010). While the seeds are bulky with a high fiber content (more than 20 percent) (Ali *et al.,* 1992), the kernels can be considered as a valuable energy feed, although low in protein (less than 10 percent DM) (de la Cruz Medina *et al.*, 2002). The use of mango kernels has been successfully investigated in several animal species, but it is unclear whether they are used in practice.

Mango peels may also be applied in the industrial production of lactic acid as has been suggested by various researchers involved on the subject. Gunstone (2006) is of the view that optimization studies on lactic acid production using mango peels showed that maximum production could be obtained in 6 days when initial medium pH of 10 and process temperature of 35 °C are utilized during fermentation of the mango peels.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter is a summary of findings, bringing out the main issues of interest from the analysis, conclusion, recommendations, limitations of the study, and culminates with the suggestion for further research.

5.2 Summary of Findings

The research investigated on the current status of waste management in the mango fruit value addition chain where three kinds of population were involved that included the farmers, processors and the marketers. The target sites were in the rural areas and urban areas where the fruits are produced and marketed respectively. This helped to evaluate the extent of waste generation and waste management in all the sectors. The study utilized an interview guide as the method of data collection from the targeted interviewees. The researcher managed to gather information from 86 interviewees which gave a response rate of 78 percent of the targeted population giving the study adequate information for analysis. The respondents had adequate experience to provide all the reliable information that was required in the study.

The study found that the mango value chain in Kenya is quite meshed with more than three routes for the fruits to reach the consumers. The study found that mangoes can reach the consumers directly from the farmers, from the retailers who purchase from farmers, processors, or distributors, from the distributors who purchases from farmers and processors and from mango processors who purchase from farmers and distributors. This being such a complex network, it was observed that a lot of transportation is involved in this which would mean that the wastage within the value chain is high. The study found that wastage is recorded in each node of the value chain from the producers to the final consumers hence making the suggested 30-50 percent wastage level to be seemingly realistic. The study observed that 11 percent of the mangoes are lost at production level, 10 percent distribution level, 8 percent at the processing level, another 8 percent at the retail level and 5 percent at consumption level resulting to a 42 percent loss across the value chain. The study revealed that overall waste production from mango fruit value chain is highest at the farm level at 26 percent followed by distribution 24 percent, processing at 20 percent retailing at 18 percent and consumption level at 12 percent. These changes were realized due to the difference in the number of units at each level of the value chain.

The study found the waste generated from mango are due to mechanical damage, spoilage during harvesting, culling, poor storage and distribution, process interruptions at the processing plants and grading, mango processing, consumption, and over-ripening. The mango waste by-products were divided into cull fruits, mango seeds, mango seed kernels, de-oiled mango kernel meal, mango peels, and mango processing waste.

The study found that mango waste has an impact to the environment as it was found to contribute to have a significant carbon footprint as it contributes to greenhouse gas emission. Use of mango waste to feed livestock was found to reduce growth rate and lethal to animals if swallowed whole. Mangoes were observed to affect the rumination in animals and possible ethanol intoxication. Mango peels are also linked to some dermatitis conditions and rancidity in human beings. On top of this, the mango waste is an eye sore and brings flies, rats and general air pollution when they rot.

Farmers stated different methods of mango waste disposal: decomposing the excess by products from the mango fruit; animal feeding; and planting back the mango seeds. Most of the marketers and processors used garbage bins and land filling method to disposes the waste material generated in marketing and value addition respectively. Wash water was mainly recycled and the solid wastes disposed in the garbage sites. However most of the interviewees were not satisfied by the current performance of the authority that should control the waste disposal in the mango fruit processing sector.

The high amount of wastes acquired in the mango value chain implies that more effort should be put in place to minimize the amount of waste generated and also enforce rules that should control the amount of waste products disposed into the environment. The study found that some waste minimization measures for mangoes are already in place at all nodes of the value chain. The study found that measures such as ensuring harvesting equipment permits additional stems, leaves and culled materials to remain in the field during harvest, and farm waste is used to feed livestock. At the processing level, water conservation and water-solids separation are done. Consumers should be encouraged to consume more parts of the fruits and reuse of mango waste introduced such as use of mango peels to produce lactic acid, and creating energy feed from the mango seeds.

5.3 Conclusion

The study found that majority of both the commercial farmers and the processors had been involved in the production and processing of the mango fruits for more than 5 years whereas the majority of the marketers. Their long experience gives them the experience on how to manage waste among other issues involved in the process.

This study focused on waste management in mango fruit value addition chain. It was conclusive that combined efforts of waste minimization during the production process, environmentally friendly preservation of the product, and utilization of side-products would substantially reduce the amount of waste, as well as boost the environmental profile of fruit industry in Kenya.

Value addition and processing of mango fruits generated about 30-50 percent from each mango and other waste for instance stems, leaves and culled materials, the mango peel/skin, seeds, and stones and liquid waste (juice and wash-waters). This in turn developed poor conditions caused by flies, rats, and air pollution at the market places and vegetable and fruits shops.

Land filling or garbage bins are a form of waste disposal that showed highest percentage of applicability. Though placed at the bottom of the waste hierarchy, it is generally regarded as the option of last resort. Land filling/ garbage bins has been costly to the environment, has limited availability and is becoming increasingly expensive since much of the land especially in urban areas is inhabited.

It generally agreed from the interviewees that mango processing produced waste materials at all stages. Not many of them showed methods that they applied to utilize the waste products from the mango fruits. However, the study observed a dire need to implement waste reduction strategies within the mango value chain.

5.4 Recommendations

5.4.1: At the production, processing and marketing levels

The study recommends that the government and the relevant authority should come up with a new strategy that will ensure that the waste products generated from the mango fruit value addition processes are collected from the urban areas and disposed back to the production lands. The waste products can be disposed into the decomposing silages which would be act as soil conditioners and manure for farming activities.

The study recommends that a considerable waste reduction can be achieved if harvesting equipment permits additional stems, leaves and culled materials to remain in the field during harvest. This would reduce the number of process that mango fruit could be taken through in the fruits processing plants.

The amount of wash-waters used in processing the mango fruits should be reduced and that consumers should be encouraged to utilize more parts of the fruit to ensure that only a smaller percentage of the fruit lower than 20 percent is wasted.

The study recommends implementation of an awareness program to every intermediary involved in processing and consumption of mango fruits on the importance of managing and utilizing the waste generated from processing and consumption of the fruit. This will ensure that all stakeholders in the processing and consumption of mango fruits are informed on the importance and methods of conserving the environment.

5.4.2 Recommendation for Further Studies

Further studies should be carried out to evaluate the amount waste material generated from different production and processing sectors both in urban and rural sites in Kenya. This study would greatly help to analyses the extent of waste generated from each sector so that control measures can be implemented in the waste management.

There is also the need for a study to determine the amount of waste generate during value addition process for the mango fruit so that proper planning for the waste management is adopted. This would trigger other related studies in other sectors of Kenya thus effective waste management across the country.

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APPENDICES

Appendix I:Interview Guide for Producers/Farmers

1. For how long have you been involved in production of mango fruits?
   Less than 1 year [ ] 2-3 years [ ] 4-5 years [ ]
   More than 5 years [ ]

2. What kind waste materials are mostly generated in the mango fruit production?

3. What is the estimate percentage of wastes that are generated in the production level of mango fruits?

4. Do think that there is a way that the waste generated at the production level of mango fruits can be managed? (Yes or NO)

5. If yes in the above question, in which ways do you ensure that wastes generation is minimized at production level of the mango fruits?

6. Which methods do you mostly apply in the disposal of waste material?

7. Would suggest any other alternative method of waste disposal in the production level of mango fruits? (Briefly explain)

8. Do you think that the environmental authority concerned with waste management has done enough to reduce inappropriate disposal of waste into the environment? (Yes or No and Briefly explain)

9. If (No) in the above question, what would you suggest that the authority concerned should put in place to ensure that waste management is maintained in mango fruit production?

Appendix II:Interview Guide for Processors

1. For how long have you been involved in processing of the mango fruits?
   Less than 1 year [ ] 2-3 years [ ] 4-5 years [ ]
   More than 5 years [ ]

2. What kinds of waste materials are mostly generated in the mango fruit value addition?

3. What is the estimate percentage of wastes that are generated at processing level of mango fruits?

4. Do think that there is a way to manage the waste generated in mango fruits value addition process? (Yes or NO)

5. If yes in the above question, in which ways do you ensure that the wastes generation at processing level of the mango fruits is minimized?

6. What is the estimate percentage of mango fruits go to waste during the value addition process?

7. Which methods are mostly applied in the disposal of waste material from the processed mango fruits?

8. Would suggest any other alternative method of waste disposal to the processors? (Briefly explain)

9. Do you think that the environmental authority concerned with waste management has done enough to reduce inappropriate disposal of waste into the environment? (Yes or No and Briefly explain)

10. If (No) in the above question, what would you suggest that the authority concerned should put in place to ensure that waste management is maintained in the food sector?

Appendix III:Interview Guide for Marketers

1. For how long have you been involved in marketing the mango fruit?

   Less than 1 year [ ] 2-3 years [ ] 4-5 years [ ]

   More than 5 years [ ]

2. What kinds of waste materials are mostly generated in the process of marketing the mango fruit?

3. What is the estimate percentage of wastes that are generated when marketing the mango fruits?

4. Do think that there is a way that the waste generated at the marketing level of mango fruits can be managed? (Yes or NO)

5. If yes in the above question, in which ways do you ensure that wastes generation is minimized when marketing the mango fruits?

6. What is the estimate percentage of mango fruits go to waste at the markets?

7. Which methods are mostly applied in the disposal of waste material from the mango fruits at the markets?

8. Would suggest any other alternative method of waste disposal at the markets? (Briefly explain)

9. Do you think that the environmental authority concerned with waste management has done enough to reduce inappropriate disposal of waste into the environment? (Yes or No and Briefly explain)

10. If (No) in the above question, what would you suggest that the authority concerned should put in place to ensure that waste management is maintained in the food sector?