Managing Plastic Waste in Urban Kenya:

Niche Innovations in Production and Recycling

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Leah Oyake-Ombis

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Preface

The thinking and analysis that fuelled this thesis stems from my personal experience and interaction with actors in both the solid waste management system and those from plastic production system. These actors have to continuously deal with the problem of plastic waste. This set a perfect ground to investigate how and to what extent the activities of actors from the two systems can enhance plastic waste management and further foster collaboration between them. Indeed this is one of the most noble and memorable projects that I have undertaken. Many individuals and organizations variedly contributed to this project at different stages. Without their support, this work would not have been completed.

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List of Abbreviations

AFP	Agence France-Presse
AIDS	Acquired Immune Deficiency Syndrome
AWSB	Athi Water Services Board
BASF	Badische Anilin und Soda Fabrik
CAs	City Authorities
CBO	Community Based Organization
CBD	Central Business District
CBS	Central Bureau of Statistics
CCN	City Council of Nairobi
CDF	Constituency Development Fund
CILOR	Contribution in Lieu Of Rates
COMESA	Common Market for Eastern and Southern Africa
CP	Cleaner Production
DTI	Department of Trade and Industry
EAPA	East Africa Plastic Association
EAC	East African Community
EIA	Environmental Impact Assessment
ELCI	Environment Liaison Centre International
EMCA	Environmental Management and Coordination Act
EPZ	Export Processing Zones
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GrSCM	Green Supply Chain Management
HDPE	High Density Polyethylene
HIV	Human Immunodeficiency Virus
ILO	International Labour Organization
IMF	International Monetary Fund
ISO	International Organization for Standardization
ISWM	Integrated Sustainable Waste management
IWBs	Itinerant Waste Buyers
JICA	Japan International Cooperation Agency
KAM	Kenya Association of Manufacturers
KARA	Kenya Alliance of Residents Association
KEBS	Kenya Bureau of Standards
KIE	Kenya Industrial Estates
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KIRDI	Kenya Industrial Research and Development Institute
KISWAMP	Kisumu Integrated Solid Waste Management Programme
KIWAMA	Kisumu Waste Management Association
KMC	Kisumu Municipal Council
KNCPC	Kenya National Cleaner Production Centre
Ksh	Kenya Shilling

LATF	Local Authority Transfer Fund
LC	Letter of Credit
LDPE	Low Density Polyethylene
LLDPE	Linear Low Density Polyethylene
MLP	Multi-Level Perspective
MOH	Medical Officer of Health
MOLG	Ministry of Local Government
MSMIs	Micro, Small and Medium Industries
MSMEs	Micro, Small and Medium Enterprises
MSE	Micro and Small Enterprise
MSW	Municipal Solid Waste
MUB	Manufacture Under Bond
NEC	National Environment Council
NEMA	National Environment Management Authority
NES	National Exports Strategy
NIC	Newly Industrialized Countries
NGO	Non-Governmental Organization
OTA	Office of Technology Assessment
PCPW	Post Consumer Plastic Waste
PET	Polyethylene Tetra phthalate
PIL	Packaging Industries Limited
PMF	Plastics Management Fund
PP	Polypropylene
PPP	Purchasing Power Parity
REG	Riruta Environmental Group
R&D	Research and Development
RMLF	Road Maintenance Levy Fund
RTA	Regional Trade Agreement
SACCO	Savings and Credit Cooperative Society
SAP	Structural Adjustment Programme
SMEs	Small and Medium Enterprises
SNM	Strategic Niche Management
SWM	Solid Waste Management
UK	United Kingdom
UN	United Nations
UNCHS	United Nations Centre for Human Settlements
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
USD	United States Dollar
USEPA	United States Environmental Protection Agency
VAT	Value Added Tax

WBCSD	World Business Council on Sustainable Development
WRAP	Wellness Recovery Action Plan
YEF	Youth Enterprise Fund

1 INTRODUCTION

1.1 Plastics, plastic waste management and the environment

In time plastics may come to be seen as one of the most important technical achievements of the 20th Century: they have enabled new inventions and replaced other materials in existing products. Plastics are synthetic, macromolecular, substances mostly made from crude oil. The macromolecules are strings of chemically identical monomers, generally called polymers. A wide variety of molecules can function as monomers, and a large variety of additives can be added to the polymers to improve their performance or to reduce costs (Mol, 1995). Plastics have a number of advantages over their substitutes (such as paper and metal) and, as a result, have secured a firm place in the consumer economy of today, including in emerging African urban centers (Bahri, 2005).

Globally, over 260 million tons of plastics are produced every year, accounting for about 8 percent of the world's oil production (Miller, 2005; Thompson *et al*., 2009; Luís and Spínola, 2010). Nearly one trillion plastic bags are produced and used globally per annum, making the packaging sector the most important user of plastic materials (http://www.foodproductiondaily; Bahri, 2005). More than half of these plastic bags end up in urban waste streams, where they constitute between 5% and 10% of the solid waste stream (Barnes *et al*., 2009). Globally, more than half of all plastic waste materials are low density plastic bags (Nhamo, 2008).

Kenya does not have petrochemical industries and hence the raw materials for the plastics and polythene industries are imported from overseas (KAM, 2006). Despite this heavy reliance on imported raw materials for manufacturing plastics, the number of manufacturing industries, as well as the product variety, is increasing (Central Bureau of Statistics, 2005). The manufacturing and consumption of plastic bags boomed in the early 1990s, strongly driven by rising general consumer demand (Environmental Liaison Centre International, 2005:26). Major Kenyan supermarkets and traders at open air markets began using them in preference to paper bags which were scarce and expensive. A study conducted by the Kenya National Cleaner Production Centre (KNCPC, 2006) indicated that 192,836 tonnes of plastic materials are produced each year in Kenya. Plastic bags account for 49,000 tonnes (around 25%) of this production. Around half of these plastic bags (25,000 tonnes) are less than 15 microns thick and are primarily used for carrying consumer products. Over 8 million plastic shopping bags are handed out per month by major supermarkets and twice this number by small-scale retailers (UNEP, 2005a). More than half of these bags end up in the solid waste steam (Njeru, 2006). The rest are either re-used or intercepted and returned back to the industry as raw materials.

Urbanization and the increasing consumption of plastics have resulted in a rapid increase in the generation of plastic waste, making it a major component of the solid waste stream. Generally, plastic waste is the third major component of municipal waste in

cities after food and paper waste (UNEP, 2009). Even African cities with low economic growth have started producing more plastic waste due to the increased use of plastic packaging, plastic shopping bags, PET bottles and other goods that use plastic as a major component. Most countries in sub-Sahara Africa do not have data on waste stream composition and there is a lack of detailed knowledge on waste characteristics. Yet there is acknowledgement of the growing magnitude and prominence of the problem of plastic waste in the region (World Bank, 1996; KNCPC, 2006). In Kenya's major cities (Nairobi, Mombasa, Kisumu and Nakuru), plastic waste is known to constitute about 10% of the cities' waste streams (see Table 1-1), giving evidence of the present-day linear mode of production, consumption and disposal.

Table 1-1 City population, solid waste and socio-economic characteristics

City	*Population*	*Solid waste generation (tons/day)*	*Solid waste collection (%)*	*Plastic waste as proportion of solid waste (%)*	*Population living in informal settlements (slums) (%)*	*Unemployment rates (%)*	*Absolute poverty[1] (%)*
Nairobi	3,240,000	1,850	33	10.5[2]	57	48	52.2
Mombasa	913,362	700	30	10.2[3]	80	45	38.3
Kisumu	409,928	400	20	10.2[4]	70	60	63.8
Nakuru	307,990	350	20	N.A.	65	35	40.6

Source: Constructed with information obtained from Republic of Kenya, 2010a; JICA, 2010; Rotich *et al*., 2006 and filed interviews with directors of environment in respective cities.

Plastics have two main impacts on the environment: those connected with the raw materials and production processes and those connected with plastic littering and wastes. There has been a remarkably increase in plastic usage globally during the last decade, putting pressure on the source of raw materials and the environment (Stevens, 2002). The magnitude of plastic use now poses a major challenge to city authorities, who are responsible for solid waste management and sanitation. While many cities in developed countries have made great strides towards instituting effective approaches to waste management that recognize different waste sources, their value, and seek to separate them

[1] Absolute poverty according to a UN declaration that resulted from the World Summit on Social Development in Copenhagen in 1995 is defined as "a condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information." However the World Bank (2005) puts a measure as, proportion of the population living on less than USD 1.25 a day. The World Bank's global poverty measures have been based on an international poverty line that is representative of the national poverty lines found in the world's poorest countries. Initially these were based on USD 1 a day purchasing power parity (PPP) for the consumption expenditures of households.

[2] JICA, 2010.

[3] Republic of Kenya, 2010b.

[4] KISWAMP, 2008.

(Scheinberg, 2003; Saarikoski, 2006; UNCHS, 2010), the situation for cities in Africa in general, and Kenya in particular, is different.

According to Van Dijk (2006), the delivery of public services has, for a long time, been failing in developing countries and, in Africa, access to adequate waste collection and sanitation is still very low (see also Crook and Ayee, 2006; Oosterveer, 2009). For close to two decades, the solid waste management systems of Kenya's major urban centers have been declining due to numerous problems ranging from a poor resource base, human and technological inadequacies, and the poor organization of operational processes (Karanja, 2005). Central-local government relations in the country also contribute to the problem as the local authorities have very little autonomy to make their own financial and administrative decisions, which might (as is often the case elsewhere), include responding to challenges of plastic and other wastes (UNCHS, 1998). The poor waste management situation is evident in the very low waste collection levels (see Table 1-1) which, in most cases, are confined to the central business districts of cities and high income neighborhoods. The urban poor, usually residing in informal settlements (see Table 1-1) have little or no access to solid waste collection and disposal and are permanently vulnerable and exposed to the consequences of poor solid waste collection and the harmful effects of (plastic) waste. Plastic wastes are an eyesore within the informal settlements, compromise the aesthetic quality of cities, block open drains and gutters, cause stagnation of water and cause deaths among animals and livestock (Ramaswamy and Sharma, 2011; Njeru, 2006). According to the 2004 Nobel Peace Laureate, the late Wangari Maathai, "plastic bags provide several million habitats for mosquitoes to breed that increase the risk of malaria" (quoted in AFP, 2005). Plastic waste is a common feature at the disposal sites of Kenyan cities (see Photo image 1-1). Open dumping of solid waste, a common practice in Kenya, means that waste, especially lightweight shopping bags are easily blown around by the wind and scattered. Consequently, plastic waste is a challenge for the already limited solid waste collection and disposal systems of city authorities, and is a factor in environmental degradation (JICA, 2010).

Photo Image 1-1 Dandora dump site in Nairobi (Photo by Leah Oyake-Ombis)

Even though Kenya's solid waste management performance is dismal, the problem is well acknowledged by key governmental policy organs and other societal actors. A variety of responses, including the contracting of private actors by city authorities, have been instituted. Similarly, formal and informal actors have spontaneously become engaged in solid waste collection, recycling and disposal and do help to reduce the problems associated with ever-increasing amounts of solid waste. Nonetheless, these actions have a very limited effect. Kenyan cities have limited capacities to process or promote the re-use of plastic waste in a cost-efficient and safe manner (Karanja, 2005). They have also been slow to institute preventive strategies that would facilitate the use of alternative materials instead of plastic shopping bags. Plastic waste therefore remains a challenge. It is far from being clear what the potential is within public and private initiatives for improving environmental performance in plastic production, consumption and waste management.

Previous studies on waste management in the East African region, and in Kenya in particular have focused on municipal authorities, seeing them as the only institutions which could offer sustainable systems for waste management (Kassim and Ali, 2005; Karanja, 2005; Bahri, 2005). These studies looked at problems of plastic waste from the perspective of urban authorities and focused on solid waste and the post-consumer aspects of plastic materials. Other studies (e.g. Mugambi, 2001; Njeru, 2006) have focused on the production side of plastic materials, analyzing the production of plastic products from virgin or recycled materials. Rarely have these two perspectives, and the two systems, been dealt with as a whole.

This thesis examines the problem of plastic waste management in a more holistic way by integrating the two perspectives. The remainder of this chapter presents a brief outline of the existing responses to waste and plastic waste management in Kenya; beyond effective waste collection and disposal. It also outlines the objectives of the thesis, the research questions asked and provides an overview of the contents and structure.

1.2 Responses to waste and plastic waste management in Kenya

In the history of solid waste management (SWM) in Kenya, local authorities have been the principal actors, primarily performing waste collection and disposal and setting related policy and regulatory guidelines. Plastic waste management has been carried within classical SWM management practices that centers on collection and disposal. However, with increased quantities of solid waste generation, the changing life style of urban people, the demand for better services and the stagnating capacities and resources of municipal authorities for waste management, such classical systems have proven inappropriate and largely fail to meet both public health and environmental goals for SWM. Most plastic waste is not properly collected or disposed of and creates negative

environmental and health impacts. This solid waste management crisis in urban Kenya has increasingly attracted the attention of urban environmental policy makers and researchers (Bahri, 2005; Karanja, 2005; Rotich *et al*., 2006; Mugambi, 2001). Failing waste collection and disposal is particularly significant for plastic waste as it does not degrade under natural conditions, but can persist in illegal waste dumps, on roadsides and other open public places.

The Kenyan government recognizes the problems connected to SWM, including plastics, and has designed and implemented a number of interventions in response. In 1995, a Directive was issued for local authorities to create environmental departments as independent units within their administrative structures. This was followed in 1999 by the enactment of the Environmental Management and Coordination Act (EMCA), which created the National Environment Management Authority (NEMA) to coordinate and supervise environmentally related activities, including SWM. In tandem with these developments, the major city authorities (of Nairobi, Mombasa, Kisumu and Nakuru) created environmental departments to provide overall policy guidance, including the direction of SWM services. In addition, and in light of the ever-expanding need for better SWM services, city authorities started to incorporate the private sector in waste collection and disposal services, particularly focusing on the central business districts of cities.

According to Karanja (2005), there was an attempt to privatize SWM services in Nairobi as early as 1906. However, it only became part of cities' SWM strategies in 1990s. In 1997, the City Council of Nairobi (CCN) contracted Kenya Refuse Handlers - a private firm - to conduct street sweeping, waste collection, transportation and disposal within the central business district. Since then, the major city authorities have issued numerous management contracts to cover waste collection, transportation and disposal from various locations within their jurisdictions. Such contracts, however, have provided limited service coverage and in most cases, neglect the informal parts of cities, where the majority of people live. Furthermore, solid waste is inadequately and inappropriately disposed of. This poor state of SWM provision has prompted the spontaneous emergence of other informal private actors, engaged in specific solid waste collection and helping meet the disposal needs of residents in different parts of the cities. These responses, which take different forms, are rarely regulated by city authorities. The formal private actors, who mostly cover high and middle income residential neighborhoods, provide services in a structured manner and sign service contracts with their customers. Informal actors, such as Community Based Organizations (CBOs) and individual waste collectors, provide services mainly to low income residential neighborhoods including informal settlement areas that are based on 'loose' arrangements. Such arrangements are not always based on a structured payment system and the service provided is not always reliable. These responses have boosted the levels of solid waste collection and also expanded service coverage to areas which have, for a long time, been neglected by city authorities.

While these public and private interventions are positive steps towards better SWM services, they remain inadequate and do nothing to reduce the flow of plastic waste to solid waste streams. Their orientation has been to improve the efficiency of waste collection and disposal and to meet public health goals. This approach has failed to realize the material value of plastic waste which could ensure its return to the production system. They also lack a preventive dimension and fail to capture the potential environmental benefits of a more integrated approach to SWM. The SWM situation in Kenyan cities is thus still far from being addressed and plastic waste is an almost permanent feature in public places including residential neighbourhoods.

1.3 Beyond effective plastic waste collection and disposal

Trading in plastic waste has been practiced in Kenya since the 1980s, when waste pickers and small-scale traders sold unprocessed plastic waste directly to plastic producers which used these materials to manufacture new plastic products. However, when solid waste started to become a problem for city authorities in the early 1990s, plastic waste became an ever-present source of visual pollution within Kenyan cities. Since then and partly driven by a general lack of employment and high poverty levels (see Table 1-1), some community based organizations (CBOs) involved in waste collection and disposal started to venture into recovery of plastic waste. They often worked together with Savings and Credit Cooperative Societies (SACCOs- organizations where individuals and CBOs place their savings and receive advantageous rates when they need loans, as well as other social benefits). The CBOs, CBO-SACCOs and small-scale traders have since been recovering plastic waste, diverting it from MSW streams to the plastic production system and adding value to it. Many authors, from different perspectives, have stressed the important and sometimes vital contribution of informal private actors in effective waste management (e.g. Allison *et al*., 1998; UNDP, 2006; WASTE, 2004; Scheinberg and Mol, 2010; Liyala, 2011; and Tukahirwa *et al*., 2011).

Parallel to the plastic waste management activities of informal actors, plastic producers and other chain actors have also for several decades explored the use of plastic waste as a raw material in Kenyan plastic production (Mugambi, 2001; KNCPC, 2006). Easy access to technology and liberalization of trade at regional and global levels has diversified the use of plastic waste as a raw material in production processes, one with the potential to contribute towards environmental management, economic development and improved livelihoods. An extensive body of literature on waste management underscores the benefits of promoting plastic waste recovery and recycling as a viable strategy to sustainable plastic waste management (Furedy 1997; Karanja *et al*., 2004; Scheinberg, 2011). A common thread throughout these writings is the complementary roles that actors from different societal classes can play in plastic recycling and waste management. In Kenya, private industrial actors largely rely on informal actors to provide them with

plastic waste to use as a raw material. This brings us to question the extent of the novelty of these actors' plastic waste management activities and whether better collaboration between the SWM system and plastic production system would increase the amount of plastic waste removed from the environment and make it more widely used as a raw material.

Other strategies might be employed to reduce the amount of plastic in the solid waste stream. Some scholars of environmental management and policy makers belief that reuse of plastic (especially shopping bags) at the point of generation is one promising way to delay the release of plastic as waste to disposal sites or the environment. Others point to the potential of using different packaging materials to prevent the increased use of plastic materials. Song *et al*. (2009) have argued for increased use of biodegradable materials which can contribute to sustainability and reduce the adverse environmental impacts associated with the disposal of oil-based polymers. In Kenya, biodegradable plastic bags have recently become available.

These 'new' activities, which will be termed environmental 'innovations', for plastic waste management, recycling and prevention, cover both the SWM system and plastic production system. At present their potential for contributing to the overall management of plastic waste within Kenya's urban environment is not known, nor do we know what sorts of collaboration would be required between the two systems. Other relatively unknown aspects include how these innovations might be implemented, the conditions that would facilitate this implementation and the various actors that could carry such innovations forwards.

1.4 Thesis objectives and research questions

The management of plastic waste, and especially collection, recycling and prevention, in Kenya has attracted a multiplicity of informal and formal, private and public actors who carry out activities that have the potential to change the way that waste is handled. The new collection, prevention and recycling activities (innovations) create a relationship between the solid waste management system and the plastic production system. Plastic waste from the SWM system becomes a source of raw material for the production of plastic materials. No systematic study has been carried to analyze the interdependencies between the two systems and their potential for improving plastic waste management in urban Africa. There is also a need to identify the actors (and roles they might play) to carry forward the process of integrating the two systems. This thesis aims to fill these gaps.

The central aim of this research is therefore, to analyze the innovative activities on the collection, prevention and recycling of plastic waste, in order to provide insights into how plastic waste might be better managed in the urban centres of Kenya. In order to achieve this central objective, this research addresses the following research questions:

1) How are the solid waste management and the plastic production systems organized in Kenya?
2) How, and to what extent, do current (and can potential future) environmental innovations contribute to the overall management and prevention of plastic waste in Kenya?
3) Which current and potential environmental innovations foster the integration between SWM and plastic production systems and what insights can be gained from such innovations for building an integrated regime for plastic waste management?

1.5 Outline of the thesis

This study is organized into seven chapters, including this introductory chapter. The next chapter (chapter 2) provides background information on the evolution of both solid waste management and plastic production systems in Kenya. The chapter explains how the solid waste management system has evolved from a city monopoly, solely focusing on achieving public health goals, to multi-actor participation that aims at better service provision. Plastic waste is a constituent of municipal solid waste and the production of plastic materials has a direct impact on plastic waste, which ultimately ends up in cities' municipal waste streams. The chapter also outlines the industrial policies that have determined the growth of the manufacturing sector in Kenya. The main focus is on the plastic industry, the use of raw materials in plastic production and how industrial policies try to balance industrial development and environmental management.

Chapter 3 introduces the theoretical framework for this thesis. After reviewing the literature on socio-technological change, it introduces the main concepts from transition theory and strategic niche management. These include social network composition, the shaping and convergence of actors' expectations, actors' learning processes, regimes and landscapes. These are used as the basis for analyzing the innovation activities. The chapter also contains a methodological intermezzo, which introduces the study cities, the research methodology and the data collection activities.

Chapters 4, 5 and 6 present the empirical findings of this thesis. Chapter 4 analyzes plastic waste management activities among three different categories of actors: CBOs, CBO-SACCOs and yard-shop operators. The chapter specifically investigates the ways in which these actors' activities depart from the traditional governmental approach to solid waste management and seek to develop niche innovations, with a potential to transform plastic waste management. Chapter 5 analyzes the plastic waste recycling activities of industrial actors within the plastic production socio-technical system. The chapter evaluates the intermediary role played by a group of semi-processors in the flow of plastic waste from the SWM socio-technical system to the plastic production socio-

technical system. The chapter also assesses and compares plastic recycling activities among three different categories of industrial actors: exporters, conventional plastic industries and home-grown industries. Chapter 6 analyzes the development and policy debates including the production, retail and consumption of biodegradable plastic bags in Kenya.

Finally, chapter 7 presents the conclusions of this thesis. It identifies areas for future research and provides policy recommendations.

2 KENYA'S SOLID WASTE MANAGEMENT AND PLASTIC PRODUCTION SYSTEMS

2.1 Introduction

This chapter focuses on the historical development of Kenya's SWM system and plastics industry, the current state of these two sectors and the effect that they have on the plastic waste stream (production, disposal and recycling) within Kenya. Sections 2.2 and 2.3, presents developments within the SWM system and section 2.4 presents developments within Kenya's plastic production system.

2.2 The development of Kenya's solid waste management system

The contemporary solid waste management (SWM) systems of Kenya's major urban centres are a manifestation of the relict structures left behind from British colonial times. The main goals of these systems were to protect people's health and public places. As such they encompassed three basic elements: collection, transportation and disposal. These systems are mostly run under two main legal frameworks: the Local Government Act, Cap 265 and the Public Health Act, Cap 242. These Acts give local authorities the power to deal with solid waste management and charge them with the responsibility of providing SWM services and to maintain cleanliness and good sanitary conditions in their areas of jurisdiction. It is therefore the responsibility of local authorities (under the supervision of the local government ministry) to organize and provide for the collection, transportation and disposal of all types of solid waste generated within their jurisdiction.

However, over the past couple of decades, the performance of these local authorities -run SWM systems have systematically been declining. This has resulted in a lot of uncollected solid waste, which has attracted other actors to become involved in SWM activities. One of these activities has been the recovery of materials from the waste streams and returning them to industry as raw materials for manufacturing. In this way some plastic waste has been finding its way back to the plastic production system.

There is some anecdotal literature about Kenya's SWM system which suggests that the situation was much worse in the period before 1990. The literature on SWM in Kenya focuses largely describing its performance and the causes of waste and household waste generation behaviour. (Otieno, 1992; Mwanthi *et al.*, 1997; JICA, 1998; Gatheru and shaw, 1998; Mulei and Bokea, 1999; Ikiara *et al.*, 2004a; Bahri, 2005; Karanja, 2005; Rotich *et al*, 2006; Njeru, 2006; JICA, 2010). Less has been written about the characteristics of solid waste, service providers and the injustices associated with SWM. The studies cited above only focused on the situation in Nairobi. There are hardly any comprehensive and substantive studies about SWM concerning other Kenya's major

cities (Mombasa, Kisumu and Nakuru). This lack of consistent historical data makes it difficult to undertake a temporal analysis or typology of Kenya's SWM system. This said, the following sub-sections attempt to analyze the Kenyan solid waste management system before and after 1990.

2.2.1 The period before 1990

The organization and operation of the SWM system

Since the inception of the SWM system, local authorities, under the Ministry of Local Government (MOLG), have always provided – and had monopoly control over – SWM services (Mullei and Bokea, 1999). If there was a need for any other actor or organization to handle solid waste materials, a written agreement was required from the relevant local authority. The overriding objective of the SWM system was to protect public health, with an emphasis on the prompt removal of waste from residential and other areas, and disposal at approved sites. The SWM system was organized at two levels: national and local. The national level was dominated by the Ministry of Local Government (MOLG), which had the main responsibility for policy formulation, providing technical assistance to city authorities, as well as supervisory oversight and guidance. Occasionally, funds were advanced to the local level, to finance specific projects.

The centre of SWM activities, however, was at the local level. Under the guidance and supervision of the MOLG, city authorities were primarily responsible for providing and regulating SWM services (JICA, 2010). Established as autonomous and independent corporate entities, city authorities were headed by a mayor and consisted of both popularly elected and nominated councilors. City authorities' responsibilities, including those of SWM, were managed through policy-making committees, consisting of councilors. SWM was usually managed by the Public Health Committee. However, the members of this committee, including the mayor, had no executive powers. Thus, policies on SWM at this time were implemented by the Medical Officers of Health (MOH), who had to report to the Chief Executive Officer, commonly referred to as the City Clerk, an appointee of the MOLG. The exact demarcation of the roles and powers of MOLG and of city authorities remained unclear, since councilors also engaged in policy making. This unclear demarcation of roles and powers had the potential to create conflicts of interest in service provision.

To manage solid waste operations, the MOH coordinated activities with a number of other departments of the city authorities. For example, formulation of solid waste management by-laws (which during these years viewed solid waste solely as a nuisance requiring immediate disposal) was done in consultation with the legal departments and sections. Enforcement of by-laws was the responsibility of city enforcement officers under the inspectorate departments. The penalties for those found illegally dumping were

not punitive. City engineering and planning departments were consulted on infrastructural needs for SWM, with the planning department having the sole responsibility of providing disposal sites (as stipulated under the Physical Planning Act, Cap, 286). In terms of financing SWM services, it was the duty of the MOH to prepare annual operational and financial plans, and present these to the City Treasurer. Solid waste management services were mainly financed through general property taxes and other city fees charged at the local level. The only SWM service charge was on collection and disposal in the form of a fixed and uniform container charge, collected through water bills by the water and sewerage departments, also part of the city authorities. This charge was never reviewed and was applied uniformly to all types of solid waste, irrespective of quantity, and was insufficient to finance SWM services.

Even though no systematic recording of operational activities exists at the City Council of Nairobi, Ikiara *et al.* (2004a) note that as recently as 1980 Nairobi collected almost all the solid waste generated within its jurisdiction, that solid waste was never a major public health threat, and its management did not cause any public concern. SWM activities were satisfactorily aligned and coordinated through the financial and planning structures. The public health officers, who oversaw SWM activities, were able to respond to potential risks that might jeopardize Nairobi. There is no reason to believe the situation was any different in Mombasa, Kisumu and Nakuru.

Despite the heavy emphasis of SWM on meeting public health goals, there was never adequate disposal infrastructure and open dumping was widely practiced. Provisions made under the Physical Planning Act (see Appendix 2) were never invoked. City authorities generally made use of the most convenient sand and stone quarry pits for waste disposal. Despite the lack of environmentally sound disposal sites, the SWM services delivered by the cities were reliable. Solid waste collection and disposal services did not discriminate between rich and poor. Waste material recovery, where it did exist, mainly involved informally-organized waste pickers, working without any legal approval from the city authorities. Such activities were rare and did not involve plastics.

With increased population growth and changing lifestyles, the capacities of Kenyan urban authorities to provide satisfactory collection and disposal services started to decline. Kenya had one of the highest rates of urban growth in the world in the 1990s (8.5 %). Demand for better SWM services started to escalate as city authorities failed to accomplish their basic statutory responsibility (Karanja, 2005). The city of Nairobi serves as an example. According to Adler (1995), the city's capacity to effectively co-ordinate the collection, transportation and disposal of solid waste was falling short of meeting resident's expectations. A scarcity of resources was seen as the main obstacle to achieving satisfactory SWM services. The framework under which the service provision and delivery took place was also problematic as it was highly fragmented and activities were poorly co-ordinated (Karanja, 2005). Furthermore, increased consumption of plastic materials, especially as packaging materials, started to complicate solid waste collection

and disposal (Bahri, 2005; Ikiara *et al.*, 2004a). In line with international obligations, such as those on the implementation of Agenda 21 (from the 1992 Rio summit), to which the Kenyan government was a signatory, and donor priorities and strategies, a number of initiatives by government and other non-state actors started to emerge in response to the ever-deteriorating public SWM services.

2.2.2 Post 1990

The internal restructuring of the SWM activities

Since 1990 the solid waste management systems of city authorities in Kenya have been restructured. As city authorities continued to have direct responsibility for SWM services, they begun seeking to strengthen their roles in SWM. They switched from being responsible for waste collection and disposal to providing supervisory services and creating an enabling atmosphere managing solid waste and the problems it creates. Accordingly, all the four city authorities in this study have created autonomous environmental departments out of their public health departments. This signals a departure from the traditional public health orientation to solid waste to one with an environmental management orientation. These departments play a central role in implementing environmental policies. Their functions and mandate go beyond solid waste collection and disposal and include the following:

(a) Formulating and implementing SWM policies and regulations;
(b) Monitoring and regulating the activities of all major generators of solid waste;
(c) Monitoring and regulating private organizations engaged in solid waste activities;
(d) Coordinating environmental activities with other departments within city authorities, with donor agencies, civil society organizations and other government departments involved in solid waste management; and
(e) Managing open spaces and recreational places.

Nairobi was the first local authority to form a Department of Environment in 1996, followed by Mombasa in 1998, Kisumu in 2000 and Nakuru in 2001.[5] Besides the creation of Environment Departments, city authorities have also received significant resources from the national level. There has been an increased and consistent flow of financial resources towards local expenditure. Contribution in Lieu of Rates (CILOR), the Road Maintenance Levy Fund (RMLF) and Local Authority Transfer Fund (LATF)[6] are the most common mechanisms for transferring funds to city authorities, and these supplement their own resources, derived from taxes and permit revenues.

[5] Information obtained from the Directors of Environment from the four city authorities during face to face and telephone interviews between February to April, 2010

[6] These three mechanisms are government transfer funds made to all local authorities.

Despite this major structural shift and the increased financial support, the performance of the Environment Departments is still far from being satisfactory. Solid waste collection services are still marred with an array of inefficiencies. A recent review of the solid waste management master plan for Nairobi shows that only 33% of the total waste generated is collected and disposed of properly (JICA, 2010). Ikiara *et al*. (2004a) reported a total waste collection of 25% in Nairobi and, according to Palczynski (2002), (70-80) % of solid waste generated in Nairobi remained uncollected. Kwach (2002) estimates that most of the 500 tons of solid waste generated daily in Kisumu remains uncollected, with a collection efficiency of about 20 % (the collections are split between the municipal authority and a few private collectors). Most waste from high income residential areas is collected, but the poor peri-urban neighborhoods are largely neglected.

Proper solid waste disposal is also lacking and open burning is still widespread. The waste that is disposed of is often not properly managed (JICA, 2010). Indiscriminate disposal has become a permanent feature of the SWM systems of Kenya's major cities. Plastic waste (particularly low density plastic) strewn along highways is a glaring and familiar sight to most urban Kenyans (Sonkoyo, 2006). Many studies show that even with the re-structuring of the solid waste sector, Kenya's rapidly growing cities are not making any progress with solid waste collection and disposal. According to Hoornweg and Thomas (1999), these cities only manage to collect and dispose of between (30-50)% of the total waste generated. In most cases, this low level of solid waste collection still manages to consume between 20 and 50 percent of cities' total budgets (Van Beukering*et al*., 1999). Estimates from the World Resources Institute and USAID indicate that, in the early 1990s, developing countries spent over 30% of their budgets on refuse collection and disposal but collected at most, (50-70)% of municipal solid waste (Matrix Development Consultants, 1993). In 2010 the City Council of Nairobi spent 10 per cent of its budget of Ksh. 9.95 billion (USD 133 million)[7] on waste collection and disposal services.[8] The Environment Department ranked 5th (out of sixteen departments) in terms of expenditures, demonstrates the lack of priority given to SWM services. Despite increased financial support from the central government, the resources of Environment Departments have not been increased. City authorities still work under chronic financial constraints and it is difficult for them to substantially improve the SWM budget, boost collection levels or provide safe waste treatment and disposal. Solid waste management is still a long way from the centre of city financial planning. Even the newly-created Environmental Committees have not been effective in lobbying for adequate financial allocations, nor have they contested the decisions made by other local council committees that have led to the neglect of solid waste management services.

[7] 1 USD=Ksh 75

[8] Interview with Mr. Gatimu, Chief Accountant of City Treasurer's Department, City Council of Nairobi, on 17 December, 2009

The lack of priority accorded to SWM services by city authorities is well exemplified in Kisumu. According to Opande (2005) the city's annual per capita waste management expenditure is equivalent to just USD 0.77. In reality these services are not charged for. The waste collection and disposal fees, which used to be raised through water bills, ceased to exist in 2003 following water sector reforms (Republic of Kenya, 2002). Since then, city authorities have not been able to formulate a new charging structure which would ensure that SWM services were self-financing. Negotiations with the new water service providers to re-establish billing water consumers for solid waste collection and disposal have not borne any fruit. There is a high level of scepticism by the water companies about whether the city authorities would offer such services if this levy was raised. The central government has also been slow to intervene and ensure that SWM services are appropriately financed. Central planning of SWM has also been challenged by proponents of bottom up and market-led decentralized models (Larkin, 1994; Ahmed and Ali, 2004). Some studies, such as that by the Omamo Commission of 1995, point out the advantages of privatization or self-financing of SWM, as this would insulate tariff structures from the potential of political manipulation (Government of Kenya, 1995).

Kenya's SWM services also suffer from a lack of trained, qualified and experienced manpower; vehicles; equipment and technological know-how (ibid).

Table 2-1 Staffing of Environment Departments (2010)

City	***Staff training policy***	***Number of personnel***		
		Professionals	Non-professionals	Total
Nairobi	In place	10	670	680
Mombasa	Not in place	6	550	556
Kisumu	Not in place	2	43	45
Nakuru	Not in place	1	83	84

Source: Constructed with information obtained from heads of the Environment Departments of the four city authorities

The establishment of Environment Departments has not significantly improved city- level environmental management services. They employ very few professionals (see Table 2-1) and the Heads of the Departments mostly lack relevant environmental training. The problem is further compounded by a lack of training and up-grading of staff skills. Even Nairobi city, which has a training policy (see Table 2-1), does not prioritize training needs for the Environmental Department based on departmental mandates and individual needs assessment.

Another issue that hampers the performance of Environment Departments is the tendency of councilors to appoint non-professionals to key positions. Councilors also often interfere with the duties allocated to such officers (JICA, 1998). Such interference makes it difficult to establish managerial hierarchies and set clear performance targets, as staff have divided loyalties. All these factors contribute to poor service delivery and mean

that SWM is influenced more by the search for market driven solutions than by meeting social obligations and environmental goals.

Nonetheless, some improvements are occurring. Some city authorities, such as Nairobi, have formulated policies and by-laws in an attempt to promote recycling and composting within different waste streams. For example, the city's policy on recycling and composting emphasizes provision of open spaces for informal actors to conduct recycling and composting activities (City Council of Nairobi, 2002). However, a lack of coordination between the Environmental and Planning Departments has hampered the implementation of this policy. Moreover, such provisions may not be feasible in the absence of a comprehensive solid waste management strategy for the city. Several cities (including Nairobi, Kisumu and Nakuru) have drafted solid waste management strategy plans, with a focus on recovering waste material - often with funding from foreign governments (JICA, 2010; KISWMP, 2008; Nakuru Municipal Council *et al*., 2007). However, none of these plans has been officially approved by the relevant committee. It is unclear whether and when such plans will receive the necessary approval (and budget) to be realized.

Overall, the responses of city authorities since 1990 remain inadequate and lack the internal coordination needed to steer the solid waste management agenda towards achieving both public health and environmental goals. Against this background, the service provision monopoly that city authorities have enjoyed over the years is coming under increasing criticism and non-state actors are becoming increasingly involved in the SWM activities.

2.2.3 Other actors in urban SWM services

Poor and inconsistent SWM services by city authorities – particularly within the informal settlements that host more than half of cities' populations (Ikiara *et al.* 2004a) – has led to non-state actors becoming increasingly involved in these activities. These actors are involved in a number of different aspects of SWM: providing collection and disposal services, waste material recovery activities' cleaning the environment and, advocacy activities in service provision. Consumer preferences, which hardly played any role when the system was homogeneous and centralized, are increasingly becoming visible now that alternative services are emerging. The public character of SWM service provision is being increasingly questioned by formal and informal private local agents involved in solid waste management.

A household survey on solid waste collection and disposal services, conducted as part of this study, reveals the extent of infiltration by the new service providers. While the city authorities' performance has declined over the years, CBOs and private companies are increasingly taking over waste collection and disposal services. Nevertheless their involvement does not present a complete solution to the problem

associated with waste collection and disposal as more waste than ever before remains uncollected. Almost 30 % of solid waste generated is self-disposed (see Table 2-2). This is mainly in open grounds which become illegal dump sites, attracting unregulated scavenging activities and posing a potential threat to health, the quality of life and the environment.

Table 2-2 Solid waste collection and disposal service providers in major cities of Kenya

Solid waste collector	***City of residence***				***Total***
	Nairobi (N = 408)	Nakuru (N= 253)	Kisumu (N = 262)	Mombasa (N = 283)	*(N= 1206)*
City authorities	21.1%	10.3%	8.3%	12.0%	13.0%
CBO	23.2%	21.3%	52.7%	40.3%	34.4%
Private Firms	33.1%	31.6%	18.7%	15.2%	24.6%
Self-disposal	22.6%	36.7%	20.3%	32.5%	28.0%
Total	100.0%	100.0%	100.0%	100.0%	100. 0%

Source: Constructed from the household survey

Service innovations by private solid waste collection companies

In the 1990s private waste collection companies emerged as new, smaller and flexible, alternatives to the public services. The City Council of Nairobi tried to engage the private sector to provide services in the Central Business District (CBD) through a management contract in 1997. This was in response to an outcry over the ever-deteriorating state of the city's environment. The contract covered street sweeping, solid waste collection, transportation and disposal (Karanja, 2005; Ikiara *et al.* 2004a). It was the first large-scale SWM management contract concluded by a Kenyan city authority, but was abruptly terminated by the company after persistent problems with payments. Despite this, private businesses have become a permanent feature in waste collection and disposal services in Kenya's cities. Guided by economic efficiency, private waste collection companies are now the main SWM providers in high and middle income residential neighbourhoods and business and industrial premises of cities (JICA, 1998; JICA, 2010). Characteristically they operate and deliver their services under conditions of open, and largely unregulated, competition. Private waste collection companies are free to provide services to whom they want and in places of their own choice, and to apply different pricing structures. In most instances, city authorities have no contractual involvement with them, except through a limited licensing procedure that is limited in its effectiveness to monitor their operations.

Because the private sector is barely regulated and can choose which sections of the city to provide their services, this gives rise to conflicts between these companies and individual waste pickers who retrieve valuable materials from solid waste especially in the central business districts (CBDs) of cities (KISWMP, 2008). Furthermore, their

involvement in SWM and the freedom they have to choose where to operate means that informal urban areas do not experience any benefits, since the companies deliberately exclude such areas from their services. Interviews with five leading private waste collection companies in Nairobi revealed that their operations are concentrated in high income areas. Moreover the interviewees showed a complete lack of concern about waste separation and material recovery from different waste streams, which if it were a priority, could reduce the amount of waste transported to disposal sites.[9] Some studies show that private sector operators indiscriminately (and illegally) dispose waste in low income and informal urban residential areas (KNCPC, 2006; KSWMP, 2008; Murimi, 2008). As Oosterveer (2008: 8) puts it, "from the private sector's perspective, low income areas are unattractive and have high levels of risk *hence are less likely to fetch maximum profits*" (italics added). While economic efficiency is the major driving force for the private waste management companies, many city residents are not able to pay their charges. For this reason, city authorities still have to take charge of SWM service delivery and to provide and implement regulatory measures for (private) services and for (private) service providers (Crook and Ayee, 2006 in Oosterveer, 2008:8; Mohr, 2008; JICA, 2010).

Service innovations by Community Based Organizations

Community Based Organizations (CBOs) have also begun to provide solid waste collection and disposal services, mainly within informal areas of the cities. Community involvement in sanitation in Kenya's urban centres emerged in the early 1990s (JICA, 1998; Ikiara *et al.*, 2004a). Compelled by failure of services from the existing providers, young people voluntarily came together and created CBOs to offer social services including security and environmental clean ups (Kwach, 2002; Gitonga, 2002; Karanja, 2005). Usually operating with a deficient infrastructure, CBOs are gradually becoming the preferred waste collection and disposal service providers in Kenyan urban centres (Tukahirwa, *et al.* 2011). Ikiara *et al.* (2004a) found out that neighbourhood cleaning was the main preoccupation of these CBOs, followed by composting of organic solid waste and material recovery. Tukahirwa *et al.* (2010) did a study of civil society participation in urban sanitation and solid waste management in Uganda and identified CBOs and NGOs as new modernizing agents of traditional SWM systems. A survey carried out by Practical Action in 2005 identified over 150 community groups and individuals actively involved in SWM activities in the Kenya's four major urban centres. The activities of CBOs and other youth groups in low and medium income residential areas account for over 77% of solid waste collection services in Nairobi City. Their average charge is around Ksh. 100 (USD1.33) per month per household (Practical Action, 2005; JICA, 2010).

[9] Interviews with representatives of Zoa Taka, Bio-bins, Bins Nairobi Ltd, Environ Clean Ltd and Masters on 23 July, 2009

Some CBOs have amalgamated and formed Savings and Credit Co-operative Societies (SACCOs). These SACCOs mainly began operations with waste material recovery. Karanja's study (2005) of SWM in Nairobi found that the first such umbrella organization was established at the Dandora dump where CBOs recovered waste materials and sold them to the Mukuru Recycling Centre. This SACCO was a consortium of CBOs initiated by a Catholic Church. The consortium has since split up and there are at least three CBO splinter groups today.[10]

Despite the involvement of CBOs in the collection and disposal of solid waste, much waste is still being dumped in residential neighbourhoods. This raises the possibility that CBOs could just be transferring the solid waste problem from one part of the city to another. As long as city authorities fail to monitor and regulate CBO solid waste collection and disposal activities, it is possible that the CBOs are not necessarily contributing to the improvement of SWM structures but, instead, are transferring the problem and exacerbating the waste situation in some urban areas.

Waste pickers and traders

Waste pickers and traders are a distinct group of actors who have, for a long time, created a useful link between the SWM regime and the production economy. Many authors allude to sizeable population in developing countries' cities who eke a livelihood out of waste picking and trading activities (Bernache, 2003; Ahmed and Ali, 2004; Wilson *et al*., 2006). Operating as individuals, waste pickers work at disposal sites to recover different valuable waste materials, which they then sell to traders or to other actors within the recycling chain. Pickers and traders are a common phenomenon in SWM systems of Kenyan cities. Haan *et al*. (1998) found that pickers commonly collect plastics, paper, cardboard, aluminium, steel, glass, textiles and other metals. They almost always operate informally and are often vulnerable to (unlawful) arrest by the city authorities' law enforcement officers. Pickers are nonetheless able to earn monthly Ksh. 3,000 (USD 40), which makes waste picking an important livelihood activity.

Traders provide the link between waste pickers and the recycling industries. Driven by the value of waste, traders also source waste directly from institutions and households (Van Beukering 1994). They are involved in washing, sorting and bulking waste before selling it to processors in a particular commodity chain. Because of the value traders add to the solid waste, they earn more than the waste pickers (Baud *et al*., 2001).

There is conflicting information about the recycling and reuse of materials, such as post-consumer plastic waste. Mwai (2008) estimated the quantities of recovered and recycled solid waste to range between 20 to 30 tons per day in Nairobi. In contrast, Practical Action (2005) found that over 100 tons of plastic waste was collected, shredded

[10] Interview with Mr. Adendo, the dump site manager on 15 February, 2010.

and sold every month by different groups in Nairobi, and over 66 tons of waste paper being collected daily from Nairobi's Central Business District alone.

Supermarkets and plastic waste recovery

Until the mid-1990s the solid waste generated by major supermarket outlets in Kenya was handled by city authorities. Usually the city authorities provided the supermarkets with large (10 cubic metre) metal container bins for their internally generated waste. These containers were promptly and regularly emptied. Most of the waste was packaging materials designed to protect the consumables during transportation. Curran *et al*. (2006) show how a large amount of secondary packaging[11] waste originates from supermarkets. As the SWM systems of major city authorities fell into decline, there was systematic withdrawal of the container system, which had an effect on the institutions which had become accustomed to such facilities. Supermarkets were the first casualties in this withdrawal programme, as they seen by the city authorities of being able to contract in services from the private sector. Consequently, the major supermarkets turned to private waste collection companies to meet their collection and disposal needs. They also institutionalized internal plastic waste recovery activities and began to undertake some responsibility for plastic waste management. This was prompted by the increased quantities of plastic waste being generated by the supermarkets and the increasing demand from consumers for plastic shopping bags. According to Davis and Song (2006) over the last two decades, synthetic polymers such as cling wraps, have substantially replaced traditional forms of secondary packaging such as metal, paper, glass, and pulp-based materials.

Table 2-3 shows the use and disposal of plastics among three leading Kenyan supermarkets. Supermarkets provide millions of plastic bags to consumers each year (see Table 2-3) and no decisive steps have yet been taken to manage plastic bag waste. By contrast the internal plastic waste recovery activities of the supermarkets show clear progress. Nakumatt Holding and Tusky's Supermarkets have similar arrangements to manage their plastic waste. Tusky's Supermarket has an informal arrangement with an individual retailer based in Nairobi to collect waste plastic from all its outlets while; Nakumatt Holding sells plastic waste from all its branches directly to a recycling industry. Each outlet of Uchumi Supermarket sells its own plastic waste.[12]

[11] Secondary packaging is the wrapping or containment of products for safety while being transported or distributed and for bulk selling of products.
[12] Interview with supermarket officials, between April and May 2009.

Table 2-3 Major Kenyan supermarkets and their plastic profiles

Operations	*Uchumi*	*Nakumatt Holding*	*Tuskys*
Year of establishment	1975	1987	1989
No. of outlets in Kenya	16	19	18
Supplier of plastic bags	East African Packaging industries	Packaging Industries Limited	Packaging Industries Limited
Number of plastic bags per month	over 7,000,000	over 8,000,000	5,000,000
Amount of secondary plastic waste generated (tons/month)	Not accounted for	approx. 25	approx. 20.8
Plastic waste handler	retailer	recycling industry	retailer
Extended responsibility over environment & plastic waste management	• Payment of yearly audits • placement of public container bins • 3R message on plastic carrier bags	• Payment of yearly audits, • quarterly magazines for customer communication • constructed ground for plastic waste separation, • installed public container bins	• Payment of yearly audits, • placement of public container bins, • 3R message on carrier bags

Source: Constructed with information obtained from supermarkets officials

Residence Associations-increasing the governance space for SWM services

Under the banner of the Kenyan Alliance of Residents Association (KARA), residential neighbourhood associations (RNAs) have started to emerge. Sometimes they are focused on defending residents' rights and access to service provision; in other cases they organize such services themselves. While Nairobi has the most RNAs, over 20 local authorities (including Mombasa, Kisumu and Nakuru) have RNAs that are affiliated to KARA.[13] The alliance has over 200 associations and specifically lobbies city authorities and other government departments for efficient public service delivery.

Membership to KARA has grown to include CBOs and private waste collection and disposal companies. KARA prioritizes the issues of accessibility, quality, reliability, affordability and the participation of residents in city governance structures. At the moment, the organization is leading an exercise of directly monitoring the performance of service provision, including water and sanitation, solid waste collection and security. Through a bi-weekly newsletter and other public forums, KARA keeps its members and city residents informed about its activities. KARA has been successful in bridging the gap between the consumers and providers of solid waste management service and increased consumers' voice in the governance of SWM. It has empowered city residents to make choices on service providers. It's monitoring of waste collection services, a service that city authorities have neglected, is increasingly valued by consumers and has led city

[13] Interview with Mr. Mutoro, Chief Executive Officer of KARA, on 15 April, 2009.

authorities to re-think their service provision methods. However, KARA's emphasis is largely on consumer satisfaction, so its interventions are not completely aligned with the environmental goal of encouraging resource material recovery in SWM services.

2.3 SWM services at the national level

Until the enactment of EMCA, 1999 (Republic of Kenya, 2000a) Kenya never had a specific national solid waste management policy. Local authorities exercised monopoly over sanitation and SWM services under the Local Government Act (CAP 265) and the Public Health Act (CAP 242) (Ikiara *et al*., 2004a; JICA, 1998, 2010). However, these Acts did not set standards for service provision, nor did they contain any requirement for waste minimization, resource recovery or recycling. Furthermore, they omitted to either define waste or classify it. Recently, pressure has increased on the national government to provide strategic direction for the management of solid waste.

EMCA (1999) was enacted to provide an overall framework for the management of environmental affairs in Kenya. It grants citizens an entitlement to a clean environment, while also placing a responsibility on them for safeguarding the environment. Citizens can now compel polluters, including those indiscriminately disposing of solid waste, to pay for the nuisance caused and have the power to report environmental offences to the responsible agencies. At the same time, citizens also have a responsibility for proper waste management by, for example, making payments for environmental services. EMCA provides procedures and standards to regulate the management of solid waste and categorized waste (e.g. hazardous and non-hazardous) in order to facilitate its proper management. City authorities and their designated agents are now subordinate to the NEMA, an organization created under EMCA. Those involved in transporting solid waste and operating SWM facilities including recycling plants are required to obtain licenses from NEMA. New treatment facilities require an environmental impact assessment (EIA) – which can only be conducted by NEMA, licensed experts - before they get a license to operate. Economic instruments for better management and abatement of environmental degradation have been installed, in the form of taxes and other fiscal incentives or fees to encourage environmental programmes and technologies (Republic of Kenya, 2000a). EMCA has removed the monopoly of local authorities over SWM services and programmes are being developed for better environmental management. For example, the solid waste management regulations of 2006 provide for plastic waste recycling (Republic of Kenya, 2006), signalling recognition of the value of plastic in municipal solid waste streams.

The provisions and requirements of EMCA have triggered other organizations to develop solid waste management related programmes. For example, the Ministry of Local Government has provided a new directive to local authorities to gradually move from disposal-oriented to material recovery-oriented solid waste management practices.

The new directive sets ambitious recycling targets for local authorities. Appendices 1, 2 and 3 of this thesis summarize the national policies, laws and organizations that are relevant to solid waste management.

In conclusion, there has been considerable progress at the national policy making in terms of setting goals, and an agenda, for solid waste management (see Appendices 1 & 3). However, there is still much uncertainty about how such policies are to be implemented, as well as a near complete absence of coordination between actors in this field. After ten years, full implementation of EMCA is still a distant prospect. The incentives and provisions are a good statement on paper, but the details about the methods and procedures still need working out. For examples, city authorities have no register of non-state actors involved in encouraging waste minimization through various activities including recycling. While NEMA initiated the process of registering a variety of actors and organizations involved in waste management activities, these registers are not coordinated nor are they shared with the city authorities within whose jurisdiction such activities occur. NEMA and city authorities continue to work apart rather than in collaboration.[14] Problems have also emerged with respect to licensing of solid waste collection and transportation, which is currently undertaken by both the city authorities and by NEMA. Non-state actors consider licensing by NEMA as a way of charging them twice for the same paperwork and the city authorities view the double-licensing system as a violation of their legal mandate.[15] Finally, the Draft National Solid Waste Management Strategy, prepared by the Office of Deputy Prime Minister and the Ministry of Local Government in 2008, has not yet led city authorities to set up proper waste management systems that embrace multi-actor participation and provide the necessary financial and technical requirements. Even the Sessional Paper No. 2 of 2005 (Republic of Kenya, 2005), which aims to provide a conducive environment for small-scale business operations, including those involved in solid waste recovery, has not stimulated solid waste recovery.

2.4 Kenya's plastic production system

This section reviews development of Kenya's plastic production system. The review focuses on policies for industrial development and how they affected the sub-sector, the contribution that the plastic manufacturing sector makes to Kenya's economy and raw material use within the plastic production system.

[14] Interview with Mr. Njenga, Acting Director of the Environment, City Council of Nairobi, on 2nd February, 2010.

[15] Interviews with representatives of the following companies: Zoa Taka, Bio-bins, Bins Nairobi Ltd, Environ Clean Ltd and Masters on 23r July, 2009 and with Mr. Njenga (see above) on 9th December, 2008

Kenya's plastic production system can be traced back to the end of the 1930s. Its development should be understood within the context of the wider manufacturing industry and the evolution of the government's macroeconomic and industrial policies. Plastic production has been one of the key pillars to economic growth and employment creation in Kenya (KAM, 2006; KAM, 2007). Kenya does not have its own petrochemical industries; hence, 89% of raw materials for plastic production are obtained from overseas, with 11 per cent being locally sourced from post-consumer waste materials (KAM, 2006). The main raw materials that are imported are Polyethylene granulates, Polypropylene granulates, Polyvinylchloride granulates, Nylon, Polytetra flonoroethylene granulates, Polyurethane granulates, dyes, antioxidants and fillers (KAM, 2006). In most cases, they are imported as polymers in their primary forms and used to manufacture a variety of plastic products, including furniture, household wares, industrial packaging, agricultural products, disposables, sewage and water tanks and automotive parts. The main sectors (in order of production are) industrial packaging products, household containers and water and sewerage tanks (KNCPC, 2006).

The three main plastic processing technologies are blow and injection mouldings and film extrusion. The thermoplastic plastic products are known for their versatility and wide range of applications, especially in the packaging industry. The moulds, processing machinery and spare parts and mould makers are mainly imported from Europe, Asia and the Middle East (KAM, 2006).

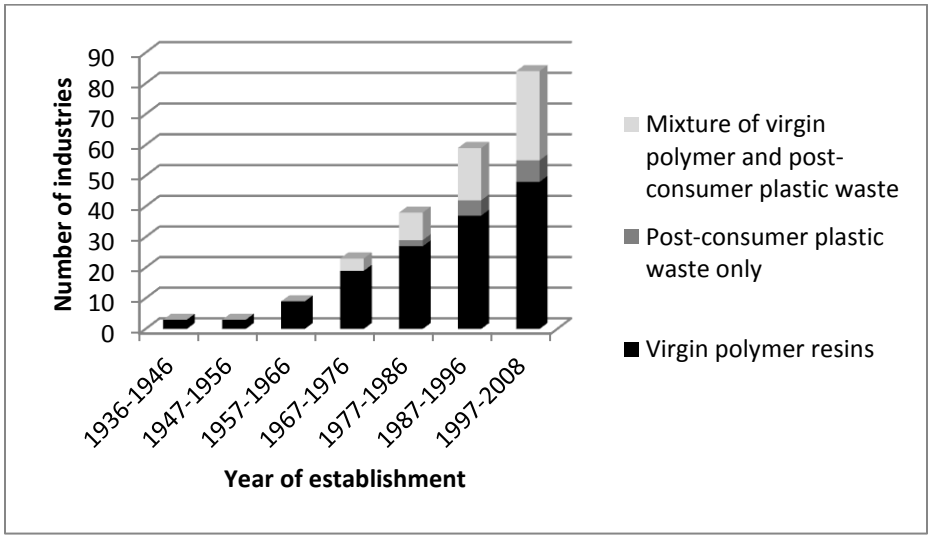


Figure 2-1 Resources used by the plastic industry (Constructed by the author using the database of the Ministry of Industrialization and survey data by KNCPC, 2006)

2.4.1 The pre-1990 period

Import Substitution Industrialization Policies

Kenya has never had sector specific industrial policies, except for a few key agro-based products (Republic of Kenya, 2008a) – this despite evidence from newly industrialized Asian countries (NICs) that industrialization is best achieved with focused and discreet industrial policies (Lall, 1986; Gachino, 2009). Kenya inherited Import Substitution Industrialization (ISI) policies at her independence in 1963.These policies advocated domestic production as a method of import substitution and protected these infant industries from international competition. The main policy instruments for protecting domestic industries were quantitative restrictions, import licensing, foreign exchange controls, high tariffs on competing imports and exchange rate management (Ronge and Nyangito, 2000). The policies aimed to achieve rapid industrial growth, ease the balance of payments, increase domestic control of the economy and generate employment. Several organizations were established by the government to promote this agenda. For example, Kenya Industrial Estates (KIE) was established in 1967 to offer financial and technical support to indigenous firms. The Kenya Industrial Research and Development Institute (KIRDI) and the Kenya Bureau of Standards (KEBS) were crucial in providing technical assistance and standardizing products, respectively.

The policy of ISI is generally credited for the growth of industries producing consumer goods for domestic consumption. The overall growth of the manufacturing industry stood at eight per cent p.a. towards the end of 1970s, just before the second world oil shock in 1977 and the anti-export bias of the import substitution strategy (Ikiara *et al*. 2004b; Lall, 2001; Wangwe, 1995; Glenday and Ndii, 2000). These protective measures contributed to the plastic production industry growing more than twice as fast as the rest of the manufacturing sector, doubling its output between 1976 and 1985 (Kenya Government, 1986). Figure 2-1 indicates a consistent growth in the numbers of plastic manufacturing industries since the mid-1950s. The Kenyan Government (1997) and the Central Bureau of Statistics (2005) indicate that until the mid-1960s the plastic industry was not significant (in terms of capacity and numbers) and almost all the companies involved were concentrated in Nairobi.

Restrictions on technology imports, imposed to counter the effects of foreign exchange crisis at the beginning of 1970s, meant that only a few plastic businesses were established in this period. According to Mugambi (2001), in 1982 there was only one firm involved in calendering, as was the case with fabric coating, sheet extrusion, lamination and vacuum forming. Two firms were engaged in compression moulding and three firms produced plastic pipes. Other branches of fabrication had more than three firms established.

While the growth of the plastic industry required imported virgin raw materials, the industry also reprocessed its own waste material and relied on post-consumer plastic

waste, especially in the post 1980s period (see Figure 2-1). Other factors facilitated the diversification of raw materials used in the plastic industry. The two oil crises of the early 1970s and 1979 and the economic recession of the late 1970s increased the costs of oil and polymer resins. This compelled the plastic industry to diversify its sources of raw materials, including the use of industrial waste and other waste materials sourced from municipal waste streams. The change in consumption patterns, especially in packaging, increased the availability of post-consumer waste. Since the mid-1980s plastic packaging has increasingly replaced conventional packaging materials, including paper (Environment Liaison Centre International, 2005).

However, not all was well with the highly protected domestic industrial sector, which was not competitive. This was also true for the plastic industry, which had few companies, competing for the domestic market but with no export strategy (Swamy, 1994; Kenya Government, 1986). Other problems included technological backwardness, a lack of information on technology, and limited managerial, technical and financial capacities. According to Lall and Pietrobelli (2002), Kenya's plastic industries failed to develop the required competitive capacity to penetrate international markets. Other obstacles included restrictions on imports of technology and a lack of incentives to strengthen technological capacities (Wignaraja and Ikiara, 1999). In general, Kenya's manufacturing industry including the plastic sector had failed to become the "engine of the country's growth" earlier envisioned (Kenya Government, 1994). By the mid-1980s, the country needed a more flexible industrial policy and to internationalize - and this led to the adoption of market liberalization policies in the late 1980s.

Macro-economic policies

Faced with declining economic growth and increasing debt, and under pressure from the World Bank and the IMF, Kenya's government adopted a more outward-oriented industrial policy in the late 1980s. At this time Structural Adjustment Programmes (SAPs) were increasingly being recommended and enforced upon African countries by the World Bank and the IMF (Logan and Kidane, 1993). The main aim of SAPs was to address the structural rigidities, price instability and macroeconomic imbalances that had become embedded in Africa's economies. It was envisioned that such a shift would transform the manufacturing sector from its focus on a highly protected domestic market pushing it into a more competitive environment, making increased use of local resources, creating employment and more focused on exports. The main components of SAPs included lifting quotas and administrative controls, removing controls on prices, tariff reforms, devaluation of the exchange rate through liberalization, and financial sector reforms (Republic of Kenya, 2008a). These institutional reforms were intended to encourage Foreign Direct Investment (FDI). Free entry into production, services and trade resulted in a slight recovery of the economy, with GDP growing by 5% per annum in the period 1986-1990 (Glenday and Ndii, 2000). Growth rates in the manufacturing

rose by 5.7 per cent in the same period. According to Glenday and Ndii (2000), merchandise exports (as a percentage of GDP) escalated to 13% between 1978 and 1992. Despite the improvement in economic performance, the benefits were short lived as the government failed to seriously commit to the reforms. According to Ronge and Nyangito (2000), the liberalization measures introduced at the end of the 1980s were either reversed, applied intermittently or halted altogether. The plastic production system, however, showed resilient development throughout this period.

2.4.2 Post-1990 plastic industries

Export oriented policies

Kenya began to adopt an export oriented industrial strategy when it became clear that the ISI strategy and SAPs had failed to achieve the intended industrial growth. The new strategy offered incentives to encourage industries to produce for export. The main objectives were to improve efficiency, stimulate private investment and increase foreign exchange earnings. The liberalization measures also included the removal of quantitative restrictions, tariff reductions, measures to stimulate exports and the establishment of a flexible exchange rate regime. Administrative controls on international trade, including import licensing and foreign exchange controls were abolished. Export promotion measures were introduced, including Manufacture under Bond (MUB), which exempted producers of machinery and raw materials used to produce manufactured goods meant for exports from duty and VAT. Export Processing Zones (EPZ) were also established. These provided investors with ten-year tax holidays, placed no restrictions on foreign ownership and or on the employment of foreigners with technological knowledge (Republic of Kenya, 2008a). These efforts marked the beginning of the serious liberalization policies of the early 1990s, focused on stimulating certain exports and improving access to advanced technologies (Ikiara and Mutua, 2004). During this period the maximum tariff rates for imports were reduced from 170% to 70% (Mwega, 2003). More shifts in trade policy came in 1993, when trade licensing requirements and foreign exchange controls were abolished (Ndung'u, 2000; Were *et al*., 2002). In an attempt to attract Foreign Direct Investment (FDI), to stimulate external trade and expand exports, a number of organizations and export schemes were established. There was also a process of trade liberalization in the newly created East African Community (EAC), better access to the Common Market for Eastern and Southern Africa (COMESA), and to the European Union's market. Exports to COMESA increased from 15% of total exports in 1990-92 to 34% in 1996-98 (Glenday and Ndii, 2000).

The trade liberalization policies had positive implications for the plastic production industry. More industries were being set up, though there were major geographical disparities in the expansion. Around 2005 the majority of plastics

businesses (84.1%) were located in Nairobi with other cities only managing very small shares: 9.4% for Mombasa, 2.9% in Eldoret, 2.5% in Kisumu and 1.1% in Nakuru (KNCPC, 2006).

This regional trade that emerged in the late 1990s and early 2000s created new demand for Kenya's manufactured plastic products. The plastic industry grew steadily, supported by rapid technological changes, product diversification and the entry of new firms. The number of plastic businesses rose from 70 in 1998 to 134 in 2005 (KNCPC, 2006). More expatriates, especially of Indian origin, came in large numbers and started new production facilities, either as Direct Foreign Investments (DFI) or as Joint Ventures (JVs) with locals, boosting the knowledge in the sector (Kenya Government, 1997; Njeru, 2006). The low rates of import duty on inputs of plastic products resulted in an ever increasing supply of plastic products both locally and within the East African Community.

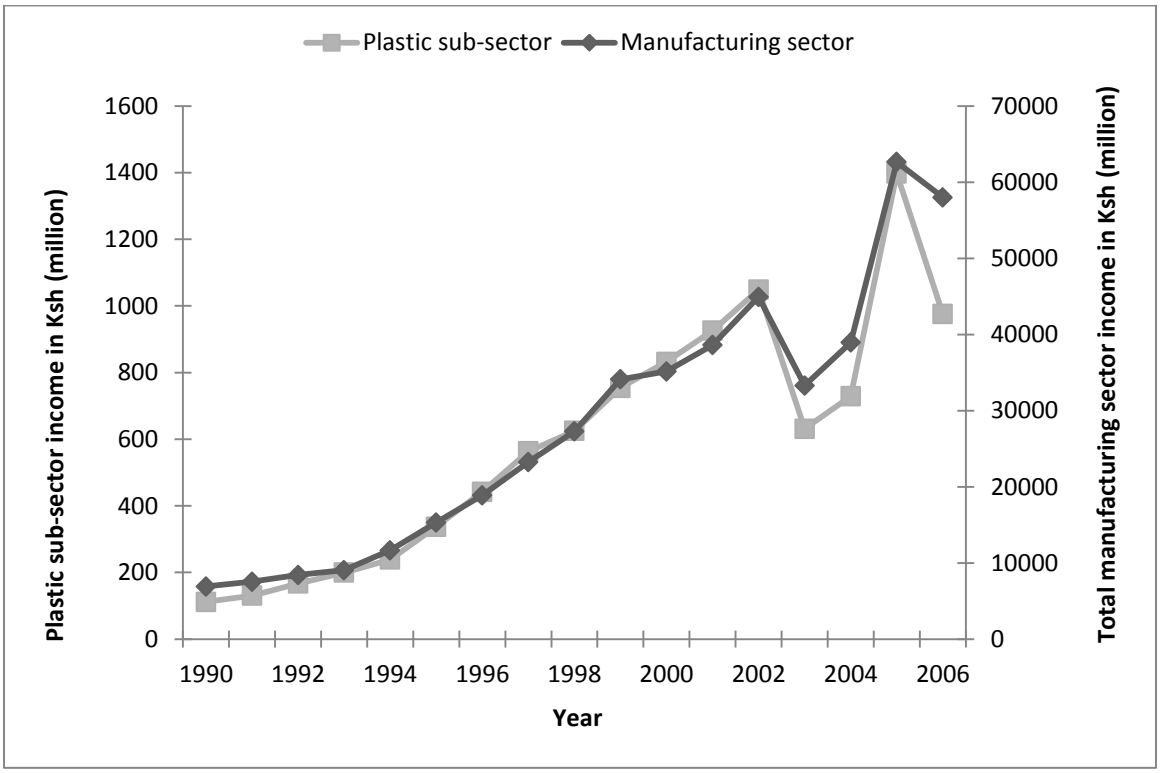


Figure 2-2 Trends in manufacturing income (Source: Constructed by author using data from Ministry of Planning and Development)

The contribution of the plastic sub-sector to Kenyan manufacturing

In spite of Kenya's inconsistent economic performance (Republic of Kenya, 2008b; KAM, 2006), the plastic manufacturing sub-sector's contribution to GDP has remained at about 2% of that of the overall manufacturing sector for almost 20 years (computed from

Figure 2-2). The growth of the plastic manufacturing industry closely follows the trend set by the manufacturing sector overall. This is an indication that external factors influencing the performance of the wider manufacturing sector also affect the plastics sub-sector.

The overall income from the plastics sub-sector substantially dropped from over Ksh. 1 billion in 2002 to about 631 million in 2003, before picking up again in 2005, following the pattern for the manufacturing sector as a whole. The decline is mainly attributable to the uncertainties that surrounded the 2002 presidential election, which led to a different political regime, with new development policies, assuming power in 2003, The sub-sector's performance was once again disrupted in the run-up to the 2007 presidential election, recording total earning of Ksh. 975.7 million in 2006 compared to Ksh. 1.4 billion in 2005 (KAM, 2006).

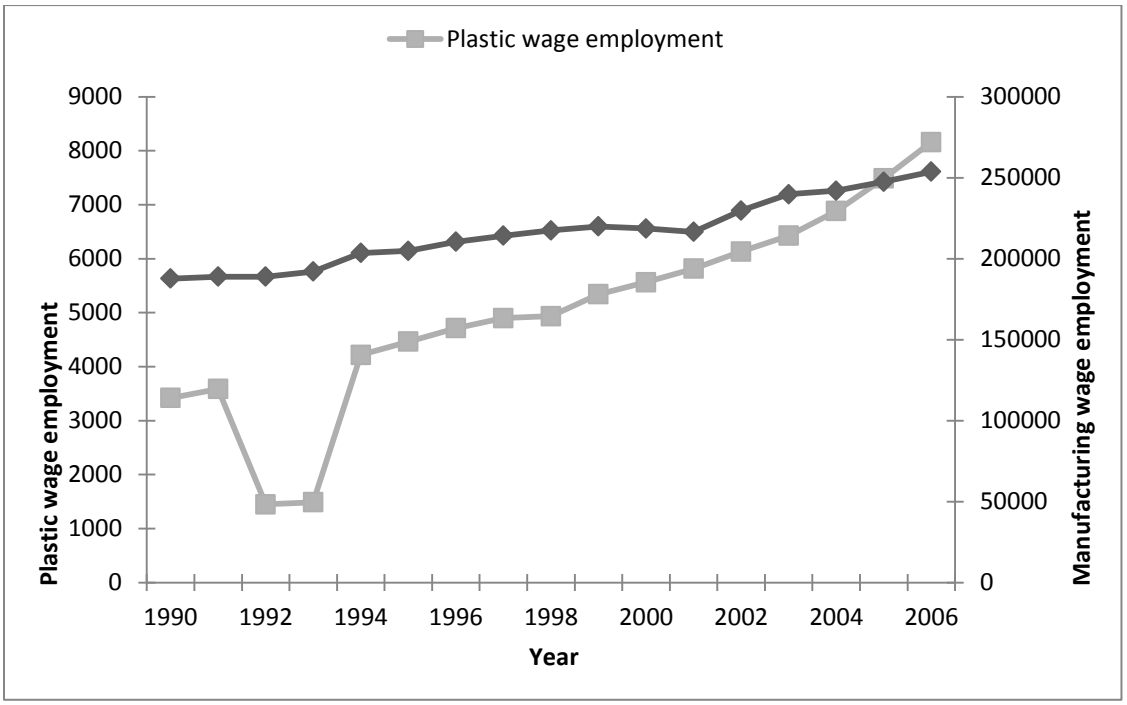


Figure 2-3 Trends in wage employment (Source: Constructed by author using data from Ministry of Planning and Development)

Sub-sector employment

Employment in the plastic production sub-sector has continued to grow, accounting for a share of between 2 - 3.2% for the entire period except for the years 1992 and 1993 when it fell to 0.77% (see Figure 2-3). The general increase in employment opportunities in the sub-sector is largely due to the increased up-take of new technologies and an expansion in investment in the sub-sector (Republic of Kenya, 2008a). The drastic drop in 1992-3 can be attributed to fears about the future (and particularly about future policy towards

FDIs) caused by the Kenya's first multi-party elections. These contributed to the temporary closure of many of the businesses many of which are owned by Kenyan nationals of Asian origin. These uncertainties did not affect the larger manufacturing sector.

While government sources indicate that the plastic manufacturing sub-sector makes a relatively minor contribution to the country's economy, information from the industry shows a different picture. According to the East Africa Plastics Association (2008), the sub-sector in Kenya directly employs over 20,000 people in the manufacturing firms, with nearly 60,000 people being indirectly dependent on plastic production. This discrepancy in information about the plastic production industry suggests that the government is not keeping abreast with developments within the wider manufacturing sector and the plastic production in particular.

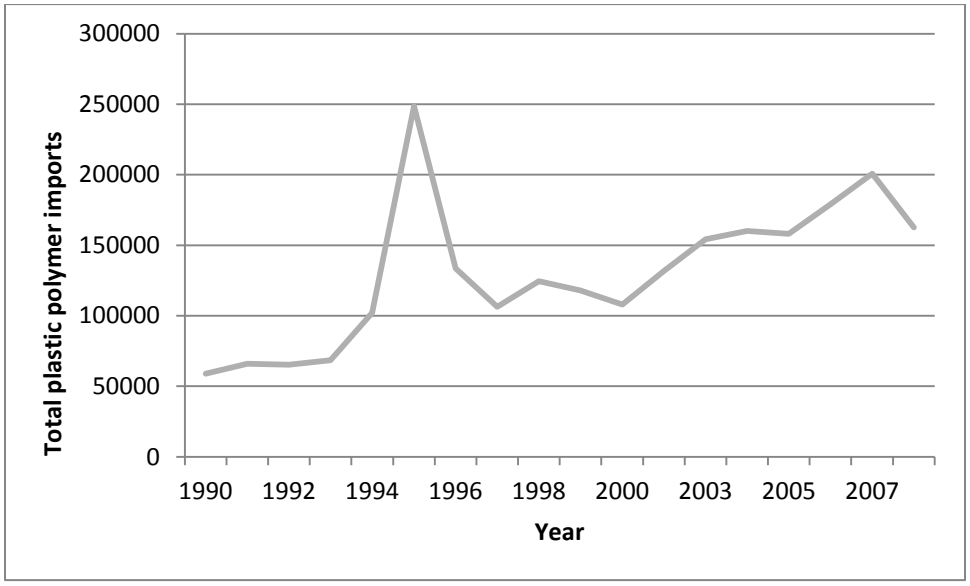


Figure 2-4 Plastic polymer imports into Kenya 1990-2007 (Source: Constructed by author using data obtained from Kenya Revenue Authority)

Raw material imports

With no polymer factories within Kenya, the plastic manufacturing sector is highly dependent on imports of raw materials (see Figure 2-4 and Figure 2-5). There has been a consistent growth in imports of both Polyethylene and Polypropylene raw materials. Worldwide, (and in Kenya) these materials are two of the major ingredients in plastic manufacture (http://www.plasticseurope.org) (KNCPC, 2006).

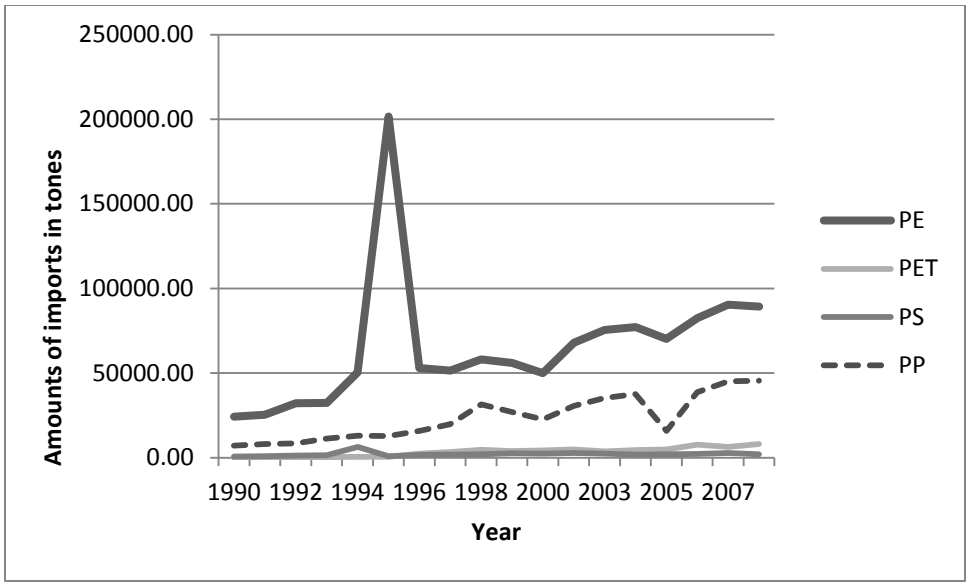


Figure 2-5 Imports of the major virgin polymer resins 1990-2007 (Source: Constructed by author using data obtained from Kenya Revenue Authority)

While imports of Polyethylene Tere-phthalate and Polystyrene have somehow remained low and constant for the last 18 years, Polyethylene and Polypropylene imports have been increasing. 1995 saw the highest level of imports of plastic raw materials, caused by a peak in Polyethylene imports. This outlier effect is due to friendly import policies, which saw a 0% duty on basic raw materials, one of 10% for resins and a relaxation of exchange rate controls (KAM, 2006; Kenya Government, 1998). As a result Kenya became the importer of raw materials for Ugandan and Tanzanian industries in that year.[16] It is possible that the decline from this peak in the next year was a result of measures taken by the governments of Uganda and Tanzania to protect their local industries.

Despite the consistent contribution that the plastics industry has made to Kenya's economy, Kenya's economic growth record has been patchy. According to Gachino (2009) in the 1990s, the overall economy recorded the lowest growth level since the country's independence, falling to an average of 1.5% in the period 1991-1994 and 2.5% between 1995 and 2000. Manufacturing declined from 2.2% of the national GDP in the period, 1991-1994 to 1.8% in the period 1995-2000. In recent years Kenya has also come to recognize and deal with the intricate balance between the environment and industrial development. In the midst of all these challenges, in 2005 the government launched a new effort towards industrialization, aimed at transforming Kenya into a newly industrialized country by 2020. The new policy is also contained in Kenya Vision 2030, the current blueprint for Kenya's overall economic development, formulated in 2008.

[16]Interview with Eng. Kuloba - Assistant Director of the Kenyan Industrial Research and Development Institute, on 17th November, 2010.

The new National Industrialization Policy

The period leading to 2000 Kenya started to formulate a new national industrialization policy. The policy endeavours to tackle issues that affect the manufacturing sector by establishing broad strategies to provide the sector with meaningful opportunities to realize its full potential. One priority is the provision of a framework to better engage stakeholders from the public and private sectors, as well as civil society organizations. The National Industrialization Policy became the Kenya's first industrial policy to highlight the contribution of micro, small and medium industries (MSMIs)[17] and call for the enhancement of their growth. These currently constitute about 87% of the businesses in the country and it is recognized that these will form the bedrock for Kenya's industrial development (Republic of Kenya, 2005). The policy also calls for an integrated approach to industrial development that protects the integrity of the environment and ensures sustainable resource use and management.

According to Nyenze (1998) at the start of the 21st Century, the Kenyan Government started to consider instituting measures to enable plastic (and other) manufacturers to embrace effective strategies to reduce environmental degradation. These included lower taxes on machinery and technologies for reduction and promoting the re-use and recycling of plastic wastes. They also considered the imposition of taxes on industrial inputs and outputs in order to reduce pollution (Musungu, 1997; East Africa Plastic Association, 2008). However, as several commentators have noted these ideas have only been articulated in government publications and public forums, and have not yet become part of programme implementation strategies (Republic of Kenya, 1996; Frijns and Malombe, 1997; Nyenze, 1998; Kamau and Sonkoyo, 2006).

Under the new *National Industrialization Policy* framework, the contribution of relevant organizations towards environmental management, particularly plastic waste, is increasingly becoming evident. The creation of the KNCPC in 2000 represented a major step towards institutionalizing the goals of better environmental management within industrial production. The Centre has been instrumental in building national capacity in preventive industrial environmental management. It has published a study that shows the quantities of plastics produced in Kenya and setting out proposals for possible management options to handle plastic waste (KNCPC, 2006). The enactment of EMCA in 1999, which requires the preparation of environmental impact assessments and audits of industries, is yet another milestone towards creating a balance between production and the environment. A survey conducted towards the end of 2003 by the Kenyan Institute for

[17]The Kenyan Government defines MSMIs as manufacturing micro, small and medium enterprises (MSMEs) with no more than 100 full-time employees or an annual sales turnover of not more than Ksh. 150 million. MSMIs are further categorized into micro, small, and medium-sized industries. Micro-industries are those with annual sales turnover not exceeding Ksh. 5 million or not more than 10 full time employees; small industries are those with an annual sales turnover of between Ksh. 5 million and Ksh. 50 million or employing between 11 and 50 workers; medium industries are those with an annual sales turnover of between Ksh. 50 million and Ksh. 150 million or employing between 51 and 100 workers.

Public Policy Research and Analysis (KIPPRA) revealed a fairly vibrant trade in environmental goods and services in urban areas of Kenya. Trade in waste management services is growing and water harvesting tanks made from recycled plastic wastes are becoming increasingly popular. Trade in waste plastics is generating new economic activity and industrial development. To support the growth of these environmental goods and services, import tariffs of goods related to this sector – an important source of government revenue – are gradually being reduced while taxes and duties on equipment for these goods are also getting lower (KIPPRA, 2003).

In the new Millennium, there has been more collaboration between government organizations and the plastic manufacturing industry in tackling plastic waste problems. For example, recently, the Kenyan Bureau of Standards has organized a series of round table meetings between plastic manufacturing industries represented by the Kenyan Association of Manufacturers (KAM), NEMA and KIPPRA, culminating in the development of a standard for plastic bags (KIPPRA, 2006). The development of this standard can be seen as a landmark achievement. Plastic industries have since up-graded their production technologies and are able to demonstrate a higher level of plastic waste recycling, which is reflected in the increased number of businesses being set up.

Despite this new policy approach to industrial development, inconsistencies, random sanctions and institutional inadequacies within the government, still threaten meaningful progress. There are reported examples of industrial policies being changed without sufficient advance notice, debate and of policies being interpreted in contrasting (and contradictory) ways (KAM, 2006). According to Practical Action, (2005), most of the plastic recycling initiatives in the country are small and medium scale enterprises (SMEs). This group of enterprises works with insufficient capital and is vulnerable to shocks; any abrupt change in government policy is a potential threat to their survival.

There are a few key organizations at the centre of industrial policy in Kenya, which could potentially play an important role in strengthening the industry's role in handling plastic waste. The Kenyan Bureau of Standards (KEBS) is mandated to develop product standards, but has insufficient funding to do so properly. Manufacturing industries do not appear keen to patronize KEBS, seeing that it lacks capacity and only acts when under public pressure.[18] Even though some collaborative standards development is done, KEBS lacks a structured system to foster meaningful cooperation with the industry.

KIRDI supports the implementation of industrial policy with research and knowledge development. KIRDI was established under the Science and Technology Act Cap. 250. Its main purpose is to promote national industrial innovation through the development of a sufficient national capacity in industrial technologies for the attainment of self-sustaining industrialization process. The plastic industry could benefit from KIRDI's knowledge to further develop recycling technologies.

[18]Interview with Mr. Shah, Operations Manager of Premier Industries Limited, on 17 April, 2010

The NEMA is the authority that facilitates and directs industry to achieve set environmental objectives. NEMA uses a combination of regulatory and incentive programmes to target industrial actors (see Appendix 3).

KAM is the main national representative organization for manufacturing industries. KAM serve as the industry's voice in relations with the government and other sectors. KAM played a prominent role in lobbying industries to adopt environmental control measures, including waste recycling. KAM is well placed to link small-scale actors involved in plastic recycling with major manufacturing industries.

2.5 Conclusion

This chapter has described the development of the SWM system and the plastic production system and the influence that these have on the management of plastic waste. It is clear that concerns about plastic waste management are starting to gain prominence. Recycling plastic waste is increasingly receiving policy attention at the national level. This is exemplified by the various policy efforts of different government organizations. However, these aspirations have not yet achieved major results, and plastic waste is still high on the agenda of Kenyan environmental politics. The city authorities seem to lack the will, technical and financial capacity, to roll out a comprehensive solid waste management plan that can adequately address the problems of plastic waste. Public pressure to find a solution has not yet reached critical mass.

For years the plastic production industry has been using plastic waste in its production processes. There is the capacity to recycle more waste and more industries are being set up to respond to the increasing demand for plastic products. But it is unclear how effective this system of plastic waste recycling is, how well it is supported and facilitated by industrial policy, and whether or not it hinders the adoption of more preventive plastic waste strategies. This situation led the research to investigate who is involved in the plastic waste recycling chain and the nature of their involvement. It also provoked the questions of whether plastic waste recycling is the only viable strategy for managing plastic waste or whether other (preventive) strategies might address the problems of plastic waste more effectively. The next chapter presents the theoretical framework that will guide the answering of these questions.

3 INNOVATIONS IN PLASTIC WASTE MANAGEMENT: TOWARDS A THEORETICAL FRAMEWORK

3.1 Introduction

The objective of this thesis is to provide insights and tools for better management of plastic waste in the urban centers of Kenya. It is a search for innovation activities and actors for the prevention and better management of plastic wastes. The innovation activities, labeled here *environmental innovations*, depart from the normal practices for management of plastic waste, and they can be linked to the waste management system or to the plastic production system. The aim of this chapter is to develop a theoretical perspective for the analysis of such innovations.

Previous studies on this subject have either focused on the solid waste management socio-technical system or the plastic production socio-technical system. In the East African region, and Kenya in particular, analyses on solid waste management system innovations have been carried out by among others Kassim and Ali (2005); Karanja, (2005); Bahri (2005); and Baud (2004). They have been slow to appreciate the material value of plastic waste that may require solutions to transcend the waste management system and include the plastic production socio-technical system. Similarly, studies done by Mol (1995); Mugambi (2001); Nampoothiri *et al*., (2010) and Gupta and Sharma (2010) have focused primarily on the plastic production system. Over time, analyses of the two systems have remained two worlds apart. There is therefore a need to conceptualize management of plastic waste in a more holistic and integrative manner, spanning from solid waste management socio-technical systems, through consumption, to plastic production socio-technical systems. It is only through this multi-system understanding of innovation activities that the compounding problems of plastic waste may ultimately be solved in Kenya.

In section 3.2 a theoretical overview is given of the evolution of solid waste management socio-technical systems. Integrated Sustainable Waste Management (ISWM) is discussed as the point of convergence for policy and waste managers enshrining environmental sustainability in the affairs of solid waste management. Section 3.3 reviews the literature on Large Technical Systems as a general infrastructural concept providing useful insights to the functioning and development of a socio-technical system. Section 3.4 introduces Cleaner Production (CP) practices and 3.5 Green Supply Chain Management (GrSCM) as sustainability concepts within the production industry. Section 3.6 introduces transition theory as a perspective for understanding system change in socio-technical systems, regardless of whether these are solid waste management socio-technical systems or plastic production socio-technical systems. Within that theory the notion of strategic niche management is used to analyze niche innovations. Section 3.7 presents the conceptual model used in this study which is based on transition theory and niche innovations but which conceptualizes the parallel innovations in two systems

(SWM and plastic production) eventually leading to system integration as an outcome of the transition.

3.2 Evolution of solid waste management systems in developing countries

Until the 1970s, when environmental protection came to the forefront, classical solid waste management systems existed, particularly in developing countries. These systems were conceived as viable public health entities with the sole objective of providing efficient collection and disposal. According to Scheinberg (2011), removal of waste from cities emerged as a public health priority as the cities were urbanizing. Migration to the cities increased both the absolute population and its density. Newcomers into the cities understood neither how to live in the cities, nor how to manage their wastes and excreta. Often, there was access to enough space to organize waste management activities in ways that were practiced in the countryside (Swaan, 1988). The systems that were operated by public officials were organized around three basic elements: collection, transportation and disposal. In terms of technical, planning, managing and financial control, these systems were under the purview of city authorities at the local level with policy directions coming from central governments. Any necessary improvement of the system was implemented from within or through contract-based cooperation with private organizations in a market arrangement (Chen *et al.*, 2010), while public health goals remained the sole central driving force for such improvements.

Due to the burgeoning problems emanating from continuous economic growth, urbanization and industrialization, the legitimacy of such systems to fulfill their primary mandate started to decline (UNEP, 2009). According to Karanja (2005; see also UNCHS, 1998), the classical solid waste management systems are currently under unprecedented pressure jeopardizing their capacity to meet the ever increasing demand for better SWM services. Poor resource base, human and technological inadequacies, inadequate organizational structures and lack of co-ordination of operational processes have fundamentally crippled effective and efficient collection and disposal of waste (Kassim and Ali, 2005). Relations between the central government and city authorities is also challenging, as the city authorities rarely have any free hand to make their own financial and administrative decisions to respond to the changing situations, including challenges posed by growing volumes and complexity of plastic wastes (Karanja, 2005). Besides failing to meet the primary objective of SWM, these systems have been criticized along other sustainability principles. To begin with, these systems emphasized safe disposal without any attention being paid to waste separation, resource use and recycling. Second, by virtue of public officers being their sole planners, implementers and regulators, they have been highly centralized and lacked any participation of other stakeholders, including even consumers. With increased waste generation, high complexity in solid waste and an increasing demand for better services, a new approach to SWM was required.

3.2.1 The ISWM approach

Integrated Sustainable Waste Management (ISWM) gave a new direction to solid waste management services, where waste is considered to have value and its proper management has the potential to contribute to economic and social development (Asase *et al*., 2009). Integrated Sustainable Waste Management (ISWM) was developed in mid-1980s by the Dutch NGO WASTE (WASTE, 2004). The concept of ISWM has three important dimensions: (1) the involvement of stakeholders affected by waste management, (2) the (practical and technical) elements of the waste system and (3) the sustainability aspects when assessing and planning a waste management system.

A number of stakeholders are recognized by ISWM, depending on the specific local context. The central role of city authorities towards urban cleanliness is highlighted, as well as those of citizens who use the system, and private organizations involved in collection and recycling activities. With respect to the material element of SWM, the approach gives priority to and advocates for prevention, minimization, recycling and other forms of recovery of materials, and only opts for waste disposal in landfills when treatment is impossible. The sustainability dimension involves aspects through which the existing waste management system can be assessed and a new or expanded system can be planned (WASTE, 2004). This includes political-legal, socio-cultural, institutional-organizational, technical performance, environmental-health and financial-economic aspects, all influencing solid waste activities and the sustainability of the entire system. Widely recommended as an effective method for both developed and developing countries (Hoornweg and Thomas, 1999; Seadon, 2006; van de Klundert and Anschiitz, 2000), ISWM is primarily a reference framework for the design and implementation of new waste management systems and for analyzing and optimizing existing systems (UNEP, 1996). According to McDougall *et al*. (2001), Wilson (2007) and Asase *et al*. (2009), energy consumption, pollution and loss of amenity are addressed in ISWM.

Material recovery and reuse is seen as a dramatic shift from the traditionally and widely practiced solid waste collection and disposal that characterizes solid waste management systems of most developing country cities (Zurbrügg and Schertenleib, 1998). Asase *et al*. (2009) assert that such initiatives are now being practiced in some developing countries. The participation of non-state actors in waste management is an equal deviation from conventional practices of waste management. Forester and Krumholz (1990), Keating *et al*. (1996), Sawicki and Graig (1996) and Tukahirwa *et al*. (2011), among others, emphasize the important role of CBOs in such new forms of solid waste management, also because of their strong links with and understanding of neighborhoods.

According to Wilson, (1991) CBOs are able to devolve responsibility of implementing programs that address urban problems to local people. Chen *et al*. (2009), who have applied ISWM in comparing performance of municipal solid waste management systems of Dalian in China and Waterloo in Canada, reiterate the

importance of cooperation with the informal sector. They claim that such cooperation should be based on economic and market-related tools to share benefits with and to support informal actors.

Scholars like Karanja *et al*. (2004) emphasize the need for new forms of regulation and incentive yielding structures to encourage material recovery and recycling by formal actors. Other scholars, including Wilson *et al*. (2009), Nas and Jaffe (2004), Rouse (2004) Scheinberg *et al*. (2006) and Nzeadibe (2009), remain optimistic that informal recovery of valuable waste materials, including plastics, has the potential to bring a breakthrough in solid waste management systems of developing countries. They call for an understanding, acknowledgement and, if possible, incorporation of such informal actors in the solid waste management systems.

The ISWM approach acknowledges the complex nature of solid waste management activities and actors with different interests and priorities requiring proper management and coordination (ILO, 2004). ISWM emphasizes the social and economic aspects as key ingredients to sustainable solid waste management; these are the core motivating factors that trigger informal actors to participate in waste material recovery, including plastic waste. By outlining the system elements, the approach provides possible entry points for diverse stakeholders, including those recovering plastic waste, to participate in making the system more sustainable (Wilson, 2007; WASTE, 2004; McDougall *et al*., 2001; UNEP, 2009). In this respect, ISWM lays a good foundation from where niche based innovation activities on post-consumer plastic waste can be anchored. But ISWM has a number of weaknesses as well. First, although entry points are given, it fails to explain *how* changes can be introduced in order to secure sustainability. ISWM is a descriptive approach towards waste management systems, disclosing major actors, elements and aspects but does not provide the tools for analyzing system innovation.

Second, ISWM emphasizes the central position of city authorities as the managers, operators and even coordinators of stakeholders' activities. This makes the success of any initiative dependent on the goodwill of city authorities. The incorporation of non-state actors in solid waste management is largely visible in collection and transportation, while waste material recovery activities of non-state actors, necessary for the promotion of sustainable plastic waste management, are still considered illegal activities by city authorities (JICA, 2010). A third problem in ISWM is the arbitrary list of stakeholders to be involved, which does not take into account any differentiation and specification of their position and roles in solid waste management. This listing of actors lacks a theoretical background, analytical clarity and a systematic analysis of the social dynamics through which such actors interact towards the improvement of the system (Van Koppen and Mol, 2002). Finally, ISWM lacks an explanation as to how system elements are connected and related, and as such it fails to explain the relationship between such elements and their logic flow to sustainability. In conclusion, while

organized along system principles, ISWM failure to provide a conceptualization as to how stakeholders interact with system element renders it incapable of analyzing system operations necessary in facilitating appropriate intervention whenever a problem arises. The framework therefore fails to provide an understanding as to how *change* is or can be enacted.

3.3 Large technical systems theory

The notion of large technical system refers both to an approach to understand and analyze socio-technical change and to a particular class of systems – large socio-technical infrastructural or production systems. The school of thought has its roots in the late 1980s as one of the promising new directions in the sociology and history of technology (Hughes, 1987). Scholars of large technical system theory, including Hughes (1987), Callon (1980) and Summerton (1994), explain how technologies are crucial in system development. According to large technical system theory scholars, the focus or unit of analysis should be the entire socio-technological system. Systems can be defined as constituted by different related parts or components. These components are connected by a network (Hughes, 1983). The interconnected components of the socio- technical system are centrally controlled and usually the limits of system performance are defined by its span of control. Van Vliet (2002) refers to network-bound systems, which can be seen as large technical systems involving many artifacts connected together: the social actors managing the system; the rules and resources that structure system operations; and cultural values that are associated with them (Van Vliet, 2002; Hughes, 1987; Mol, 1991 cited in Hegger, 2007; Geels, 2004a).

The evolution of large technical systems comprises four different phases, through which such systems attain momentum necessary to satisfy the intended purposes for which they are established. According to Hughes (1987), the first phase is the invention, which is mainly associated with system builders highlighting the different roles of different social groups. This is followed by the second phase, mainly referred to as 'development' involving economic and political embedding to the technological system where different agents are important in the diffusion of technology, including entrepreneurs, inventors and others. Large technical systems then proceeds to the third phase commonly referred to as 'innovation', putting the system into efficient use which mainly involves economies-of-scale. The next phase is 'transfer', which refers to mutual adaptation of the new system to environments different from the ones a system has been developed in. In this last phase, the system proceeds from 'growth' through 'competition' to 'consolidation'. The dominant system goals are rationalization and efficiency.

In Hughes study of electricity systems, he introduced some structural features and tensions of evolving systems: 'reverse salient', 'load factor' and 'momentum'. Reverse salient come up when systems grow. They are technical or organizational anomalies

resulting from uneven elaboration or evolution of a system. As technical systems expand, reverse salient develop (Hughes, 1987:73). When a reverse salient cannot be corrected within the context of an existing system, the problem becomes a radical one, the solution of which may bring a new and competing system (pp.75). Hughes mentions the change of the characteristics of a generator as a reverse salient to improve efficiency within electrical system. Another common phenomenon in the management of large technical systems is the 'load factor'. It stands for the ratio of average output to the maximum output during a specific period. It is usually presented in a curve, showing the peaks and deeps in daily - or weekly or yearly – output. The lead factor steers the system in specific directions but does not necessarily stimulate their growth. Diversification of demand is a way to spread peaks over time. Consequently, extensions over a larger geographical area with different loads provide increased diversity and the opportunity to manage the load to improve the load factor (Hughes, 1987:72).

Large technical system would always grow as long as there is adequate demand for its output. The system finally acquires substantial momentum which is a characteristic of the final fourth phase of system development and growth. The momentum arises because the system has consolidated physical artifacts and technical, organizational and social actors for its optimal performance. Investments (sunk costs) have been made, institutions set up and trajectories of innovation outlined. In the whole, large technical systems are characterized by the presence of a complex physical network, besides a similarly complex social network of actors and institutions involved in developing, managing and using the technological system. System builders, users and managers have vested interest on certain defined trajectories locked in large technical systems. Within the boundaries of the system and following a particular logic, changes develop slowly and according to 'fixed' trajectories while any alternative diversions of those trajectories face high blockades. This means that technologies seeking to establish alternative paradigms outside the system boundaries will be socially and technologically resisted.

The core of this theoretical strand is that technologies cannot be viewed as isolated artifacts but are part of a larger socio-technological system that includes material technology, organizations, institutional rules, structures and cultural values (Summerton, 1994). A typical identity of a large technical system is that it is always associated with a dominant technology, with a routinized and systematic way of its implementation, and with instructions and controls trickling from a centralized point in a hierarchical organization (Guy *et al*., 2001). Large technical system scholars consider driving forces to technological change as inherent in systems or endogenous. There are no separate or external environmental forces to which technological changes yield to and therefore the economic, socio-cultural and technological factors that influence the evolution of large technical systems are influenced by this evolution at the same time (Hughes, 1987). Scholars who have analyzed large technical systems have focused on the entire system as they hold that forces that lead to technological change are internal (Callon, 1980; Callon,

1986; Summerton, 1994; Hughes, 1983; Mol, 1995). Particular focus has been on the 'seamless web' where new technologies and the user environment are constructed in at the same time in an intricate relation. The technical and social dimensions of technology are intertwined: hence the term "socio-technical systems" (Summerton, 1994). The socio-technical character of systems is normally concerned with three interrelated dimensions: system materials, actors and rules. The interrelation nature of these three dimensions is the source of stability for any socio-technical system. David (1985) and Arthur (1988) have used the notions of path-dependency and lock-in to analyze the stability at the level of existing systems (Walker, 2000; Unruh, 2000; Jacobsson and Johnson, 2000; Araujo and Harrison, 2002). First, incumbent actors have vested interests and social networks represents 'organizational capital'. Second, regulations and standards may stabilize systems, and cognitive routines may blind actors to developments outside their focus. And third, existing machines and infrastructures stabilize through sunk investments and technical complementarities between components. Such stabilizing mechanisms enable growth of systems, but they serve as obstacles to their transformation once they have achieved maturity (Berkhout *et al*., 2010).

Large technical system theory is outstanding in explaining the stability and inertia of existing systems. It also appreciates that critical problems may occur which may require radical changes. This marks then the birth of new and competing systems (Hughes, 1987; Van Vliet, 2002; Hegger, 2007). Popularly referred to as 'reverse salient', outsiders can create radical inventions resulting in the birth of such new systems especially when the existing system is already vulnerable and fatigued to offer support to and include such new inventions.

While large technical system theory is heavily coined around technology as the motherboard for system development, it is not technological deterministic. Large technical system perspectives position actors as the drivers behind technologies, which bring about change. Furthermore it provides an explanation as to how linkages between the heterogeneous parts of the system occur, making it a refined theory in explaining the logic of the system and of system operations, in comparison to ISWM. To be short, more than ISWM, large technical system theory is a theory explaining continuity and (incremental) development/change. And it moves beyond the listing of system elements, actors and aspects only.

In principle, large technical system theory has been able to explain how systems develop, what the sources of its stability are and how system actors enable incremental changes. In this respect, large technical system theory is relevant and useful in providing explanations to developments in classical solid waste management systems. However, there are some shortcomings. To begin with, the theory fails to provide actor-actor interactions within the heterogeneous parts which is fundamental in exchange of information and learning for better system performance. Second, and in reference to the intention of this study, large technical system theory fails to provide a framework for the

analysis of paradigmatic change in/of systems. Third, large technical system theory is only capable of analyzing changes within a single system. It is therefore inadequate to grasp changes that go beyond system boundaries. Because of this lack of conceptualizing changes introduced by outsiders, and especially when such changes go beyond the system boundary, a more comprehensive and integrative concept is required.
However, before such an integrative theoretical conceptualization is outlined, the subsequent two sections provide a review of theoretical school of thoughts that explains environmental reforms within production systems.

3.4 Cleaner production approach

Up to 1980s, end-of-pipe solutions instigated by command-and-control policies of the nation-state were dominant in dealing with point source pollutions. As Ecological Modernization scholars have reported in much depth, various developments were behind the uneasiness with this approach in the 1980s and developments towards alternatives. The 1992 Rio Summit culminated in a new 'paradigm' that would be more proactive and holistic towards the management of environmental pollution caused by industries and other point and non-point sources of pollution. Key elements of this new 'paradigm' were: attacking the problem at different levels, deviating from the traditional government policy of direct regulation, monitoring and enforcement to inclusion of more self-regulation, an emphasis on prevention, and an integration of environmental technologies with production technologies. Cleaner production was part of this new paradigm, and so was green supply chain management (see next section). Developed over two decades ago, cleaner production can be defined as the approach in which process and activities are carried out in such a manner that the environmental impact thereof is as low as possible (Mamery *et al*., 2005). UNEP, one of the advocating organizations of cleaner production defines cleaner production as "the continuous application of an integrated preventive environmental strategy to processes, products and services, to increase efficiency and reduce risks to humans and the environment" (UNEP, 1994b:3).

The concept of cleaner production refers usually to continuous improvement of industrial production processes so as to reduce the flow of waste products and save costs through better resource efficiencies and less spending on waste treatment. Important practices undertaken include product improvement, material substitution, process/equipment improvement, waste separation and reuse, factory management, lifecycle management and training processes (Dodić *et al*., 2010). For processes, cleaner production means conserving materials and energy, eliminating the use of toxic raw materials, and reducing the quantity and toxicity of all emissions and waste before they leave a production process (Van Berkel *et al*., 1997). Related to products, cleaner production attempts to reduce environmental impacts along the entire life cycle, from raw material extraction via consumption to disposal (UNEP, 1994a). It therefore means that

concepts of process optimization, resource recovery and life cycle approaches are crucial to successful cleaner production.

According to UNEP (1994a) and the World Business Council on Sustainable Development (WBCSD/UNEP, 1996), cleaner production provides a window for possible win-win solutions, as industries reduce their operational costs and environmental and other liabilities by using less energy, water and materials, handling chemicals and waste safely, and generating less waste and pollutants. One essential feature which is often emphasized about cleaner production is that it is a problem-solving *strategy* rather than a solution in itself. By adopting a preventive mind-set, cleaner production develops alternative solutions within the broader frame of technical, operational, educational, and managerial practices. Thus, cleaner production is not seen in terms of a fixed set of solutions, organizational schemes and/or technologies to environmental problems of producers.

Cleaner production was first practiced in industrialized countries, notably in North America (OTA, 1986; Dorfman *et al*., 1992; Freeman *et al*., 1992; USEPA, 1997) and Western Europe (DTI, 1990; Backman *et al*., 1990; Dieleman and de Hoo, 1993). Later, the United Nations Industrial Development Organization (UNIDO) has been cooperating with the United Nations Environment Programme (UNEP) to ensure up-take of cleaner production especially in developing countries (Van Berkel, 2010). Through such cooperation, national cleaner production centers (NCPCs) have been established in quite a number of developing countries including Kenya (UNEP, 1993; UNEP and UNIDO, 2002; UNEP, 1994b).

Cleaner production is widely supported as a useful concept and strategy for environmental risk minimization. But it has also raised a number of debates. Cleaner production can be viewed as a perspective and decision making tool which assist industries to make environmentally and socially conducive choices in design and investments of production processes. In terms of the breadth of environmental impacts addressed through cleaner production practices, they are exhaustive in coverage and directly target discharge of materials into the environment. However, with regard to resource consumption, the current cleaner production practices are limited to minimization of the volume of resource input into society and do less address conservation of the quality of natural resources. Re-use and recycling, broadly viewed as fundamental attributes of resource conservation, are only limited to in-plants waste materials in cleaner production strategies.

Cleaner production practices have mainly been implemented at the discretion of industry executives, while its governance remains dominated by governments and concerned industries. Concerns, perspectives, insights and priorities of other stakeholders are hardly addressed and integrated in the cleaner production process if these deviate from those of industries and states. A fundamental criticism of current cleaner production practices is that these practices take the existing industrial activity as a starting point for

environmental improvement (fore-casting approach), while achieving sustainability might call for new concepts and visions on how to fulfill basic human needs (back-casting approach) (Vergragt and Van Grootveld, 1994). In addition, cleaner production generally starts with cost effective environmental improvements, and leaves less cost-effective, but perhaps more ecologically sound environmental improvements, often unaddressed. Other scholars faults the lack of a system view of design and manufacturing processes in cleaner production approaches and beg for its elevation beyond the identification and implementation of the "ready to implement" options, which Van Berkel (1994) refers to as "low hanging fruit".

Although based on a preventive mind-set, cleaner production options are still too often added in the final phases of industrial development rather than being built in the design right from the beginning. It is often concluded that cleaner production practices are important environmental improvements, but not radical environmental innovations; while such radical innovations are deemed needed to transform the architecture of the industrial processes in order to achieve sustainability (Van Berkel *et al*., 1997). On the other hand, cleaner production practices have succeeded in inculcating a new thinking of changing technologies with right attitudes, responsible environmental management, in line with national policy environments, and through evaluating technology options (UNEP, 2002). The sum has been economic benefits to the industry, as well as a significant contribution to environmental management through effective pollution prevention (http://www.ea.gov.au/industry/eecp/case-studies/index.html).

In the perspective of this study, re-use and recycling of plastic waste materials as a cleaner production practice is useful and a fertile ground through which waste recovery activities can take place. Nonetheless, decisions for cleaner production practices remain at the discretion of plastic industry executives and governments, while other stakeholders are hardly present in the decision making process. Even though the application of cleaner production has gone beyond single industries by collaboration and clustering of industries together in waste treatment and reuse, the concept is not very attentive to co-operation beyond industries. Supply chain management moves beyond industries in designing environmental improvements.

3.5 Green supply chain management

Supply chain management, with its roots in the 1960s, is a concept of logistics management – a planning tool that seeks to develop a system-wide, integrated view of the firm and its supply chain (Lazzarini *et al*., 2001). In the words of Handfield and Nichols Jr. (1999: 2), supply chain is conceived as "a series of linked suppliers and customers". It encompasses all activities associated with the flow and transportation of goods from the raw materials stage through the end-user, including the concomitant information and financial flows. According to Simchi-Levi *et al*. (2000), it is the coordination and

alignment of material, financial and information flows for all activities and processes involved in a supply chain. Christopher (1998) defines supply chain management as the integrated planning, implementation, coordination and control of all business processes and activities necessary to produce and deliver, as efficient as possible, products that satisfy market requirements. Traditionally viewed as a process wherein raw materials are converted into final products and then delivered to end-consumers (Beaman, 1999), it involves extraction and exploitation of the natural resources (Srivastava, 2007). Earlier models that were used for the study of supply chain management focused on the optimization of production and operations as a key source of value involving quantitative cost-based and technical efficiency measures and qualitative indicators of customer responsiveness and satisfaction (Beamon, 1998; Srivastava, 2007).

However, with the emergence of sustainable development in all sectors of the economy at the onset of the1990s, supply chain management gained a new dimension and goal (Wu and Dunn, 1995). Adding 'green' to the concept of supply chain management made it part and instrument of a new paradigm (Srivastava, 2007). The concept of green supply chain management, commonly referred to as GrSCM, has been argued for from different angles by key scholars. The works of Carter and Ellram, (1998), Srivastava and Srivastava (2006), Shih (2001), Nagorney and Toyasaki (2005), and Min *et al*. (2006), among others, discuss reverse logistics, whereas for instance Arena *et al*. (2003) and Beamon (1999) discusses life-cycle analysis. These contributions cover the broad themes of green design, green operations, reverse logistics, waste management and green manufacturing (Guide and Srivastava, 1998; Srivastava, 2007). Over the years these themes have gained in popularity in the academic domain and amongst practitioners with the aim of reducing waste and preserving the quality of product-life and natural resources. This has been helped by governments who raised the bar for regulatory requirements and compliance and for purchasing, and consumers who launched unprecedented demand for green products.

In achieving GrSCM, industries have adopted different approaches: reactive, proactive and value-seeking (Kopicki *et al*., 1993; van Hoek, 1999). In the reactive approach, industries only commit minimal resources to supply chain wide environmental management. They start by labeling products that are recyclable and use 'end of pipe' initiatives to lower the environmental impact of production. In a proactive approach, companies start to pre-empt new environmental laws by realizing commitment to initiate recycling of products and designing green products. In the value-seeking approach, industries integrate environmental activities, such as green purchasing of inputs, environmental auditing and certification requirements of suppliers, and ISO 14001, to enable them to extend the environmental responsibility to their suppliers along the supply chain (Arimura *et al*., 2009). By gradually inculcating these three approaches into the manufacturing, the perspective changes from greening as a burden to greening as a potential source of competitive advantage and value addition (van Hoek, 1999). Scholars

like Owen, (1993) and Sarkis (1995) label that environmentally conscious manufacturing, and Gungor and Gupta (1999) underscores the advantages that may accrue as a result of interactions among stakeholders on integrated GrSCM. They further highlight how global market demands and government pressures are pushing businesses and their supply chains to become more sustainable. Walton *et al*. (1998) claim that executive discussions and strategic planning for GrSCM in companies is a manifestation of increasing government regulations coupled with a strong public mandate for environmental accountability.

Green manufacturing, reverse logistics and waste management are three key concepts in GrSCM that have relevance for our study, and which I will shortly introduce. Green manufacturing is an important industrial operation since it targets the use of energy and use of virgin raw materials (Srivastava, 2007). In green manufacturing, industries apply techniques for minimum resource consumption as well as recycling to reduce the use of virgin raw materials (Lee *et al*., 1995). For the plastic production system, green manufacturing has been based on production of products based either purely on post-consumer plastic waste or on a mixture of virgin raw materials and post-consumer plastic waste. These products are not only more environmentally friendly and in some instances cheaper, but have also facilitated the take back of used products at the end of life (Mutha and Pokharel, 2009). Because of economic motives and regulatory pressure, industries have over time recycled material content of used and non-functioning products in the manufacture of new products.

According to Ashayeri *et al*. (1996), Isaacs and Gupta (1997), Tan *et al*. (2002) and Krikke *et al*. (1998), automobiles, electronic and paper recycling are the most common examples of product recovery and the focus has been largely on mathematical modeling for maximum performance. Van der Laan *et al*. (1999) develop a push-and-pull model for the manufacturing of photocopiers using both new and recovered parts. Reuse of used products with value addition is not a new concept within the manufacturing industry. Industries have substituted certain parts and materials by recycled and environment friendly alternatives (Isaacs and Gupta, 1997). Expensive products such as turbines used in airplanes and electricity generation systems have been remanufactured for quite some time. In these cases, recovery of used products/parts is economically more attractive than disposal (Koh *et al*., 2002). According to Carter and Ellram, (1998), manufacturing industries have implemented both formal and informal networks to take back their products to sustain remanufacturing. Mutha and Pokharel (2009) emphasize that networks for return of products should be handled efficiently so that less cost is incurred in the manufacturing of new products.

Reverse logistics, which mainly involves redesigning the industry's logistics network to accommodate product return, has been studied by several researchers, especially focusing on cost effectiveness. Such studies have generally concluded that for recycling of returned products, logistics costs account for a large share of the total costs

(Jahre, 1995). The physical location of facilities and transportation links are chosen in order to convey used products from their former users to a producer and to future markets again (Fleischmann *et al*., 2000). Srivastava and Srivastava (2005) provide a hierarchical decision-making framework to find the feasibility of profit-driven reverse logistics networks. Kroon and Vrijens (1995) have considered the design of a logistics system for used plastic containers in which they determine the number of containers required to run a surveillance system, the appropriate service and distribution and collection fee per shipment for empty containers, and the location of depots for empty containers. Reverse logistics, although compelled by economic certitudes, connect manufacturing industries with their used products in ensuring green production. Savaskan *et al*. (2004) and De Koster *et al.* (2002) indicate that optimal results are achieved when the retailer collects the returned waste products, instead of the manufacturer or a designated third party.

Third, waste management as a green practice has been studied from a number of fronts. Caruso *et al*. (1993) model a solid waste management system including collection, transportation, incineration, composting, recycling and disposal through a multi-objective location-allocation model. Haastrup *et al*. (1998) provide a decision support system for urban waste management to evaluate general policies for collection and to identify suitable locations for disposal, treatment facilities and transportation. The source reduction and pollution prevention strategies focus on 'preventing' pollution at the source (in products as well as manufacturing processes). Hardly do they cover 'removal' of waste after it has been generated (Gupta and Sharma, 1995). Dunn and El-Halwagi (1993) have developed a methodology for the optimal design of recycling/re-use networks to minimize the emission of hydrogen sulphide from pulp and paper plants. This scholarly contribution lays down a practical approach to enhancing return and utilization of waste materials by production industries.

GrSCM has been able to demonstrate that in the realization of green products, industries have applied different logistics to ensure the return of their product waste. This can be interpreted as reaching out of the production socio-technical system to the SWM socio-technical system. Through reverse logistics post-consumer plastic waste can return to the industry. Reverse logistics is a potential avenue through which industries can collaborate with innovation actors at the solid waste management socio-technical system, thus providing a link with production industry. However, environmental intervention along the supply chain remains incremental, as economic benefits and national legislations still determine the extent to which industries are able to engage in reverse logistics (Guide *et al*., 2003). The process nature in GrSCM overlooks the role of actors in initiating improvements. It further lacks the explanation as to how such actors may collaborate along the chain to ensure integration of their specialized and individual/group contributions in supply chain management. Roy and Whelan (1992), emphasize the need for collaboration in successful implementation of any green product strategy, not just because of the multi-sector (or value chain) participation required in green product, but

also because of the benefits that accrue from a well-constructed collaborative framework. Furthermore, innovation is fostered in a collaborative environment through cross-fertilization of skills, and complementary knowledge of technology and markets (*ibid*).

But GrSCM fails to explain how radical changes can be introduced and who should champion such changes. Furthermore, GrSCM is limited to formal economic actors in the supply chain and hardly includes the informal sector which is a crucial element in this study. Thus GrSCM does not fully fulfill the need for an inclusive framework capable of explaining change and relationships between (formal and informal) actors within and across the two systems (of solid waste management and plastic production) exhibited. The next section reviews transition literature as a theory that is focused on explaining change in complex systems involving multiple actors at different levels.

3.6 Transition theory

Transition theory has emerged as a school of thought bridging science, society and technology in an attempt to understand socio-technological change as well as to contribute to resolving some of the major challenges facing society today. Evidence from diverse societal systems, including agriculture, energy transport, and others, indicate that business as usual will threaten the environment and render society incapable of meeting the needs of future generations. A group of transition scholars advanced the argument that better insight in processes of transitions could provide knowledge to transform complex and persistent structural problems which hinder sustainable development (Hofman *et al*., 2004; Geels, 2002; Elzen *et al*., 2004; Rotmans *et al*., 2001). Their argument is that sustainability will remain elusive if society continues to look for solutions within the existing development paths and trajectories. They called for transitions through system innovation, which will affect the whole basic structure of the society (Geels *et al*., 2004). Rotmans *et al*. (2001) introduced the transition concept in the field of sustainable development, governance and policy. Their basic hypothesis is that through the understanding of processes of structural societal change, it must be possible to formulate governance principles, methods and tools to deal with complex societal problems. In the realization of this proposition, different research approaches have been applied in investigating and understanding transition processes. Important to note is that all the approaches are applied at the system level. Transition processes are studied from a variety of system perspectives: socio-technical systems (Schot and Rip, 1997; Kemp *et al*., 1998; Geels, 2002; Berkhout *et al*., 2004), innovation systems (Smits and Kuhl-mann, 2004) and complex adaptive systems (Rotmans *et al*., 2001; Loorbach, 2004). However, among these different perspectives a number of commonalities exist: (a) the systems studied are open and embedded in an outside environment with which it co-evolves, (b)

this changing outside environment influences the system, and (c) the system itself exhibits non-linear behavior in order to adapt to its environment.

Loorbach (2007) defines transitions as transformation processes in which existing structures, institutions, culture and practices are broken down and new ones are established. According to Gunderson and Holling (2002), transitions are described in terms of 'degradation' and 'breakdown', followed by 'build up' and 'innovation'. Schumpeter in his contribution to innovations ultimately leading to transition, referred to it as 'creative destruction' (Schumpeter, 1934). The common denominator arising from these scholars' definition of transition is that the whole system must be shaken up and as the new system evolves, a sense of 'newness' (innovation) becomes the key driving force in establishing a new system. Even as the new order establishes itself, the process is gradual and takes a long time (Rotmans *et al*., 2001). Loorbach, (2007) talks of the gradual fading away of structures including values, institutions, regulations, markets and others as new ones emerge. In the analysis of transitions, two analytical aspects– in combination – are crucial: the multi-phase and multi-level character of transitions. This couple is essential in analyzing and understanding the underlying dynamics of transitions at different time periods (*ibid*).

From historical analyses of some societal system transitions, four phases are identified. The first is the predevelopment phase, where there is hardly any visible change but there is a lot of experimentation, followed by the take-off phase, where the process of change starts to be seen. The third phase is the acceleration phase, where structural change takes place in visible ways. This phase shows learning processes, diffusion and embedding processes, which is finally followed by a phase of stabilization with a decrease in speed of change and the establishment of a dynamic equilibrium (Geels, 2002; Loorbach *et al.*, 2003; Rotmans *et al.*, 2001; Van der Brugge, 2005; Loorbach, 2007). Because of the complex nature and organization of systems, transitions normally take long and result in multi-level changes as a result of a dynamic interplay between developments in social, economic, technical, institutional and cultural domains (Rotmans *et al*., 2001). Rip and Kemp (1998) and Geels (2002) identify three aggregate levels from where transformations involving socio-technical systems can be analyzed, framed as what is commonly referred to as a multi-level perspective on transition. Since this study is concerned with how changes in socio-technical systems are developing, the next sub-section reviews the literature on multi-level perspectives, in order to identify the analytical tools necessary for such an analysis.

3.6.1 Multi-level perspective on transition

The multi-level perspective is a branch of transition theory that adopts different analytical levels in explaining forces of change in the production, consumption and governance systems. This multi-level perspective distinguishes three levels of heuristic and analytical

concepts: niche innovations, socio-technical regimes, and socio-technical landscape (Rip and Kemp, 1998; Geels, 2002).

Text box 3-1 Definitions in transition theory

Niches: '…protected spaces for the development and use of promising technologies by means of experimentation, with the aim of 1) learning about the desirability of the new technology, and 2) enhancing the further development and the rate of application of the new technology' (Kemp *et al.*, 1998:186). They are further seen as important stepping stones for changes in socio-technical regimes.
Regimes: '…the rule set…embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures' (Rip & Kemp, 1998:340). Analysts suggest regimes can be characterized along seven dimensions: technology; user practices and application domains; symbolic meanings of technology; infrastructures; industry structure; policy; and knowledge (Geels, 2002; Schot, 1998).
Landscapes: '…background variables such as the material infrastructure, political culture and coalitions, social values, worldviews and paradigms, the macro economy, demography and the natural environment which channel transition processes and change themselves slowly in an autonomous way' (Geels, 2004b).

The multi-level perspective (MLP) is considered especially suitable for the analysis of long term developments arising from different levels of the system. Its application has largely been in transition processes in which the dominant socio-technical system or regime is gradually replaced by a different regime. It has been the basis of a number of approaches that analyze innovation and transformation processes (Rip and Kemp, 1998; Geels, 2005a). MLP emphasizes that system changes come about as a result of the interplay between processes at different levels in different phases. It highlights that radical innovations emerge in niches, which are often outside or at the fringe of the existing regime. At the niche level, there are no stable rules to support the innovations and therefore actors still engage in further work to find out the right configuration that can either compete or replace the dominant regime. As actors continue to improve the design and other aspects of such innovations, small niche markets emerge, which can support the innovation or even aid it to breakthrough to the dominant regime. Innovations may also remain stuck in these niches for a long time or fail to take-off altogether, when they face a mismatch with the existing regime and landscape. The last phase of an innovation journey is when there is a breakthrough within the existing dominant regime. The new innovation is able to embed itself in the society and create market linkages necessary to be able to compete with the existing regime (Geels and Schot, 2007). Lastly, there is the stabilization of rules and new types of structures that can support the new innovation (Geels, 2007a).

The multi-level perspective emphasizes that both internal niche dynamics and external regime and landscape developments are important in ensuring a breakthrough and diffusion of innovations. The multi-level perspective therefore explains causes in transitions, which are related to the three levels and also highlight the importance of synergistic dynamics at different levels which should come together and reinforce each

other in order for system change to occur. The multi-level perspective builds on insights from complex systems theory, general history and long-wave theory that major changes come about because processes at multiple levels link up and influence each other (Geels, 2005b). Crucial to the multi-level perspective is the alignments of trajectories and processes that take place within the subsequent levels. The multi-level perspective emphasizes how these alignments of trajectories within levels and between levels lead to transitions.

The bedrock of activities is at the regime level, which has further been broadened and refined for analytical purposes to consist of three interlinked elements: (a) a network of actors and social groups, (b) formal, cognitive and normative rules that guide the activities of actors, and (c) material and technical elements as artefacts and infrastructure (Geels, 2006). These elements are believed to account for the stability of existing socio-technical systems; and as such this perspective has a similarity with large technical system approaches. The social groups interact and form networks with mutual dependencies, resulting in what Geels (2007a) calls alignment of activities. The dominance of certain technologies or practices is further strengthened by rules that guide the operation of actors, thus further confirming system stability (Geels, 2004a; Geels, 2002; Kemp, 1994). Because of people's life styles, favorable institutional arrangements, formal regulations and accompanying infrastructures, systems are further stabilized. The alignments between different elements lead to a technological inertia making it difficult for fundamental changes to occur within systems (Hughes, 1994).

So far, the multi-level perspective has provided an analytical framework to analyze and explain (the absence of) radical changes. The next sub-section provides the tools necessary for analyzing change, and actors who champion such changes.

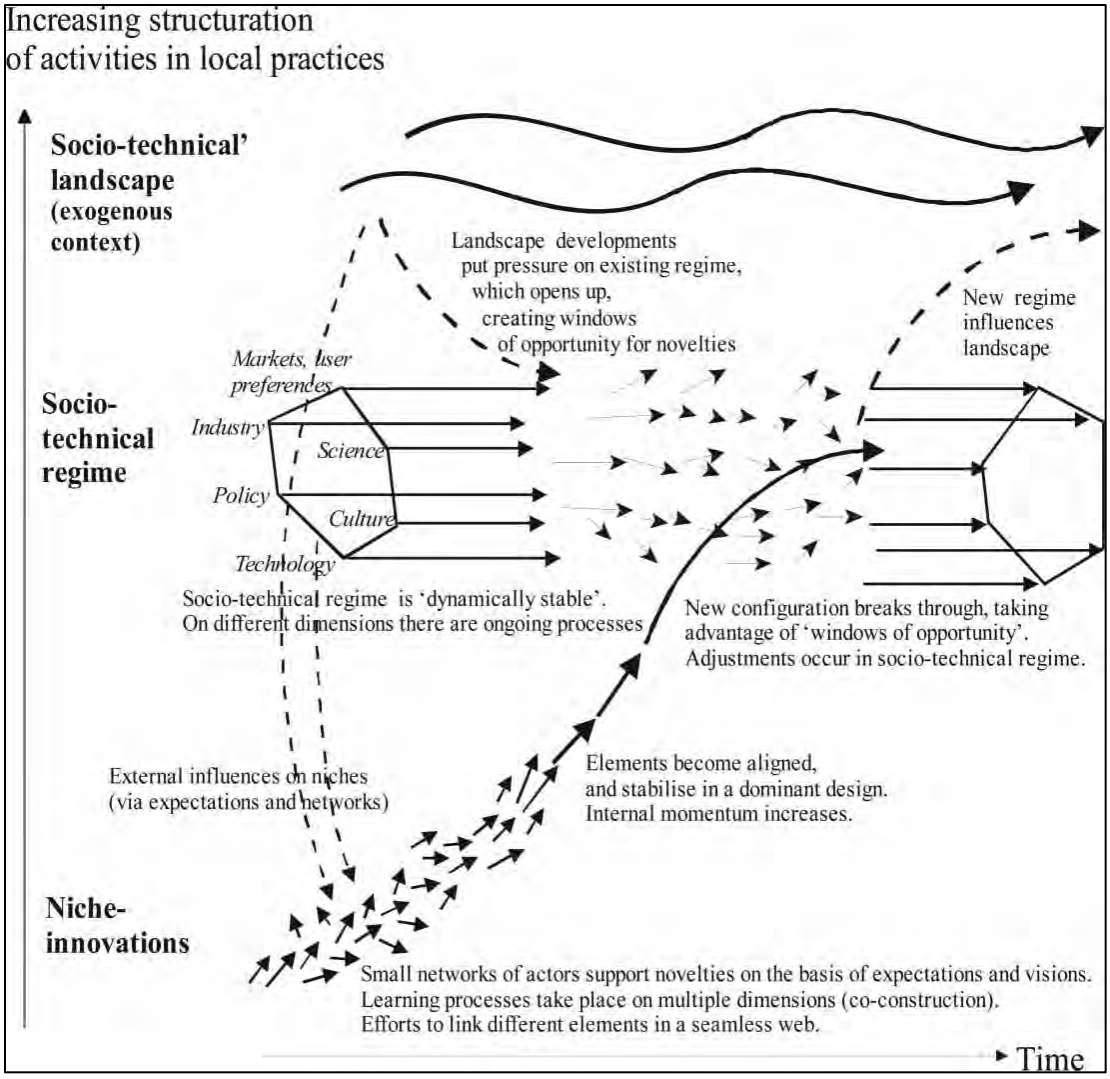


Figure 3-1 Multi-level perspective on transitions (Geels, 2002:1263)

3.6.2 Strategic niche management

Strategic niche management is one of the approaches that have been used within the multi-level transition framework to study the development of innovations in niches. As part of processes to initiate change through niche processes, setting up experiments and projects is an important step in transitions (Hegger *et al*., 2007). Scholars on transition management make quite assertive claims about the potential utility of Strategic Niche Management: it "… is not just a useful addition to a spectrum of policy instruments (…) it may be the only feasible way to transform environmentally unsustainable regimes" (Kemp *et al*., 1998:191). Niche experiments are seen within the wider context of organizing a multi-actor network, developing sustainability visions and converging expectations on them, learning processes, and evaluation and monitoring of processes of change. Such niche experiments can be carried out by different types and networks of

actors including governments, firms, non-governmental organizations (NGOs), special interest groups or even an independent individual (Kemp *et al*., 1998).

Strategic niche management departs from traditional ways of policy making in that it focuses on 'technology-push'. Strategic niche management brings together knowledge and expertise of users and other actors into socio-technical innovation processes to generate new technologies, interactive learning processes and institutional adaptation. Strategic niche management incorporates ideas about technological regimes and trajectories, highlights the value of widening participation in innovation and emphasizes the importance of niches in transforming regimes. Based on insights from innovation studies, Science and Technology Studies, evolutionary economics and history of technology, three processes for successfully constructing and taking-off of a niche innovation are distinguished (Kemp *et al.*, 1998; Van der Laak *et al*., 2007): 1) building of social networks, 2) voicing and shaping expectations and 3) learning. The three processes will be elaborated below.

Building of social networks in innovation

The building of broad social networks is important to create a constituency behind the new innovation, to facilitate interactions between relevant stakeholders and to provide necessary resources (money, people, and expertise). According to Coenen *et al*. (2010), social networks sustain developments, carry expectations, articulate new requirements and demand, as well as enable learning and diffusion of lessons and experiences between actors and over space. Such networks are also considered functional when they are facilitated by regular meetings between actors (Van Eijck and Romijn, 2008). According to Schot and Geels (2008), social networks are likely to contribute more to niche developments if they include multiple stakeholders who facilitate the articulation of multiple views and voices. Involvement of outsiders is likely to broaden cognitive frames and facilitate what is often referred to as second order learning.

The variety of stakeholder organizations that bring in resources as well as mobilize commitment of their organizations and members to the innovation process, determines the depth of participation. However, criticism of SNM argues that involvement of outsiders and second order learning does not happen easily and automatically. A number of lessons and insights have been formulated with respect to this. Brown *et al*. (2004) and Harborne *et al*. (2007), point to the role of a sense of urgency and the role that a process of structured repeated visioning could play. Hegger *et al*. (2007) argue that outsider participation is more feasible when the focus for experimentation is not only or primarily technology based, especially for demonstration projects. Hegger *et al*. (2007); Brown *et al*. (2004); Harborne *et al*. (2007), show that networks in experimentation can only be broadened and more learning encouraged when visioning precedes such experimentations. Coenen *et al*. (2010) assert that geographical proximity is most likely to stimulate social network building and thus successful niche

experimentation, because short geographical distance favors social interactions, trust-building and the development of joint expectations. At the same time, they posit that if local networking is too strong, it may lead to an introverted experiment, resulting in difficulties in up-scaling and diffusion (*ibid*).

Voicing and shaping actor expectations in innovation

SNM posits that actors participate in innovation projects because of their shared expectations and visions on the future. Expectations have to converge, and be based on or have the prospect of tangible results for all actors. According to Van Lente (1993), Brown and Michael (2003), and Borup *et al*. (2006), articulation and convergence of expectations are regarded as an important resource in niche-based experimentation. It helps to reduce uncertainties which may slow down the process of innovation. When niche actors are able to articulate their joint expectations arising from their participation in the innovation process, it means that they have pictured the future and what promises it holds for each of the actors. When such expectations are shared by a number of actors in the innovation process, it means that actors are able to relate their expectations with real and tangible outcomes (Coenen *et al.*, 2010). Also, for a niche innovation to attract attention and legitimacy, Geels and Raven (2006) hold that shared expectations are important to attract attention and resources from other actors. Furthermore such shared expectations provide direction to the learning process and technical development activities, which may further enhance niche experiments.

Historical research into earlier transitions and the role of niche experiments found that failure of some of the early niche experiments could be related to a lack of clarity in expectations, leading to divergent views held by actors (Geels and Raven, 2006). These insights are used in this research first to grasp the motivation of the actors participating in the innovation activities and second to get a sense of degree and direction of convergence of actors' expectations arising from their participation in plastic waste innovation activities.

Actor learning in innovations

Strategic niche management holds learning as crucial in innovation processes. However, the earlier learning developments in environmental innovation processes of the 1970s and 1980s were generally narrow and only focused on technical and economic dimensions, while often neglecting other equally important dimensions. Such learning was marred with failures, which only disappointed and did not lead to any breakthrough (Kemp and Rotmans, 2004). According to Schot and Geels (2008), learning processes would contribute to niche development if they are not only directed at facts and data but also enable changes in cognitive frames and assumptions, commonly referred to as second order learning (Grin and Van de Graaf, 1996). Benett and Howlett (1992) make a

distinction between the subject of learning, the object of learning and the result of learning. This therefore brings to the fore the diversity of actors who need to learn and the variety in aspects that need to be learned at different levels. Schot and Geels (2008) provide an expanded framework within which learning should take place. They outline seven dimensions of learning in innovation processes. Learning can take place with respect to (a) technical aspects and design specifications, (b) market and user preferences, (c) infrastructure and maintenance networks, (d) industry and production networks, (e) regulations and government policies, (f) social and environmental effects, and (g) cultural and symbolic meaning. In tandem with these dimensions is the ability to replicate experimentation in other geographical locations which has the ability to facilitate the diffusion rate of an innovation. Scholars like Caniëls and Romijn (2008) hold the view that development and implementation of innovations is largely a social process and that the subject of learning must not reduce it to techno-economic connotations if success is to be achieved. Van der Laak *et al*. (2007) shed insights into the outcome of learning processes as they may result in modification of instruments or facilitate the establishment of a new paradigm. Learning would therefore enhance the capacity of actors to develop a broad and flexible vision of sustainability (Van der Laak *et al*., 2007). Also important in the learning process is how to overcome system barriers that may hinder the development of an innovation leading to a new trajectory.

Having underscored the usefulness of a multi-level transition framework for the analysis of system change, as well strategic niche management analysis as an integral part of understanding system change, these types of analyses only explain changes specific to one particular system. However, innovation activities in this study cross system boundaries and involve transitions/changes in at least two systems. Innovations around plastic waste are related to the solid waste management socio-technical system as well as to the plastic production socio-technical system. Niche innovations, actor networks, learning processes and expectations and visions from one system need to be related to the counterparts of the second system in order to have a holistic understanding of the transformations useful in solving plastic waste problems. In order to understand interactions and dynamics across system boundaries, dynamics at the level of multiple regimes need to be analyzed. The next section reviews the literature related to multi-regime dynamics and linkages.

3.6.3 Multi-regime dynamics and interactions

Konrad *et al.* (2008) posit that multi-regime dynamics are relevant to consider if radical innovations create linkages to different regimes. Raven (2006) and Raven and Verbong (2007) show how radical innovations have created symbiotic relationships between formerly separated or only scarcely related regimes in their study of waste and electricity regimes and in the case of heat and power technologies. These scholars show how

landscape developments, including the collapse of global oil prices and international environmental problems such as climate change, have triggered changes in both the waste management and electricity regimes. According to Geels (2007b), multi-regime interactions can be an important process in transitions. So far, MLP has only addressed single regime dynamics, both theoretically and in historical case studies. In Geels analysis of the breakthrough of rock 'n' roll (1930-1970) he applied the multi-regime dynamics concept in the music industry to show how interactions of two different regimes changed relationships from competition to symbiotic development. Raven and Verbong (2009) have studied boundary crossing innovations in different energy sub-domains in the Netherlands. Four types of multi-regime interactions are often distinguished: 1) competitive interactions between multiple regimes, where such regimes start to fulfill similar functions; 2) symbiotic interactions, where two regimes reap mutual benefits from their cooperation; 3) integrative interactions, which occur when previously separated regimes move to each other to become one; 4) spill-over interactions, which refer to the transfer of rules from one regime to the other. Sawhney and Wang (2006) studied the dynamics of competing regimes in the gas-electricity and the telegraph-telephone battles. Sahal (1985) studied symbiotic interactions emerging in the control systems for farm tractors and electronic computers.

Raven and Verbong, (2009) proclaim that innovations with the potential to cross system boundaries, are also shaped by external pressure which creates a window of opportunity in the second system thus raising interest of actors in such a system. Boundary crossing potential besides processes as experimentation and niche creation is also shaped by external pressure which creates a window of opportunity in the second regime or system thus raising interest of actors in the second regime. Smith (2007) argues that there is need for a 'theory of linking' to explain interactions between niches and regimes. Smith makes a number of claims: that niche-regime interactions are two-way (that regimes influence niches and niches influence regimes); and that during linkage elements from a niche are affected by processes of transformation. The absorption of niche ideas and practices involves some form of further transformation for them to become embedded and functional. According to Berhout *et al*. (2010), the niche-regime dynamics draws attention to interactions and feedbacks as being fundamental to innovation and growth dynamics. Drawing from the concept of interaction, it is possible to discern the likelihood of integration of solid waste management socio-technical system and the plastic production socio-technical system through the innovation activities and further evaluate innovation activities on their prospects for integration of the two systems.

3.7 Concepts and model for analyzing environmental innovations for plastic waste management

Based on the literature review above, and strongly building upon transition theory and the concepts of multi-level frameworks and strategic niche management, this section presents the concepts used in the study of environmental innovations for plastic waste in urban Kenya and the conceptual framework for the study. First, the concepts for the study of environmental innovations are defined. Second, the conceptual model is explained.

The concepts used in the analysis of environmental innovations for the prevention and management of plastic waste in Kenya are (1) concepts related to niche and niche management; (2) regime specific concepts; (3) the landscape concept; and (4) the concept of system interactions. Before operationalizing the concepts and further demonstrating how they are used in this study, I will define the key concept of environmental innovation that lies at the heart of this study.

3.7.1 Environmental innovations

Rennings (2000) defines environmental innovations to consist of new or modified processes, practices, techniques, systems and products to prevent or reduce environmental damage. Such innovations are beneficial for the natural environment and/or contribute to environmental sustainability. In the context of this definition, the positive environmental impact of innovations is the key concern. Another definition of environmental innovation, which comes very close to the former one, is: "The production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" (MEI Report, 2008).[19]

This study defines environmental innovations in plastic waste management and prevention to include any kind of management process or practice conducted by individuals or actor groups that adds value to, or utilizes plastic waste and with that closes the material cycle or prevents plastic waste from entering the environment. As it will be further explained in a methodological intermezzo following this chapter, this study focusses on a selection of activities falling under this definition, namely to (1) plastic waste recovery/buying and the associated value addition conducted by individuals or groups at the SWM socio-technical system, (2) recovery and/or recycling of plastic waste and/or export of semi-processed plastic waste to external markets by private actors and, (3) manufacture and sale of biodegradable packaging bags by private actors

[19] In Foundations of Advanced Mathematics (MEI) Report (2008) this definition is given for an "eco-innovation" which is synonymous with environmental innovation.

3.7.2 Niche concepts

Concepts of social *network composition, shaping and convergence of actors' expectation and learning processes* are used for the analysis of innovation activities. These concepts are commonly referred to as internal niche processes, and are used in order to assess the performance of experimental innovation activities and their potential in causing system change in the management of plastic waste. Some innovation activities may not develop towards a take-off if adequate social networks do not exist, actor expectations are diverse and fail to converge amongst network actors, and if no relevant learning processes are undertaken by network actors.

Social network composition: Social network composition is used in assessing who is participating in the innovation activities, how wide or narrow the network is, what resources do different actors bring on board, how actors participation facilitate the innovation network.

Shaping and convergence of actors' expectations: This concept is used to assess what shapes or informs actors' expectations and to what extent such expectations converge amongst network actors. Expectations remain high and positive when innovation actors relate them to tangible outcomes and are able to forecast the future.

Actor learning processes: This concept is used to assess both first and second order learning undertaken by network actors around environmental innovations. Learning can be related to diverse aspects around environmental innovations, including user preferences, supply networks, regulations and government policies. Possibilities of replicating innovation activities in other geographical areas, increases the speed of innovation diffusion thus popularizing its usefulness.

3.7.3 Regime concepts

In reference to the refined regime concepts by Geels (2006) and for analytical purposes, this study broadly groups the socio-technical regime for either solid waste management or plastic production under three concepts: *actors and organizations*, *rules and socio-technical material.* Development and diffusion of innovation activities either within the SWM system or plastic production system is fundamentally influenced by the particular regime. It can present barriers or facilitate the functioning of innovations. Furthermore the regime concept is used in assessing the supportiveness or mismatches they present especially to innovations with boundary crossing potential between the SWM system and the plastic production system. It is also useful in the evaluation of the innovation activities with the potential to provide better plastic waste management in Kenya.

Actors and organizations: According to Geels (2004b), socio-technical regimes function through established organizations and the involvement of actors. Regime actors can initiate innovation activities to improve the system. On the other hand, regime actors can or fail to co-operate, collaborate and acknowledge innovation activities initiated from outside such regimes. The concept of actors and organizations is used in two ways: (1), to locate any innovation activity arising from either the solid waste management socio-technical system or the plastic production socio-technical system and (2), to also assess the extent of collaboration innovation actors enjoy from incumbent regime actors as well as the supportiveness of their organizations towards innovation activities.

Rules: Schott (1995) distinguishes three dimensions of rules as: regulatory, normative and cognitive. In this description, regulative refers to explicit, formal rules, which constrain behavior and regulate interactions for example, government regulations which structure different processes. Sociologists including Durkheim (1949) and Parsons (1937) talk of normative rules which confer values, norms, role expectations, duties and responsibilities. Cognitive rules constitute frames and reality through which meaning is made. In this thesis, one may find a departure from the scholarly tradition as the rule concept is used to reflect on national government and city government formal *laws, regulations, policies and procedures*. *T*he rule concept is used to assess how the laid down government and city *laws, regulations, policies and procedures* of either SWM system or plastic production system affect the functioning of innovation activities.

Socio-technical material: The socio-technical material which forms the context of system actors' actions in this thesis includes physical infrastructures, technologies and raw materials. This concept is used to assess how the system material facilitated or stood on the way to successful performance of innovative activities either within the SWM socio-technical system or the plastic production socio-technical system.

3.7.4 Landscape concept

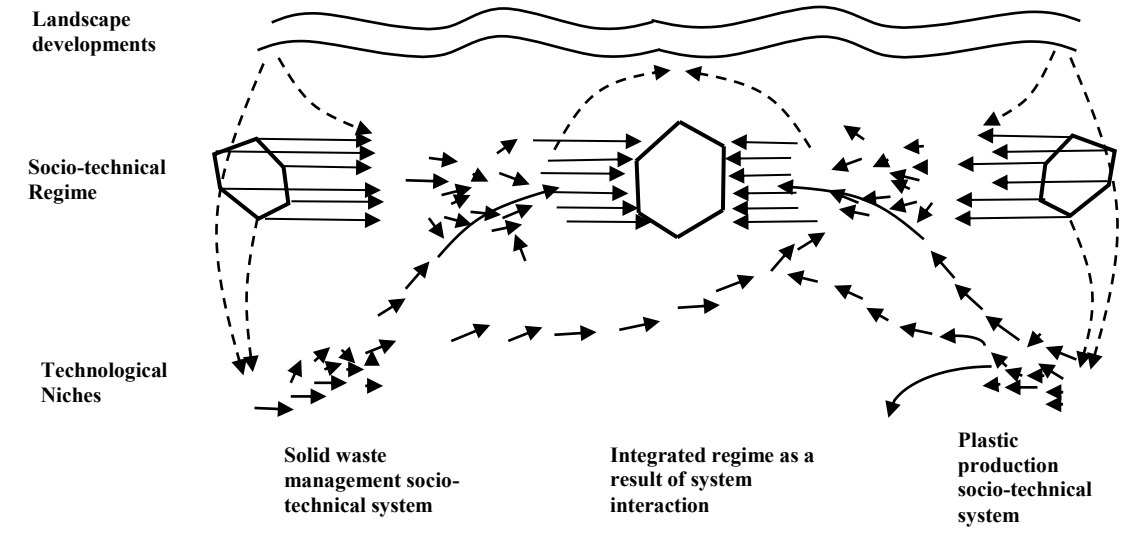
This concept is used to assess external factors, including broader socio-cultural, economic and environmental variables which either create windows of opportunities for innovation to take off towards system change or stand in the way of such further implementation and maturation of niche innovations.

3.7.5 The concept of system interactions

The concept of system interactions has emerged in the innovation literature, positing that major transformations can only occur when innovations cross system boundaries and fundamentally change the relationship between two systems. In this thesis, the concept is

used in the assessment of which (group of) innovative activities related to plastic waste management are better suited in fostering collaboration between SWM socio-technical system and the plastic production socio-technical system.

3.7.6 Conceptual model



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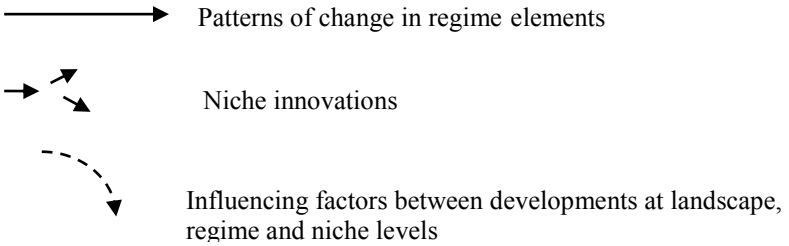

Figure 3-2 Conceptualizing interaction of solid waste management and plastic production systems through niche innovations

Figure 3-2 provides an integrative conceptual model for the study of environmental innovations within the solid waste management socio-technical system and the plastic production socio-technical system. Environmental innovations can originate from either of the two systems at the niche level.

From the SWM socio-technical system (left side of Figure 3-2), the environmental innovations originating from the niche level should find a supportive socio-technical

regime that would facilitate their adoption within the plastic production socio-technical regime. Such facilitation is aided by pressure from the landscape level. Some innovations could also fail to take off due to lack of niche formation, unfavorable regime and landscape conditions.

From the plastic production socio-technical system (right side of Figure 3-2), the environmental innovations originating from the niche level should also find a supportive socio-technical regime that would facilitate their adoption as sustainable strategy for management of the environment. The adoption of such strategies must be compelled by landscape factors upon which, regime actors would have to respond appropriately. Some innovations could also fail to take off due to lack of niche formation, unfavorable regime and landscape conditions.

At the centre of Figure 3-2, is the integrated regime for plastic waste management. This is the point at which the two socio-technical systems (SWM and plastic production) integrate. An integrated regime with alignment of innovation activities from both sides is expected to be needed for the sustainable management of plastic waste. Such an integrated regime may require a re-ordering of activities and operations of solid waste management and plastic production socio-technical systems.

METHODOLOGICAL INTERMEZZO

1 Introduction

The main research question of this thesis is to analyze how and to what extent the current and potential environmental innovations contribute to the overall management and prevention of plastic waste in Kenyan urban centers. More specifically, the study aims to define the contours of an integrative framework between SWM and plastic production systems that facilitate these innovations. The applied methodology is described in this intermezzo. First, the spatial scope of the research is delineated, introducing the selected cities and a brief introduction of environmental innovations for management and prevention of plastic waste. Second, the research methodology is described. Since the study intends to gain insights how innovation can contribute to better management of plastic waste in Kenya, the overall nature of the study was mainly a qualitative, exploratory case study. Third, the rationale of the applied case study approach is outlined, and methods of sampling and data collection described, also highlighting the limitations encountered during data collection and how they were dealt with. Finally, methods of data analysis are presented.

2 Spatial scope of the study

The study focused on the four major urban areas of Kenya, namely Nairobi**,** Mombasa, Kisumu and Nakuru (see Figure 3-3). These four urban areas were chosen because they are the largest municipalities in Kenya with great economic importance to the country. Besides, these cities have over the years been most affected by plastic waste problems and have also started a variety of new activities to cope with plastic waste problems. Analysis of the lessons learnt from existing practices in the management of plastic waste in these four cities is instrumental for designing practices for the 170 local authorities nationally.

The four urban areas are also the administrative and industrial centers of economic activities of national significance. Only Nairobi has an official city status, while the other three are designated as municipalities according to Local Government Act (Republic of Kenya, 1998). For the purpose of this study, the four urban areas will all be referred to as cities. Below detailed characteristics are reported of the cities underscoring their national significance.

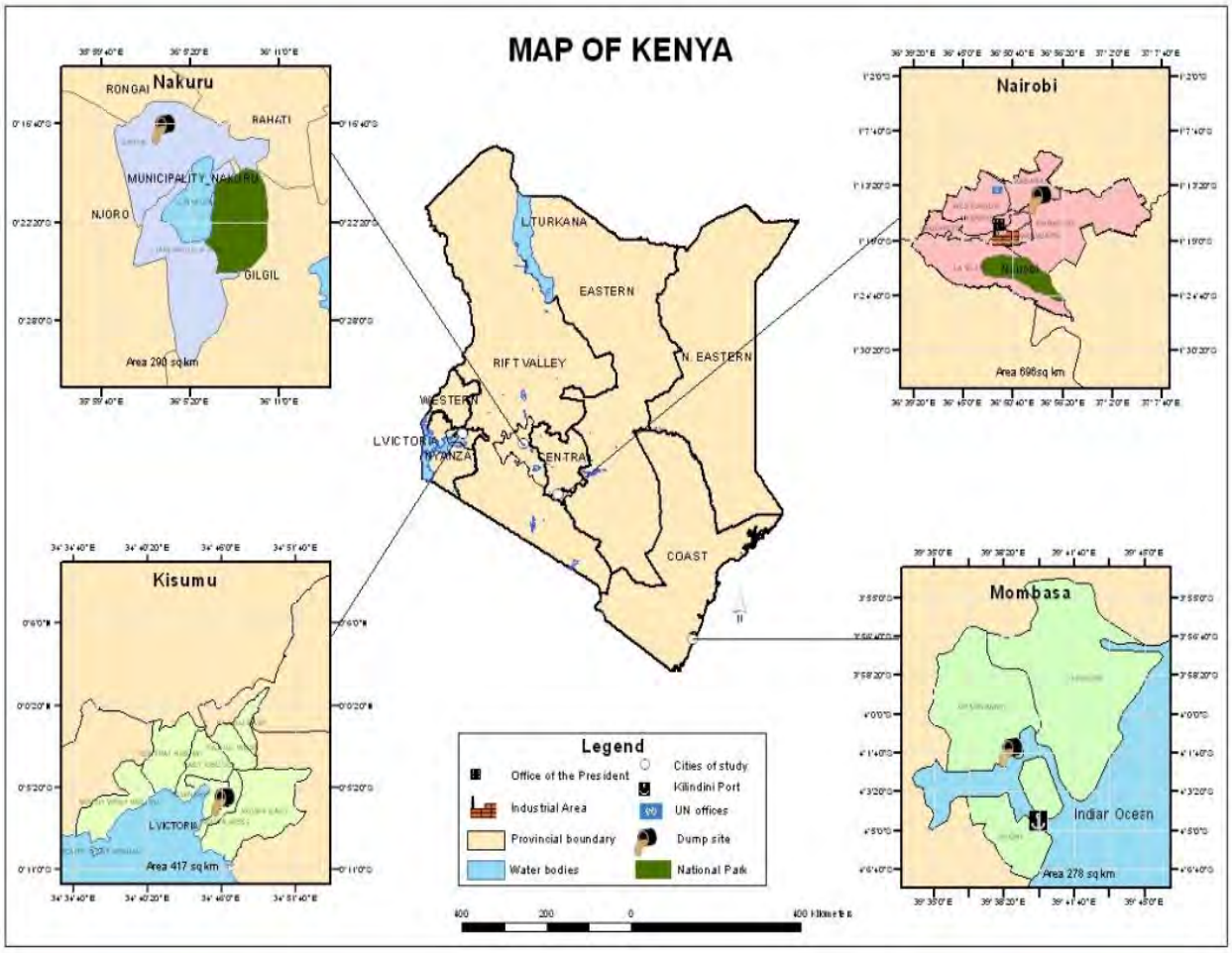

Figure 3-3 Map of Kenya with cities of study

Nairobi

Nairobi is the capital of the Republic of Kenya and the largest administrative, commercial and industrial center of the country. It produces over 60% of the country's GDP (City Council of Nairobi, 2006). Nairobi is also the center of education and culture, besides also being the world headquarters of two United Nations agencies, the United Nations Centre for Human Settlements (UN-Habitat) and United Nations Environmental Program (UNEP). In addition it houses regional offices of other United Nations agencies including United Nations Industrial Development Organization (UNIDO), United Nations Development Programme (UNDP), United Nations Scientific and Cultural Organization (UNESCO). This strategic international location reinforces Nairobi's importance as a diplomatic, commercial and cultural center in Africa (City Council of Nairobi, 2005). Nairobi city covers an area of 695.1 Km^2. A recent national population census estimated the population of Nairobi to be 3.14 million, with a density of 4,515 (Republic of Kenya,

2010a). The city generates about 1,850 tons per day of solid waste. Half of this generation is left uncollected or illegally dumped within the city's environment, where its impact goes beyond the visual pollution and affects human health (JICA, 2010).

Mombasa

Mombasa is the second largest city in Kenya. Located next to the Indian Ocean, Mombasa is a major trade center and home to Kenya's only large seaport - the Kilindini Habour. With this major port, the city serves as the center of the coastal tourism industry (Rakodi, *et al*. 2000). According to the 2009 census its population is 938,131 inhabitants (Republic of Kenya, 2010a). Mombasa covers an area of 218.8Km^2 and just like any other urban center in Kenya it has poor drainage and solid waste management services. Out of the 600-700 tonnes of solid waste generated per day, only 30% is collected and disposed at an official disposal site.[20]

Kisumu

Kisumu is the third largest city in Kenya, on the shores of Lake Victoria, the world's second largest fresh water lake. The municipal boundary covers an area of 297km^2 of land mass and 120 km^2 of Lake Victoria. It has the country's largest fishing industry (KISWMP, 2008). With some of the nation's highest population densities, Kisumu has 409,928 inhabitants (Republic of Kenya, 2010a). According to UNCHS (2004a), 60% of Kisumu city's population resides in low income areas with unprecedented perennial problems of increased urban sprawl, resulting in inadequate solid waste management services. Solid waste generation averages 400 tonnes per day with 20% being collected and delivered to the city's disposal site (Opande, 2005; UNCHS, 2004b). Also akin to the city is that it experiences one of the highest urban poverty rates in the country, standing at 48% against a national average of 29% (UNCHS, 2004b).

Nakuru

Nakuru is the fourth largest city in Kenya with an estimated 307,990 inhabitants in 2009 (Republic of Kenya, 2010a). It is located along the east-west transport route across the country, linking the Kenyan coast with the Lake Victoria region, and has a municipal area of 1495.3 Km^2. Nakuru occupies a pre-eminent position as the administrative capital of the expansive Rift Valley region, as well as the industrial, commercial and service center for the surrounding agricultural hinterland. Major economic sectors of the urban economy include commerce, industry, tourism, agriculture and tertiary services. Nakuru hosts Lake Nakuru with the flamingo birds, which supports the tourism industry (Mwangi, 2001).

[20] Information obtained from Mr. Mohammed, the Director of Environment at Mombasa Municipality on 9th April, 2010.

Once dubbed "the cleanest town in East Africa", Nakuru standards of urban services and infrastructure have fallen recently, hence compromising the quality of the living environment. Out of 350 tons of solid waste generated per day, only about 20% is collected (Mwangi, 2001).

Innovations in plastic waste management, recycling and prevention

The solid waste management sector in Kenya has over the recent years been geared towards reduction of plastic waste or prevention of plastic waste entering the environment. Activities linked with these efforts fall either under the solid waste management system, or the plastic production system, or cut across the two systems.

Activities under the solid waste management system include:

1. Domestic product/waste separation and re-use;
2. Deposit and return systems of retailers for plastic products (e.g., plastic containers);
3. Waste picking, collection and selling;
4. Waste recoveries through buying, separating and sorting, cleaning and selling;
5. Semi-processing and selling locally.

Activities under plastic production system include:

5. Semi-processing of waste and selling locally;
6. Semi-processing waste and exporting;
7. Recycling of internally generated plastic waste in processing industries;
8. Recycling of post-consumer plastic waste in processing industries;
9. Redesigning plastic products towards less waste (e.g. durable plastic bags; thin plastic bags).

Activities that cut across the two systems include:

10. Manufacturing and retailing of biodegradable plastic packaging bags;
11. Manufacturing and retailing of alternative packaging systems (paper, wood, re-usable materials);
12. Buying and using biodegradable plastic products or equivalent products made from alternative materials.

Guided by this study's definition of environmental innovations, the activities above are grouped into three distinct innovation categories:

- Activities 1, 2, 3, 4 and 5 listed under SWM system are innovations for management of plastic waste.
- Activities 5, 6, 7, 8 and 9 are grouped as innovations for recycling of plastic waste.

- Activities 10, 11 and 12 are grouped as innovations for the prevention of plastic waste.

The innovation activities are performed by different actors. Those under management involve:

1. Households who separate and re-use plastic waste;
2. Waste pickers who pick and sell plastic waste to actors within the solid waste management system or to actors in the plastic production system;
3. Individual collectors who collect and sell plastic waste;
4. Organizations such as supermarkets who take back, sort, and/or sell to other actors in the solid waste management system and to those in the plastic production system;
5. Community Based Organizations (CBOs), CBO-SACCOs and yard shop operators who recover, buy, sort, separate, clean, bulk and/or sell to actors in the plastic production system;
6. CBO-SACCOs who occasionally semi-process and sell to actors at the plastic production system.

Actors involved in innovation activities under plastic recycling involve:

1. Individuals and firms who buy plastic waste and semi-process to produce intermediary products, such as flakes and granules and sell to actors within the plastic production system;
2. Industrial firms who buy plastic waste and semi-process to produce intermediary products for export;
3. Industrial firms who use internally generated plastic waste and/or post-consumer plastic waste to make final plastic products (conventional recycling industries);
4. Industrial firms who use comingled post-consumer plastic waste to produce final plastic products (home-grown recycling industries);
5. Industrial firms who redesign plastic products so that they reduce the amount of plastic waste in the final stage.

Actors involved in innovation activities under the category of prevention involve:

1. Industrial firms who manufacture biodegradable plastic bags;
2. Retailers such as supermarkets who sell biodegradable plastic bags;
3. Industrial firms who manufacture alternatives for plastic products;
4. Retailers who sell/distribute alternatives for plastic products;
5. Household/consumers who buy biodegradable plastic products or products made of alternative materials.

3 Case study approach and case selection

A case study approach is most appropriate to investigate innovations in plastic waste management, recycling and prevention. A case study approach aims to understand the 'whole' by investigating a case under consideration within its wider context, and is particularly helpful when 'how' questions are being posed. Goode and Hatt (1952) describe case studies as a way of investigating social phenomena to preserve the unitary character of the social object being studied. Yin (1993) argues that a major rationale for using case studies is when an investigation must cover both a particular phenomenon and the context within which the phenomenon is occurring, either because (a) the context is hypothesized to contain important explanatory information about the phenomenon or (b) the boundaries between phenomenon and context are not clearly evident (Yin, 1993:31).

Further, Yin (1994, 2009) explains that case studies can be exploratory, descriptive and explanatory in nature. In this study exploratory case study approach was used, guided by the main research question which aims to understand and assess the functioning of innovative activities. De Vaus (2001) provides a different categorization of case studies, by dividing them into single and multiple. In this study multiple case study designs are used, since a number of different innovative activities were identified that serve specific purposes within the overall scope of the study. Moreover, most cases in this study are layered where each case study consist of several sub-case studies to ensure that the variability within each main case is covered. According to Yin (1994), case study research can include quantitative and qualitative research methods, often relies on multiple sources of evidence and benefits from prior development of theoretical propositions. In this study, the theories of strategic niche management and transition guided the empirical research on innovations in plastic waste management, recycling and prevention and were used to decide on what kind of information should be collected and what kind of generalizations could be made based on the cases.

Given the geographical scope of this study and the interest in innovation activities that can contribute to an integrative management and prevention of plastic waste from both solid waste management system and plastic production system perspectives, the sum of cases selected within this study has to provide a fair representation of innovations in both systems and over the three categories (as outlined above). In addition, special attention has been paid in case study selection to the potential for direct linkage of actors between the solid waste management system and the plastic production system.

Innovative activities by households, waste pickers/collectors and other organizations sorting and selling plastic waste were not selected as cases. Their contribution to innovative management of plastic waste is directly linked to other actors in the solid waste management systems who innovate in the management of solid waste. Furthermore and in particular to waste pickers, the fluid nature of their activities makes it a difficult category for in-depth study even though Katusiimeh (2012) argues differently

that informal actors including pickers have personal relationships with households which make them have territories of operations.

3.1 Case study for plastic waste management innovation

Innovations in the collection/buying, sorting, cleaning and selling of plastic waste by CBOs, CBO-SACCOs and Yard shop operators were selected as one main case study under this category. The activities of these three actor groups, apart from occasional semi-processing of CBO-SACCOs, are to a major extent quite similar but are considered as different sub-cases of environmental innovations, to enable us to determine the variability within this main case study. The times of emergence, the motivation and drive of the actors into such activities, the degree of integration with the plastic production system actors, and the scale of operation are quite different among the three categories.

3.2 Case study for plastic waste recycling innovation

Innovative recycling activities of home-grown recycling industries, conventional recycling industries and industries semi-processing for export were selected as case studies. These innovation activities all fall under the plastic production system and represent the diverse recycling trajectories of post-consumer plastic waste in Kenya. Less emphasis will be given to recycling of production waste as that is mostly common practice within plastic processing industries, and hardly a real innovative recycling activity.

3.3 Case study for prevention of plastic waste

The manufacturing and sale of biodegradable plastic bags cuts across the solid waste management and the plastic production systems and was selected as a case study representing prevention innovations. As its development cuts across the two systems, where production is subjected to conditions within the plastic production system and consumption is stronger linked to the solid waste management system, it links the two systems. Moreover, this prevention case study is still strongly related to quite a number of actors within the plastic waste and plastic production system, giving this prevention innovation preference above innovations that look at alternative materials.

Together, these cases present the diverse nature of plastic waste innovations and of the actors involved. Each of the three case categories will be analyzed using a strategic niche management approach towards the different innovations. In those situations where the innovative category involves multiple cases (in the first and the second innovation category) a comparative analysis of different sub-cases can harvest contrasts in

innovation activities which would have remained salient in a single case study. Figure 3-4 provides a schematic presentation of actors behind the different selected innovation cases.

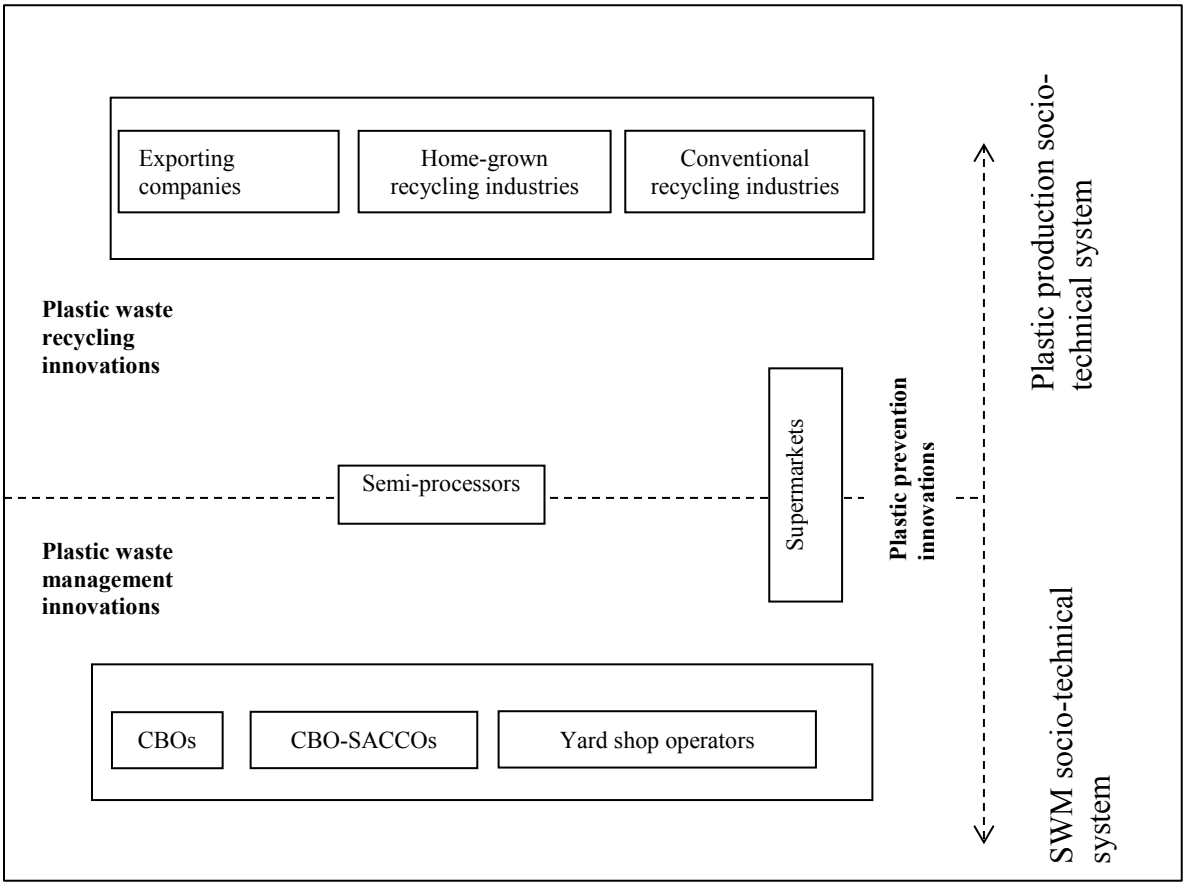

Figure 3-4 Schematic presentations of actors involved in three selected innovation cases

4 Sampling and data collection methods

Sampling and data collection was guided by the key categories of innovations, the main actors involved and the theoretical concepts of transition theory and strategic niche management theory (see Chapter 3 section 3.6). Data collection methods included review of documents; retrieval of service records, survey data and organizational records; in-depth interviews with the main actors involved in these innovations and other key informants; surveys; and direct observations.

4.1 Sampling plastic waste management innovations

Data collection for these innovations involved sampling of CBOs, CBO-SACCOs, and yard shop operators. Because no systematic and up-to date data exists about the innovative activities and these actors who perform them in the respective cities, different strategies were applied to sample; however, snowballing was mainly used.

Stratified sampling was applied for CBOs in Nairobi, according to solid waste collection divisions (Kasarani, Dagoretti, Kamkunji, Starehe, Lang'ata, Westlands, Embakasi and Makadara). In each division, a simple random procedure was conducted based on a list of the CBOs obtained from the department of environment, City Council of Nairobi. A total of 16 CBOs were included in this case study. CBOs from Mombasa and Kisumu were sampled through a 'snowballing' method. Information from directors of departments of environment enabled identification of initial CBOs. These CBOs in turn led to the identification of other CBOs. Ultimately, one CBO in Kisumu and three in Mombasa were included in the case study. No CBOs could be identified that were involved in plastic waste activities in Nakuru at the time of this study.

CBO-SACCOs were only present in Nairobi and Kisumu and were also sampled using snowballing method. Information obtained from the CBOs included in the study, led to the identification of CBO-SACCOs. Only one CBO-SACCO was found and included in the study in Nairobi, while two were found and included in Kisumu.

Due to the largely informal nature of the yard shop operators (where there is no formal organization representing them and no formal registration of the operators), a snowballing method was used in all the four cities. In Nairobi, information from a home-grown recycling industry led to the identification of the first yard shop operators interviewed, who, in turn, identified subsequent operators. City officials in the other three cities identified initial yard shop operators who, in turn, provided information that led to identification of subsequent operators. A total of 58 yard shop operators were included in our case study on yard shop operators (see Table 3-1).

4.2 Sampling plastic waste recycling innovations

Sampling for these innovations involved conventional and home-grown recycling industries and industries exporting semi-processed plastic waste. Based on lists obtained from the Ministry of Industrialization and the KNCPC, a harmonized list of 219 plastic manufacturing industries in Kenya was made. These industries were grouped according to raw material used in production, resulting in 146 industries producing with virgin polymer resins only, 59 producing with a mixture of virgin polymer resins and post-consumer plastic waste, and 14 producers producing from post-consumer plastic waste (PCPW) only. A semi-structured questionnaire was mailed to executives and operation managers of industries producing with a mixture of virgin polymers and post-consumer

plastic waste and those producing from post-consumer plastic waste only, totaling 73 industries. The 73 industries were all based in Nairobi. The questionnaire instrument was designed to capture responses pertinent to the study, e.g., source of raw material, out-put of production, networks of distribution and others (see Appendix 4). After several reminders only 16 companies filled out the questionnaire, of which one was a home-grown recycling industry and the rest were conventional recycling industries. Additional information regarding one home-grown recycling industry and one industry exporting recycled plastic waste granulates was obtained from yard shop operators who supplied these industries with waste material. In the end, after considering the information on these 18 companies, seven (7) conventional recycling industries, two (2) home-grown recycling industries and one (1) exporting industry were selected to be included in the study.

4.3 Sampling plastic waste prevention innovation

Because of the diversity in roles of different actors involved in the development and take-off of the preventive innovation (the biodegradable plastic bag), different sampling strategies were used. There was only one manufacturer (PIL) and one retailer of biodegradable plastic bags (Nakumatt holding) and hence sampling on the case study was not needed. A user perspective is crucial in discerning the extent of acceptance of biodegradable plastic bags and this was assessed through in-depth interviews (see Appendix 5) with 25 shopping consumers, sampled from the most frequented Nakumatt holding outlets of Lifestyle, Mega, Ukay, Junction and City Centre.

Data obtained from the three innovation categories were useful in discerning the three internal niche processes according to strategic niche management theory of: actor network involved in innovation activities, actors' expectations and actor learning processes. Additionally, other data like amounts of waste handled and trends in sales were instrumental in assessing the operational characteristics of actors. However, the extent to which an innovation contributes to better management of plastic waste or for its prevention depends on the support they derive from the systems under whose context they are embedded together with opportunities presented by the wider environmental context. In this respect, additional data were obtained from key informants from various organizations as well as from secondary sources.

4.4 Primary and secondary data collection methods

The sampled actors' categories in the three case studies were all involved in the interviewing scheme, through which primary data was collected. In addition, a range of other actors were interviewed, such as waste pickers, semi-processors, solid waste collectors, governmental organizations (e.g. NEMA, KIRDI, and KEBS), city authorities, industrial organizations (such as KAM), societal organizations, NGOs and consumers (see

Table 3-2). Because the study was interested in ascertaining how and to what extent actors were involved in and conducted innovation activities, their motivations, and the type of relationship they exhibited, a comprehensive semi-structured questionnaire was used to interview actors. Appendix 6 details the variables investigated.

To include a household perspective on innovations, a stratified random sample of households were surveyed from four cities of study (Table 3-3). The sample was based on the recent report on population densities and residential areas stratifications (Republic of Kenya, 2010a). A simple random sampling procedure was then conducted in each stratum. A survey questionnaire (see Appendix 7) was directly administered to household heads.

Organizational data and policy documents were used to assess the support of different organizations towards the development and implementation of innovations. Direct observations of innovation activities were used to provide additional information relating to actual conditions of actors' operations. Further, observations helped in understanding the diversity in innovation products. The interviews, together with secondary data, direct observations and household survey were used to triangulate information obtained from innovation cases. Triangulation is used for ascertaining validity of findings as advocated by Glaser and Straus (1967).

Table 3-1 Actors sampled and interviewed for innovation cases across study cities

Actors	*Nairobi*	*Mombasa*	*Kisumu*	*Nakuru*	*Total*
Yard shop operators	37	3	10	8	58
CBO	16	3	1	-	20
CBO-SACCO	1	-	2	-	3
Conventional plastic recycling industry	7	-	-	-	7
Home-grown recycling industry	2	-	-	-	2
Export industry	1	-	-	-	1
Semi-processors	7	-	-	-	7
Manufacturer of biodegradable plastic bags	1	-	-	-	1
Retailer of biodegradable plastic bag (Nakumatt holding)	1	-	-	-	1
Consumers	25	-	-	-	25
Total	**98**	**6**	**13**	**8**	**125**

Source: Field work 2008-2011

Table 3-2 Other actors interviewed

Actors	*Numbers interviewed*
Pickers	7
Supermarkets officials	4
Private waste collection companies officials	5
Government organizations officials	4
City authorities officials	6
Lobby organizations officials	3
NGO officials	1
Total	**30**

Table 3-3 Households sampled for a survey across studied cities

Actors	*Nairobi*	*Mombasa*	*Kisumu*	*Nakuru*	*Total*
Household	408	283	262	253	**1206**

Source: Field work 2008-2011

Nairobi accounted for the majority of the innovations sampled and actors interviewed in this study. Several factors account for the skewed distribution of the samples. First, it is the city with the highest concentration of plastic industries in the country (KAM, 2006), and therefore provides the nearest market proximity to the innovations for plastic waste management. In his survey study on recycling of plastic waste in Kenya, Mugambi (2001) found out that Nairobi is dominant with plastic waste recycling. Second, by virtue of being the capital city of Kenya, Nairobi has the longest history of solid waste material recovery activities, relative to the cities of Mombasa, Kisumu and Nakuru. The spirit for adventure for market value makes Nairobi an attractive center for much bigger volume of plastic waste activities. Third, some studies have shown a long tradition of picking of different waste streams in Nairobi (Odegi-Awuondo, 1994: 61-62) and it is possible that plastic waste recovery activities existed in Nairobi earlier than the other cities. Fourth, for close to two decades, the plastic waste situation in Nairobi has attracted considerable public attention, with the media highlighting its terrible state of affairs. Fifth, Nairobi has some of the success stories about innovations in urban environmental infrastructure including for solid waste management (Munywe, 2007). This makes sampling in Nairobi interesting, to understand the peculiarities inherent in these successful innovative activities. Nakuru and Mombasa generally presented poor cases of innovations where, actors hardly kept records and they could hardly recall of their activities.

This study had to rely mainly on primary data collection, partly because of the lack of systematic data from various governmental institutions, city authorities and other lead organizations. Despite the long history of plastic waste management activities within

the solid waste management system, many waste handling activities remain informal, making it difficult to obtain credible secondary and statistical data. Further, activities within the plastic production system are surrounded by high level of secrecy where data sharing is problematic. In addition, also within the plastic production system data were poorly kept. There were evident conflicts among data from different sources. Hence, this study adopted a variety of strategies for data collection and primary data collection was of key importance in that. Relying largely on primary data enhanced reliability of the findings.

5. Data analysis

Quantitative and qualitative methods have been used to analyze data. Since there were no major inter-city variations in innovations, responses were grouped along innovation categories and different actors/actor groups. A code book was developed based on responses to questions that were quantitative in nature such as waste types, quantities of waste handled, selling prices and years in operation. The data was coded into a computer using Statistical Package for Social Science software. Based on frame of analysis that captures key concerns, coded data were summarized into tables and charts and where possible subjected to trend analysis.

Qualitative data, mainly obtained from interviews and document analysis, were coded and categorized into meaningful themes and categories to allow for meaningful analysis. This analysis was done along innovation categories and innovation mechanisms and in line with key concepts of the study, such as convergence of actor's expectation, resources advanced to actors and challenges faced by actors in innovations. Comparison of sub-case studies and among actors involved in innovative activities gave additional value to understanding innovation processes. Quotes, individual remarks and case illustrations built from interviews were used to further lend valuable support to data, trends, and argumentation and illustrated actual situations. Public policy data and information was subjected to content analysis. Both quantitative and qualitative data complemented each other contributing to internal validity of this study.

4 INFORMAL ACTORS AND THEIR POST-CONSUMER PLASTIC WASTE HANDLING ACTIVITIES

4.1 Introduction

Since the 1990s, the Kenyan city authorities have experienced unprecedented decline in capacity to provide adequate and efficient solid waste management (SWM) services within their areas of jurisdiction. A range of factors, namely weak financial, human and technological resources and bureaucratic tendencies, have been fronted for this failure (Karanja, 2005; Rotich *et al*., 2006). However, as the demand for better service provision and the impacts of solid waste continued, especially within informal settlements, Community Based Organizations (CBOs) have increasingly become involved in solid waste collection and disposal, thus filling the void (Practical Action, 2005; Karanja, 2005; Rotich *et al*., 2006; Kibwage, 2002). Besides their waste collection and disposal activities, CBOs – together with their Savings and Credit Co-operative Societies (CBO-SACCOs) – are also venturing into (plastic) waste recovery activities, thus making value out of waste.

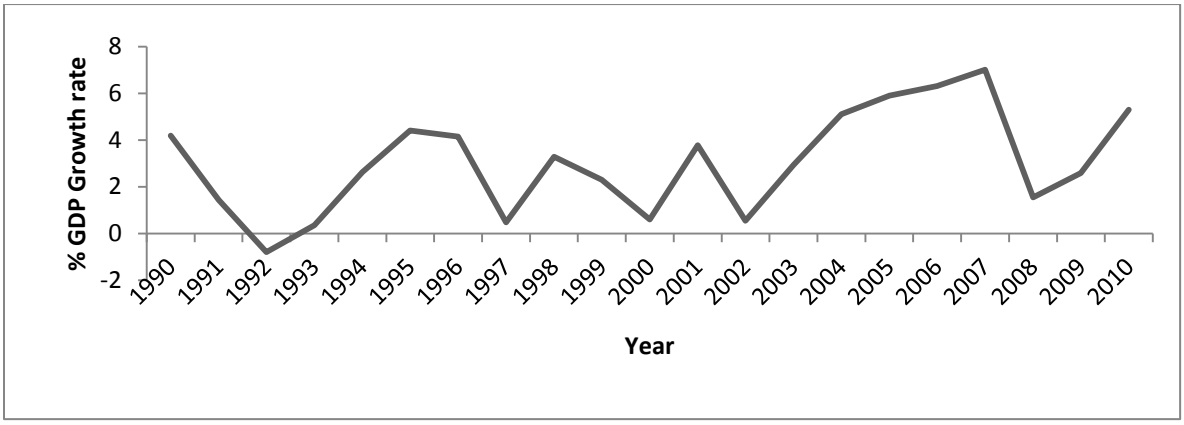

Figure 4-1 Kenya's GDP growth rate since 1990-2010 (constructed by author using World Bank data sets[21]).

On another front, Kenya's economy has been erratic and performing poorly since 1990, except for 2007 when it recorded a growth of 7% (see Figure 4-1). In uncertain economic situations, opportunities for employment have become difficult. Consequently, increasingly (young) people have resorted into informal business activities of recovering different waste streams, including plastics, and selling these to earn a living.

According to Wilson (2007), retrieval and selling of waste with material value is not a recent phenomenon. Such practices can be observed in cities in Asia, Latin America and Africa. But even as this development steadily picks up, scholars have failed to

21 http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

understand the crucial roles played by several actors whose informal plastic waste management activities are creating a bridge between solid waste management and private production processes of the plastic industry. While many scholars have repeatedly called for policy interventions regarding the involvement of waste pickers in SWM activities (Wilson *et al*., 2009; Nzeadibe 2009; Scheinberg *et al*., 2006; Nas and Jaffe 2004; Rouse 2004; Nguyen *et al*., 2003; Furedy 1997), very little is known or written about CBOs, CBO-SACCOs and yard shop operators in this respect.

In Kenya, CBOs, CBO-SACCOs and yard shop operators are becoming leading agents in post-consumer plastic waste recovery and value addition activities. This is borne out of the serious environmental challenges posed by plastic waste, as well as the economic opportunities such waste presents. Activities of these actors on plastic waste provide interplay between the solid waste management socio-technical system and the plastic production socio-technical system, thereby increasing the value of plastic waste. This has over the years been neglected by city authorities, resulting in unsanitary conditions of urban environments (Ikiara *et al.,* 2004a; Karanja 2005).

The activities of CBOs, CBO-SACCOs and yard shop operators related to SWM present a departure from the traditional practices of waste collection and disposal undertaken by the official SWM actors (Karanja 2005; Ikiara *et al.,* 2004a). These activities range from collection, separation, sorting, cleaning to bulking and in some cases semi-processing and selling. I call these organized actions as *value addition activities,* since they transform the waste material into a more valuable state, with a higher price in the plastic recycling chain. I also refer to them as environmental innovation activities, because they reduce environmental risks posed by plastic waste pollution and reduce other negative impacts of using virgin polymers in production of plastics. From an environmental perspective, innovations entail activities and actions that lead to improvement in ecological quality. In economic terms, innovations ensure economic benefits to those involved (Huber, 2003). The value addition activities of CBOs, CBO-SACCOs and yard shop operators improve ecological quality through the reduction of plastic waste in the environment and the reduction of virgin polymer production. When such wastes are ultimately recycled, they raise economic income to those working along the recycling chain.

The value addition activities undertaken by CBOs and their sister CBO-SACCOs address a common societal problem whose solution provides both social-economic and ecological benefits. Activities of yard shop operators are typical for the informal waste recycling industry and have been in existence since the plastic industry practiced internal reprocessing (Mugambi, 2001). They are run by individual small scale traders in waste, hereafter referred to as *yard shop operators,* a metaphor derived from the observation that their premises are located on strips of land enclosed by major roads of the cities. These activities fall within the informal recycling industry, although scholars often have not distinguished them. For example, the recent work of Wilson *et al*. (2009) only recognizes

four different categories of informal waste recycling, i.e. itinerant waste buyers (IWBs); street waste pickers; municipal waste collection crews and waste pickers from dumps. This contribution hence falls short of presenting the role played by yard shop operators within the recycling chain.

Until now, there is hardly any information on the exact nature neither of operations nor on the conditions under which these actors conduct their value addition activities within the SWM socio-technical system. This chapter analyses the plastic waste activities of CBOs, CBO-SACCOs and yard shop operators within the multi-level framework as introduced in Chapter 3. Specifically, the chapter explores the plastic waste processing activities of the different actors as niche innovations for the management of plastic waste. The chapter begins by introducing and describing the actors in 4.2. Section 4.3 presents the development of the actors' activities. Section 4.4 analyses the operational arrangements of the actors, using strategic niche management as a tool for analyzing social network building, shaping and convergence of actors' expectations, and learning processes. Sections 4.5 and 4.6 assess the regime and landscape variables, respectively, as they create a window of opportunity or constraint operations of CBOs, CBO-SACCOs and yard shop operators. Figure 4-2 highlights actors discussed in this chapter within the total scheme of plastic waste management and plastic recycling.

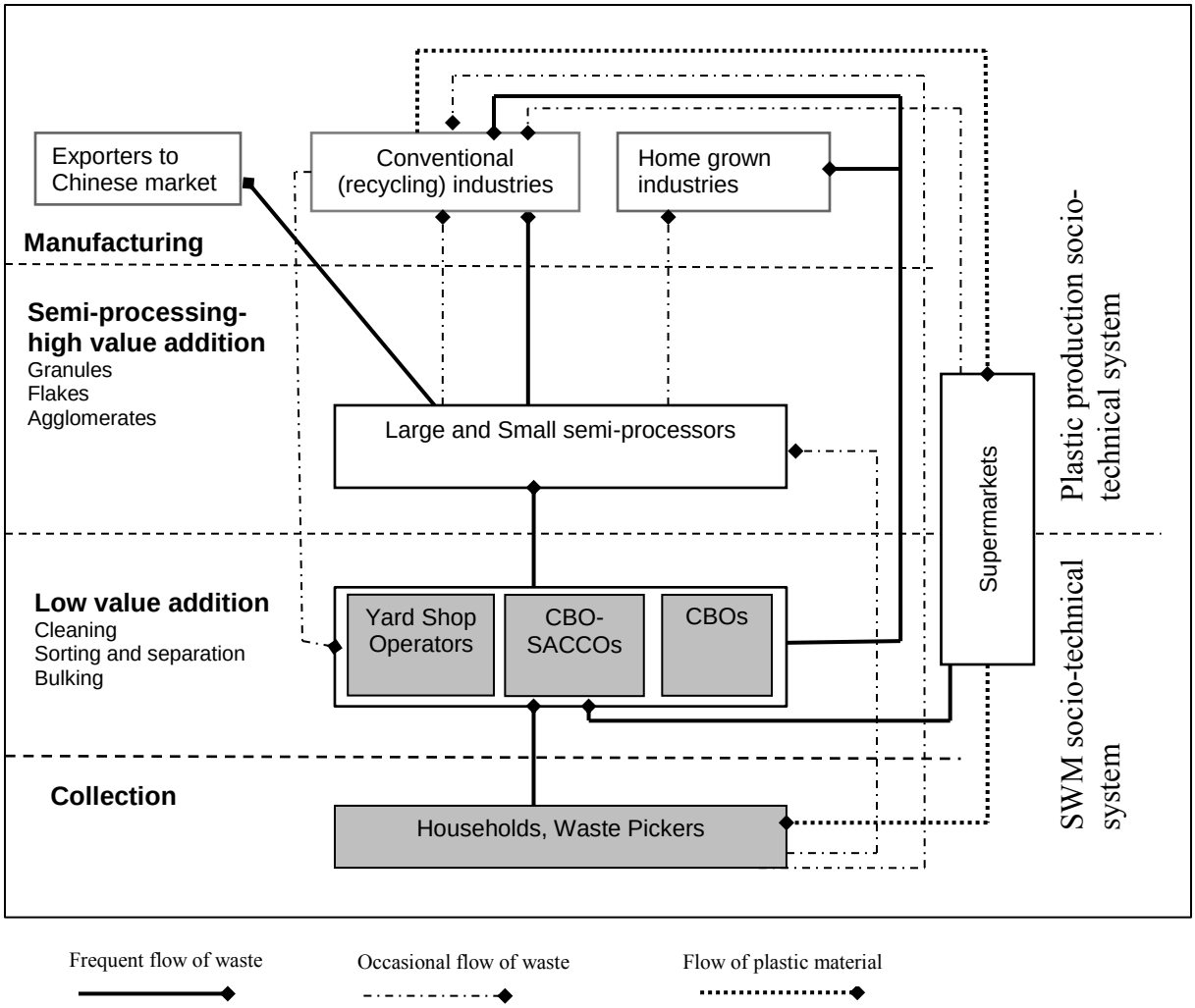

Figure 4-2 Actors embedded in plastic production, retail, consumption, and recycling activities- highlighting actors around plastic waste management innovations (constructed by author)

4.2 Distribution and characteristics of CBOs, CBO-SACCOs and yard shop operators

This section introduces the four main categories of plastic waste collectors and primary processors: waste pickers, CBOs, CBO-SACCOs and yard shop owners. Table 4-1 shows the distribution of actors within these four categories, who were interviewed in this study. Most of these interviewed actors were from Nairobi (68.2%), followed by Kisumu, (14.8%) albeit distantly. The corresponding percentages for Nakuru and Mombasa were 10.3% and 6.8% respectively. In addition to the primary waste processors who add value to the waste, 7 waste pickers were interviewed, mostly those retrieving waste from the dump site and street peripheries. Interviews with pickers were undertaken because they

play a crucial role in the recycling chain as they are the main suppliers of waste materials to the yard shop operators. Most respondents were male (87.3%) and aged between 18-35 years (55.7%).

Table 4-1 Distribution of actors in plastic waste activities by city

Actors	*Nairobi*	*Mombasa*	*Kisumu*	*Nakuru*	*Total*
Yard shop operators	37	3	10	8	**58**
CBO	16	3	1	0	**20**
CBO-SACCO	1	0	2	0	**3**
Pickers	7	0	0	0	**7**
Total	**60**	**6**	**13**	**9**	**88**

Source: Constructed by author from interviews.

Table 4-1 shows that yard shop operators were found in all the four cities. In Nakuru, the CBOs and CBO-SACCOs were completely absent, while in Mombasa there were CBOs working around post-consumer plastic waste management but without having found an association. The widespread post-consumer plastic waste management activities in Kisumu, especially of yard shop operators, is attributable to the relatively limited opportunities for income generation for its youth in particular, and to the high poverty prevalence of the Nyanza region in general-63% in 2007 (Zosa-Feranil *et al*., 2009). Around 52% of the working population in Kisumu is engaged in the informal sector, which is not significantly different from the national average of 50% (Antoine, 2004). In terms of monthly income, working in the informal sector in Kisumu, including waste recovery activities, brings a minimum income of between Ksh. 3,000 to 4,000 (USD 40-53) per month (UNCHS, 2005), compared to those in Nairobi with a minimum income of Ksh. 9,600 (USD 128) per month (Mitullah and Wachira, 2003).

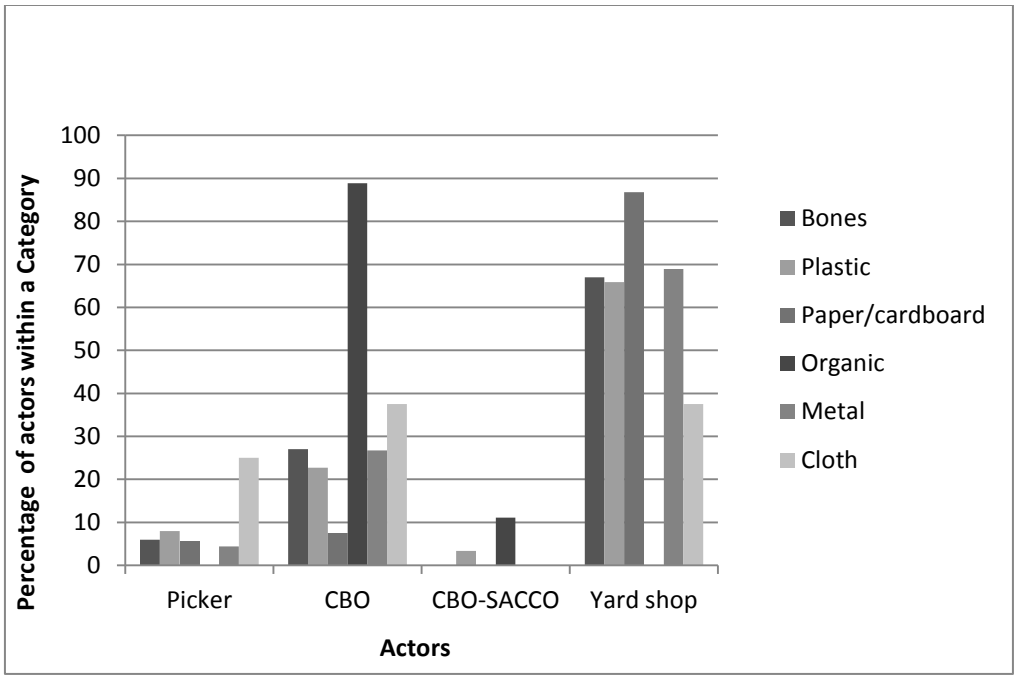

Figure 4-3 Percentage of actors interviewed within a category handling different waste streams: constructed by author from interviews

There were six types of waste materials that the actors mostly traded in: bones, plastics, paper and cardboard, organics, metal and clothes (see Figure 4-3). Yard shop operators traded mostly in metal, plastic and paper and none of them traded in organic waste. CBOs handled mostly plastic, organic and metal waste, but some also handled the other three types of waste. Even though yard shop operators traded a variety of waste, they displayed high handling capacity, both in volume and weight, for plastics. Figure 4-4 shows that the majority of yard shop operators handled over 1000+kg of plastic waste per week, compared to CBOs whose capacity was mostly within the range of <250 kg of plastic waste per week. CBO-SACCOs had similar handling capacities for plastic waste as yard shop owners.

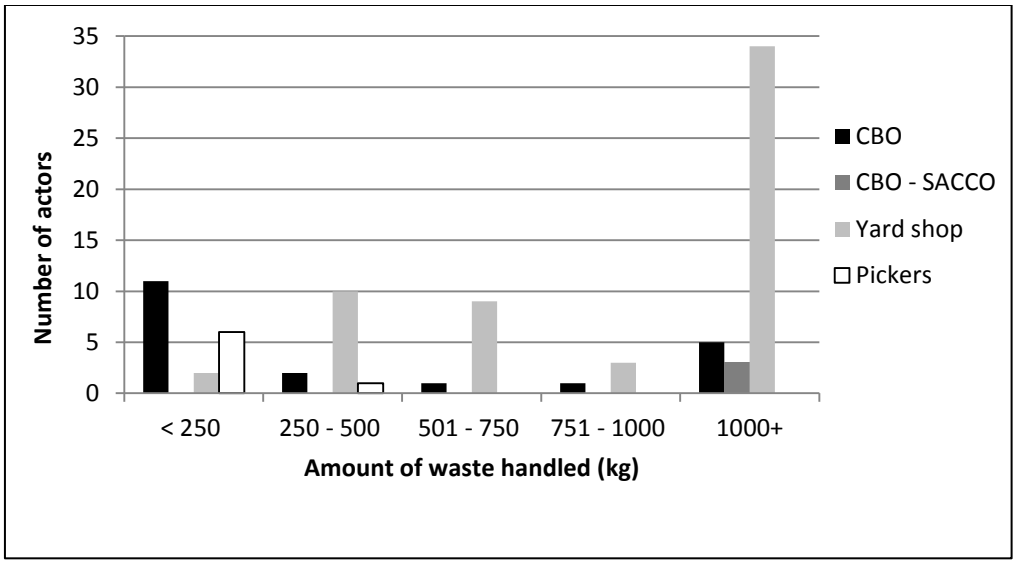

Figure 4-4 Amount of plastic waste handled per actor group: constructed by author from interviews

In contrast to the CBO-SACCOs who engaged in semi-processing and to some extent final product making, and pickers who did not add any value to the waste, CBOs and yard shop operators largely sorted, washed, dried and bulked plastic waste. All four actors were found mainly handling particular types of post-consumer plastic waste, namely high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene (PP) and polyethylene tetra phthalate (PET) (see Table 4-2). Except for a few CBOs, all actors reported not being able to meet demand, and that HDPE was the most preferred type of waste material. The selling and buying prices and market preferences for the different types of post-consumer plastic waste vary, depending on the value addition activities conducted. Generally, there were no variations between the cities in relation to preferences, buying and selling prices for different types of post-consumer plastic waste. Equally, there were no significant variations in prices across our actor categories. Actors sorted plastic waste by color, type and cleanliness before washing, drying and bulking.

Table 4-2 Type of plastic waste and unit selling price in 2010

Type of plastic waste handled	*Average selling price of sorted and washed plastic waste (Ksh./kg)*	*Average selling price of sorted, washed, agglomerated or granulated plastic waste (Ksh./kg)*
HDPE	12-22	25-30
LDPE	12-18	25-30
PP	10-15	23-25
PET	6-10	45-55

Source: Constructed by author from interviews.

Table 4-3 Actors and number of years in operation in 2010

Years in operation	*CBO*	*CBO-SACCO*	*Yard shops*	*Picker*	*Total*
Up to 3	8	2	22	0	**32**
4-9	8	1	20	6	**35**
10+	4	0	16	1	**21**
Total	20	3	58	7	**88**

Source: Constructed by author from responses to the question about number of years in operation.

Generally, the last 10 years marked a growth of plastic waste material recovery with (16 out of 20) CBOs and (42 out of 58) yard shop operators getting involved (see Table 4-3). This signals an increased demand for plastic waste material by industries, especially given the fact that these actors indicate they have difficulties in fulfilling demand.

Even though the percentage of yard shop operators who have been in operation for over 10 years is only 27.6%, their association with the plastic industry can be traced back to the 1960s (Mugambi, 2001). An interview with the longest serving yard shop operator in this study, whose value addition activities started in 1982, reveals that even in the 1980s high demand existed for plastic waste. He travelled from Nairobi to Kisumu, a distance of 384 Kms, at least twice a month to gather enough plastic waste for his clients in Nairobi. As indicated in Table 4-3, twenty two (22) out of fifty eight (58) yard shop operators were established in the last three years, with majority of them handling over 1000+ kg of plastic waste per day. The majority of CBOs (16 out of 20) had been in operation for less than 10 years, and all three CBO-SACCO had a history of less than 10 years.

While households remain the source of plastic waste materials collected by CBOs and CBO-SACCOs, yard shop operators had a variety of plastic waste sources. Pickers are principle suppliers, with supermarkets emerging as new sources of waste with near-to-virgin secondary plastic packaging waste. Yard shop operators received also significant quantities from manufacturing industries in the form of cuttings and rejects.

4.3 Development of CBOs, CBO-SACCO and yard shop operators

The evolution of these actors and their value addition activities on plastic waste are motivated and can be explained within two contexts: environmental improvement and economic empowerment. While CBOs and CBO-SACCOs evolve to respond also to environmental conditions of particular communities in which they are located, yard shop operators interpret their value addition activities primarily in terms of employment creation and economic empowerment.

4.3.1 Evolution and development of CBOs plastic waste activities

Historically, CBOs have evolved from organizations with a narrow focus on relief and welfare activities (Raman, 1994) to the current organizations that emphasize small scale self-reliant local development, in which solid waste management has an important place (Korten, 1987). In many circumstances CBOs focus on a variety of issues affecting communities, including sanitation, social welfare and employment. Their formation is ad hoc, usually – but not always (Tukahirwa *et al*., 2011) – orchestrated by genuine community needs. They usually are established with a focus on advocating social welfare issues, including inclusion of communities in governance structures, social rehabilitation, education of community members, HIV and AIDS, and environmental awareness and waste collection activities.[22] Pursuance of these social issues is always viewed in light of betterment of the community or for protection of a particular community area from threats coming from outside (Post and Mwangi, 2009). In most cases CBO agendas run along the prevailing major themes of development agendas of donors as a way to acquire funds for their operations.

While acknowledging the genuineness and voluntary orientation of CBOs, donor funding has been instrumental in their formation. This finding is in conformity with those of other scholars, including King (1996), Oosterveer (2009) and Tukahirwa *et al*. (2011). Quite a number of CBOs receive fees for the waste collection and disposal services, and for some CBOs waste collection has become a major area of activities in Kenya's major cities, a finding supported by other literature (Furedy, 1992; Raman, 1994; Tukahirwa *et al*., 2011). Gradually, CBO operations have expanded from only waste collection to material recovery from waste, which ultimately became a new responsibility they perform together with their sister CBO-SACCOs. All CBO representatives interviewed in this study operated within informal settlements and other residential areas categorized as low income[23]. These areas are characterized by limited access of the inhabitants to public solid waste management services over the years (JICA, 2010).

The CBOs studied were found to engage also in other activities than plastic and waste management activities, but the latter were their principle income sources. Some studies have found that CBOs engaged in composting activities in Nairobi had only 5 members, but on average CBO members ranged between 20 and 50 persons (Karanja, 2005; JICA, 1998). According to Karanja (2005), individual membership of CBOs usually requires payment of a fee. In this study, CBOs with registered membership required an annual fee between Ksh. 20 and Ksh. 25 and in most cases, membership ranged between 10-30 people, of whom the majority is men of diverse age groups. This number of members normally peaks to hundreds of people in the formation stage of a CBO, when representatives are elected and appointed, its operational structures are set up,

[22] This is the case with Bamato Environmental Sanitation Services based in Milimani, Kisumu City.

[23] Stratification of residential neighborhoods according to Kenya Government , population and housing report of 1999 (Republic of Kenya, 2001)

and day to day operations as financial resources are sufficiently available. In due course, number of members tends to decrease especially as (donor) funding diminishes.

The startup funds for CBOs often come from international and national NGOs, faith based organizations, and international organizations including foreign embassies. Through such funds, CBOs acquired extensive training for skill development, could equip themselves with working tools and equipment, acquired operational bases and even managed their day to day administrative needs including payment of rent and facilitation of members meetings. Characteristic of most CBOs is that they are mainly run by two officials: a chairman and a secretary. The latter keeps information regarding all activities of the CBO and coordinates all meetings. There is often no structured way of calling for such meetings, except that they are held periodically to appraise members. After donor funding stops and membership starts to decrease, usually meetings become rare. Lack of further support by donor funding sometimes resulted in abandoning plastic waste activities and a focus on both waste collection and disposal activities or on re-branding their organization with new structures and names (see Box 4-1).

The main source of waste for CBOs is households whom they serve with collection services. CBOs accumulate all waste on their ground where plastics are sorted by colour and type, washed in movable containers and subsequently dried. The market destination for plastic waste is varied. Some CBOs sell directly to recycling industries, others to the CBO-SACCOs of which they have become member, and still others make new products. For example, the CBO KEMA makes handbags, pillows, hats, fencing poles and roofing tiles from plastic waste, which they sell within their neighborhood and sometimes at show fares where they are invited either by city councils or the Ministry of Trade.[24] Returns from selling these products are low, except that KEMA also collects waste from over 4,000 households from which it earns Ksh. 100 (USD 1.33) per household per month as additional income.

Text box 4-1 Riruta Environmental Group

Based in Kawangware slums of Nairobi, the group was established as a CBO in 1999 with financial assistance from Verona Fathers of the Catholic Church. The sole purpose was rehabilitating street boys, and initial membership was 200 individuals. In 2003 and 2004, the CBO received additional finances of Ksh. 4.3 million (USD 57,333) from UNEP and the German Embassy to build capacity for waste collection and plastic waste recycling. To this end, three officials were trained in Hyderabad and New Delhi in India, for improving their technical capacity. Two of them are no longer with the CBO, only the chairman is still present. When the CBO activities were at its peak, it gathered up to 4 tons of post-consumer plastic waste per week, part of which was sold to Hala industries and the rest to Nairobi Plastic SACCO. The CBO bought 2 trucks with which it served the neighborhood with waste collection at a fee of Ksh. 100 per household per month. However, as the chairman remembered, their activities and members started to decline in 2007 when they could no longer get financial assistance to pay for administrative costs and the facilitation of regular CBO meetings. Today, the CBO has only 5 members, who have plans to start up a NGO through which their activities would once again get revived, the chairman hopes.

[24] Interview with Mr. Munywe the chairman of KEMA on 27th January, 2009. KEMA is a CBO based in Kayole, Embakasi Division-Nairobi.

In terms of capacity building, CBOs have benefited from a series of trainings and collaborations conducted by local organizations. In a few instances, such skills and knowledge is also acquired overseas. Trainings have equipped them with the necessary skills and knowledge for their day-to-day operations and also made them familiar with the regulatory and policy requirements concerning their plastic waste management activities. From oversees trainings, CBOs have learned from successful recycling programmes. At the local level, CBOs have benefited from trainings conducted by the NEMA on the provisions of the EMCA, 1999, which requires them to obtain operational licenses. Trainings by NEMA happened through technical assistance funded by donors and sometimes through free sessions NEMA always conducts in popularizing the provisions of EMCA (including solid waste management regulations and standard requirements).

CBOs and CBO-SACCOs have over time cultivated cordial relationships with city authorities. Through such relationships, some of them could acquire temporary occupational licenses to squat on public utility land and conduct their solid waste management activities. In the frame of such loose arrangements, CBOs usually pay a small fee to city authorities, which is however not always commensurate to their occupation. Others have been allocated spaces for operation without any payment; in general working space/premise does not appear as a major challenge to CBOs. Other benefits of collaborations with city authorities include incorporation of CBOs into city governance structures, e.g. participation in policy dialogue, participation in demonstration programmes, and scheduling of environmental cleanup events. CBOs do not appear to have a relationship with industries beyond the 'supplier-buyer' relationship. When asked if they ever share any information or offered any advice by the industries, only 20% answered that they received information regarding waste type, quantities required and the prevailing selling price.

In spite of CBOs having free access to waste, this study found that their performance, in terms of amount of plastic waste handled, was only remarkable during the few months after the start of activities. There was no consistency in sales. 55% of the CBOs sold their plastic waste weekly, 45% sold it monthly and over 70% handled less than 750kg of plastic waste per week (see Figure 4-2). In general, these quantities and the low frequency of sales cannot sustain CBO activities. For instance, the Mwiki Action Group could only manage to separate between 250 - 400 kg of plastic waste per week and in most cases they would wait until they had 1 ton before they could sell it to the industry, as selling small quantities involves high transport costs.[25]

Logistics, especially transportation to selling points, is a major problem to CBOs involved in plastic waste. CBOs who sold plastic waste to industries organized transport themselves, but they felt it was too expensive. For example, within Nairobi transport costs ranged between Ksh. 1500-2500 (USD 20-33.3) per trip. CBOs also have to bear costs

[25] Interview with Mr. Nyaga the chairman of Mwiki Action Group, 16th January 2009. Mwiki Action Group is a CBO based in Nairobi's Kasarani Division.

associated with water and electricity use. For water they paid only between Ksh. 400-600 (USD 5.33-8.00) per month, and for electricity CBOs paid between Ksh. 500-1000 (USD 6.67-13.33) per month. The exception, however, are the CBOs that make final products, whose combined water and electricity costs range between Ksh. 6500-8000 (USD 86.67-106.67) per month. It was difficult to estimate earnings of CBOs as there were no proper recordings and earnings from waste collection fees and from value added activities are lumped together. All interviewed CBOs claimed to not making any profit from their value-added activities.

Other constraints that were reported by CBOs: financial assistance is too limited; policies from city authorities do not yet secure them permanent land rights; fees to be paid to city authorities are still too high. Sustaining plastic waste management activities by CBO proved vulnerable when many of them were unable to trace their demand networks after the 2008 post-election violence. Only 45% of the CBOs could still connect to their waste buyers after the violence.

4.3.2 Evolution and development of CBO-SACCOs plastic waste activities

CBO-SACCOs for plastic waste are a recent phenomenon in Kenya, with only three having been formed in the last 5 years. Nairobi Plastic SACCO in Nairobi was the first to have been formed in 2005, followed by Bamato Environmental and Sanitation Initiatives in 2008 and Kisumu Waste Management Savings and Credit Cooperative Society (KIWAMA) in 2009, the last two both located in Kisumu. The evolution of CBO-SACCOs appears to coincide with the recent efforts of public organizations to try to come up with a comprehensive policy framework to address the eminent plastic bag waste problem (KIPPRA, 2006; Republic of Kenya, 2009).

CBO-SACCOs are normally legal entities registered under the Cooperative Society Act by the Ministry of Cooperative Development and Marketing. They bring together individuals and CBO groups who have a common economic objective through similar economic activities: their involvement in value addition activities on plastic waste. Normally SACCOs have over 50 individual members and over 20 CBO members. The main objective of CBO-SACCOs is to provide financial leverage to members, among others by providing loans at reasonable rates. This is possible since CBO-SACCOs manage to have a higher value added on post-consumer plastic waste. Other social benefits are payment of school fees to members' children and access to information on social problems like HIV/AIDS. Members place deposits through waste deliveries and in turn can qualify for loans whenever they require. They can even earn dividends from the sale of their waste. Under normal circumstances, membership is gained through the purchase of a minimum of 25 shares at Ksh. 20 each (USD 0.3).

In general, members gather post-consumer plastic waste and sell it to the CBO-SACCOs at a constant unit price of Ksh.5 (USD 0.07) per kilogram, regardless of plastic

waste type. Donor funding was instrumental in facilitating the initial buying of waste materials from members. The money is then left to accumulate for purposes of building a financial base for lending to the members. The fixed price may be viewed as leverage to members as it protects members from adverse effects of market price fluctuations, especially when prices for post-consumer plastic waste are lower than what CBO-SACCOs offer. In practice, the plastic waste recycling sector is very dynamic and particular plastic waste materials are sought at different times. This fluctuating demand means that prices are never fixed. Because of this, CBO-SACCOs members always seek for alternative markets for their waste materials and only take it to CBO-SACCOs when they cannot avoid it or the prize is highest at CBO-SACCOs.

Just like CBOs, CBO-SACCO formation is facilitated by international NGOs and organizations. Through technical and financial assistance from such organizations, CBO-SACCOs formulated well defined managerial structures through which they execute their operations, including conducting regular meetings for reasons of appraising members and for receiving 'field information' from the members including reports on those who would want to become members. For example, the Nairobi Plastic Recyclers SACCO, which at the time of the survey was more or less defunct (see Text box 4-2), had a management committee highest in its administrative hierarchy, supported by various sub-committees in charge of pivotal roles like credit control, supervision, marketing and awareness creation.

These well-defined structures helped the CBO-SACCO to undertake its activities and to support and enhance the capacity of CBO-SACCO members. CBO-SACCO members also learned technical issues relating to the operational standards for waste management, waste management policies and regulations, technologies for recycling of plastic waste, and marketing. CBO-SACCOs have periodic but scheduled meetings where members review their activities. However, these meetings became rare once CBO-SACCOs no longer received donor money. Furthermore, CBO-SACCOs had to finance their operational costs if they had to continue with plastic waste activities. Data obtained from Nairobi Plastic Recyclers SACCO and Bamato Environmental and Sanitation Initiatives indicate that electricity costs ranged between Ksh. 9,000 – 15,000 (USD 120 – 200) per month. Water costs were between Ksh. 3,000- 5,000 (USD 46.7-66.7) per month. In addition, Bamato Environmental and Sanitation Initiatives had to meet transport related costs, while Nairobi Plastic Recyclers SACCO had to fuel their own truck to ensure collection and delivery of waste materials. Nairobi Plastic Recyclers SACCO requires Ksh. 45,000 (USD 600) per month for maintenance of two grinders and an agglomerator.[26] At the time of this fieldwork, a newly fabricated washing machine, bought at a cost of Ksh. 350,000 (USD 4,700) had been grounded for several months and had to be repaired for Ksh. 15,000 (USD 200). Although CBO-SACCOs obtained premises for which they paid minimal fees to the respective city authorities, licensing and

[26] Interview with Mr. Awiti, Technical Officer at Nairobi Plastic Recyclers SACCO, on 2 June 2009.

other operational fees still added to their expenditures. According to CBO-SACCOs representatives, these expenditures were too high.[27]

Text box 4-2 Nairobi Plastic Recyclers Savings and Credit Cooperative Society

This SACCO was founded in 2005 and brought together 44 CBOs and 100 individual members. It is based in Makadara estate in the Eastern part of Nairobi. Its formation was hatched through a collaborative effort of different organizations, including UNEP, NEMA, and UNDP, the French embassy and Practical Action, an international NGO. With initial funding of Ksh. 9.4 million (USD 125,333) from UNEP and the French embassy, the SACCO procured a washing machine, two grinders, an agglomerator and a pelletizer. UNDP facilitated a capacity building program for the SACCO officials, which included two trips for 4 officials to Hyderabad and New Delhi in India and other local trainings for members of its 4 committees of credit, marketing, education and supervision. Members of the SACCO were also trained on entrepreneurship, operations, and legal, health and safety issues through domestic tailor made programs by different organizations, including City Council of Nairobi, NEMA and Practical Action. SACCO members furthermore benefited from participation in environmental seminars and conferences and also conducted training for youth groups and a women group from Uganda on the concept of 3Rs (Reduce, Reuse, Recycling) and recycling technologies. At the beginning, the SACCO handled up to 30.2 tons of semi-processed material per month, which they in turn sold to Ashok Plastic Manufacturers, Hala and Premier Industries at Ksh. 30 (USD 0.4) per kg. Part of the donor assistance, which included administration costs to facilitate meetings and salaries to trained members operating the machines, ended in April 2008. At the time of the interview with the Chairman, Mr. Macharia, all the machines were grounded, only with occasional operation as and when the chairman decided. The two technical staff who operated the machines had left due to non-payment of salaries. With only Riruta Environmental Group (REG) and City Garbage Recyclers still being a member, the SACCO can be considered defunct as no other members could be traced except for the Chairman and the secretary.

Much of CBO-SACCO training was organized domestically by both local organizations and international NGOs. However, some CBO-SACCO trainings were conducted oversees. For example, Nairobi Plastic Recyclers received training on recycling technologies and visits to demonstrations projects in Hyderabad and New Delhi, India. Training on technologies was crucial for this CBO-SACCO since it had acquired sophisticated technologies for further value addition on plastic waste: a washing machine, two grinders, an agglomerator, shredders and an extruder. Bamato Environmental Sanitation Initiative had only two grinders. By the time of this study, most of the machines at Nairobi Plastic Recyclers SACCO were underutilized and only operated occasionally (see Text box 4-2), while at Bamato Environmental and Sanitation Initiative, the grinders were operated alternately[28].

Well-functioning CBO-SACCOs handle an average of over 1000kg of post-consumer plastic waste per week (see Figure 4-4) and as such display a larger handling capacity than that of the majority of CBOs, even though they reported lack of meeting demand. Furthermore, CBO-SACCOs engage in higher value addition activities on plastic waste materials and thus fetch better prices, despite their low frequency of sales (often only weekly or even monthly). However, just like CBOs, CBO-SACCOs could not

[27] Interviews with Mr. Awiti, Technical Officer for Nairobi Plastic Recyclers, on 2 June 2009 and with Mr. Odhiambo, Secretary of Bamato Environmental and Sanitation Initiative, on 12 February 2010.

[28] Representatives of both Nairobi Plastic Recyclers SACCO and Bamato Environmental and Sanitation Initiative cited high maintenance costs for lack of consistent operations. The former citing costs as high as Ksh 30,000 (USD 400) per month, while the latter cited Ksh 15,000 (USD 200) per month.

sustain their operations beyond the donor funding period. At the time of this study, only Bamato Environmental and Sanitation Initiative functioned still to some extent, sustaining its operations although with difficulties. Generally, CBO-SACCOs hardly generated enough income through which they could roll out loaning systems which could sustain members' expectations. Nevertheless, CBO-SACCOs stay optimistic that when given further financial support, they are able and have the technical capacity to improve environmental conditions related to plastic waste and also contribute to employment creation.

Relations of CBO-SACCOs with industries are based on business terms, where CBO-SACCOs meet demands of industries regarding waste type and quantities. However, some industries complained about the quality of waste delivered by CBO-SACCOs, caused by lack of thorough washing.[29]

The development of CBO-SACCOs has mainly been donor driven through heavy investment in initial funding, skill development and technological infrastructure. However, failure to generate adequate income compromises the sustainability of CBO-SACCOs plastic waste activities. This state of affairs puts into question the level of commitment and capacity of individuals appointed to steer the CBO-SACCO activities, as well as the business model behind the CBO-SACCOs.

4.3.3 Development of yard shop operators on plastic waste

The history of plastic waste recycling in Kenya mainly covers plastic waste activities of pickers and itinerant waste operators who hardly engage in any value addition activities on plastic waste, but only sell it to industries (Karanja, 2005). According to Mugambi (2001), waste buying and selling is as old as the history of plastic recycling in Kenya. However, activities of yard shop operators have not received much attention in the history of informal waste recovery activities. The drive behind yard shop operators' involvement in value addition activities on plastic waste revolves around two key concerns of Kenya Government at the moment: employment creation and job security (KAM, 2006; KIPPRA, 2009).

Due to lack of employment, Kenyan youngsters – mainly ageing below 35 years – have put together either individual or family resources into the business of buying, value addition, and selling of different waste materials. The startup funds for such businesses range between Ksh. 10,000- 25,000 (USD 133 – 333). Part of the startup funds were paid for premise rents, which depend on size of the site and ranges between Ksh. 6,000-15,000 (USD 80- 200) per month. Such premises are open grounds and are exposed to a number of hazards including fire and rain. Yard shop operators predominantly deal in plastic waste and waste paper activities. Their activities start as informal trading businesses and

[29] Interview with Mr. Awiti, Technical Officer for Nairobi Plastic Recyclers on 2 June 2009.

with time they evolve to obtain a trading and waste operator license from the city authority.

Some yard shop operators obtain a waste transporter license from the NEMA if they own trucks and operate their own waste material transport. About 40% of the yard shop operators interviewed had secured these operational licenses, despite the general feeling that such licenses are expensive. Located along strips of land adjacent or close to industrial areas, yard shop operators employ 10 – 32 casual laborers (depending on the volume of work) and pay them Ksh. 200-300 (USD 2.7–4.0) per person per day. In most cases, women dominate the sorting activities as they are generally seen as more precise in executing sorting of plastic waste (see Photo Image 4-1). Sorting of plastic waste and thus isolate polymer types, requires a high degree of attention, especially when it involves the light polymers.[30] Text box 4-3 presents a case of yard shop operator activities.

Photo Image 4-1 Women sorting paper and plastic at an enterprise on Lunga-Lunga street, Nairobi (Photo series by Leah Oyake-Ombis)

Text box 4-3 Pride Street Services

Pride Street Services is a yard shop business situated at Enterprise Road in Nairobi's industrial area and is run by a young entrepreneur aged 36 years. It started in 2001 by Mr. Karume, a graduate from secondary school who had been jobless for over 10 years. The enterprise has grown both in size and handling capacity for different municipal waste streams, mainly paper and plastic wastes. Currently, the operator handles 4.7 tons of post-consumer plastic waste per week with a workforce of between 12-30 casual workers per day. Mr. Karume's activities are hosted in a rented site and he has constructed two washing troughs and bought a second hand truck. Supplied by 11 waste pickers daily and also from Tuskys supermarket at a unit price of between Ksh. 5-8 (USD 0.07- 0.1) per kg of plastic waste, he sells at between Ksh. 12-18 (USD 0.16- 0.24) after sorting, washing, drying and bulking, to Hala industries, Premier Manufacturers, Ashok Plastic Manufacturers, Green-loop International, Hi-Plast Manufacturers and Rainbow Plastics.

Unlike CBOs and CBO-SACCOs who - once the donor funding became inaccessible - could not sustain their operations, yard shop operators display a stronger business orientation. Yard shop operators not only rely on waste pickers for their plastic

[30] Interview with Mr. Mutua owner of Brule Yellow Bins based on Lunga Lunga Street in Nairobi, on 14 February, 2009. Mr. Mutua mainly received plastic waste from Tuskys supermarket one of the major supermarkets with outlets in all four major cities.

wastes, but go further to source for cleaner wastes which could boost their profit margins. They source for waste from supermarkets and in some cases industries. Waste from supermarkets is largely from secondary packaging[31] and has less contamination since supermarkets separate paper and plastic waste from other wastes they generate.[32] A kilogram of supermarket waste, regardless of polymer type, is sold to industries at Ksh. 23 (USD 0.31) while yard shop operators either get it for free or buy it at Ksh. 5 (USD 0.07). To compare, they buy the dirty waste from pickers at a price between Ksh. 6-10 (USD 0.08-0.13), depending on the waste type. Characteristic of yard shop operators' activities is that they start their activities at very early hours of the day, making phone calls to industries to ascertain their demands both in terms of type of plastic waste needed and quantities, and, in turn, make contacts with their suppliers of waste materials. Interviews were done in the afternoon when much of the organization and plans for the day's activities had been made and only bulking for delivery to the receiving industries remained.

Some yard shop operators have invested in infrastructure and logistics out of their own resources, although many complained on the lack of financial capital for such investments. For instance, many have constructed open troughs for washing low density polyethylene plastic waste and bought second hand trucks for transportation needs. These infrastructural requirements remain crucial and have top priority for yard shop operators.[33] Yard shop operators have other operational costs associated with electricity and water. For electricity, costs are minimal as their operations are only conducted during day time and are mostly manual. Electricity costs range between Ksh. 500–3500 (USD 7–47) per month. Water costs range between Ksh. 1500–6000 (USD 20–80) per month. When asked on their motivation to venture into plastic waste management activities, all (58) interviewed yard shop operators mentioned employment creation as priority. Other motivations are improvement of environmental cleanliness and facilitation of industrial growth. As yard shop operators have not institutionalized any internal management structures in their operations, all decisions are executed by the owners/operators, but sometimes they appoint particular employees in charge of different activities.

Yard shop operators sell their plastic waste to semi-processors and manufacturing industries; 52% sell it daily and 48% sell it weekly. Many of them maintain a consistent client base of between 3-5 industries. Just like CBOs and CBO-SACCOs, yard shop operators report that they are not able to meet the demand for plastic waste. Yard shop operators share information with (67.2%) and receive advises (74%) from industries regarding a number of issues. Yard shop operators rely on industries to provide them market information, e.g. on prices, type of plastic waste in demand, and quality

[31] Secondary packaging is used for covering large quantities of primary packed items. It is mainly applied to facilitate transportation and protect goods from damage.

[32] Interviews with representatives of three major supermarkets: Nakumatt holding, Uchumi and Tuskys supermarkets.

[33] Interviews with all yard shop operators.

specifications. Advices were received concerning health hazards associated with waste activities and protective measures to avoid their employees from being affected (gloves, dust masks). Other advises regarded monthly as opposed to daily payments, such that yard shop operators would accumulate substantial amounts to enable them undertake investments. Industries also pointed at possibilities of lending from micro-financing institutions. Relationships between yard shop operators and industries are cordial and could be considered beneficial to both. On the side, yard shop operators received cash advances purely on trust that they would deliver waste materials at a later date whenever they were cash stripped.[34] In situations where yard shop operators are unable to hire transport for delivery of waste materials especially, industries sent their vehicles to pick up the waste, while being reimbursed once payments are made. Yard shop operators refer industries to the sites of their colleagues on instances when they are unable to respond to waste material demands.

Yard shop operators' relationship with city authorities is frosty. In several instances, they are at loggerheads with city enforcement officials for allegations of dumping and creation of nuisance, despite a good proportion (58.6%) of them having received waste operational licenses.[35] Such allegations are frequent and render them liable to constant arrests. Yard shop operators mostly overcome such problems with payment of what can be called 'protection fees'. Such payments were made weekly to errant individual enforcement officers, of course without any receipt in return.

A number of yard shop operators have been trained for free by the NEMA officials on the provisions of the Environmental Management and Coordination Act, 1999, especially regarding the operational standards for waste handlers and the licensing procedures as contained in waste management regulations of 2006. While yard shop operators in general view waste management policies and regulations as useful for their businesses, some of them feel that licensing requirements are expensive (34.5%), as well as compliance to waste management regulations (51.7%). Some (41.3%) yard shop operators have undergone entrepreneurship skills development training, organized by organizations such as Faulu Kenya and K-Rep, which are micro-financing organizations providing financial services to microenterprises which are excluded access to the formal financial sector. Through such training, yard shop operators have learnt book and record keeping of quantities of waste bought and sold, payments for these quantities and for different utilities, including salaries. They have also become aware of how much profits they accrue from every sale over the last few months preceding this survey.

The development of yard shop operators' value added activities on plastic waste has been marked by an increased number of highly committed individuals, despite the unsupportive policy and donor environment. Better contribution to both environmental

[34] Interviews with a number of yard shop operators on different occasions.
[35] Interviews with 4 different yard shop operators in Nairobi, Mombasa, Nakuru and Kisumu on 8 January, 16 April, 27 May and 9 April 2009, respectively.

improvement and employment creation is feasible when access to financial capital is better secured, which enable them to deal with larger quantities of waste as well as improve their infrastructures and working premises.

4.4 Analyzing the niche formation of non-state actors activities on plastic waste

Having presented the operational features and development CBOs, CBO-SACCOs and yard shop operators with respect to their involvement in post-consumer plastic waste management, this section presents an analysis of the extent to which these niche activities of the three actor groups are able to bring about a more substantial contribution to managing plastic waste. In this analysis, the actor networks that are involved in these innovations are assessed, the shaping and convergence of actors expectations evaluated and the learning processes identified. Figure 4-5 shows the actor network exhibited by the three waste handling actors and the type of resources exchanged between the actors in these networks.

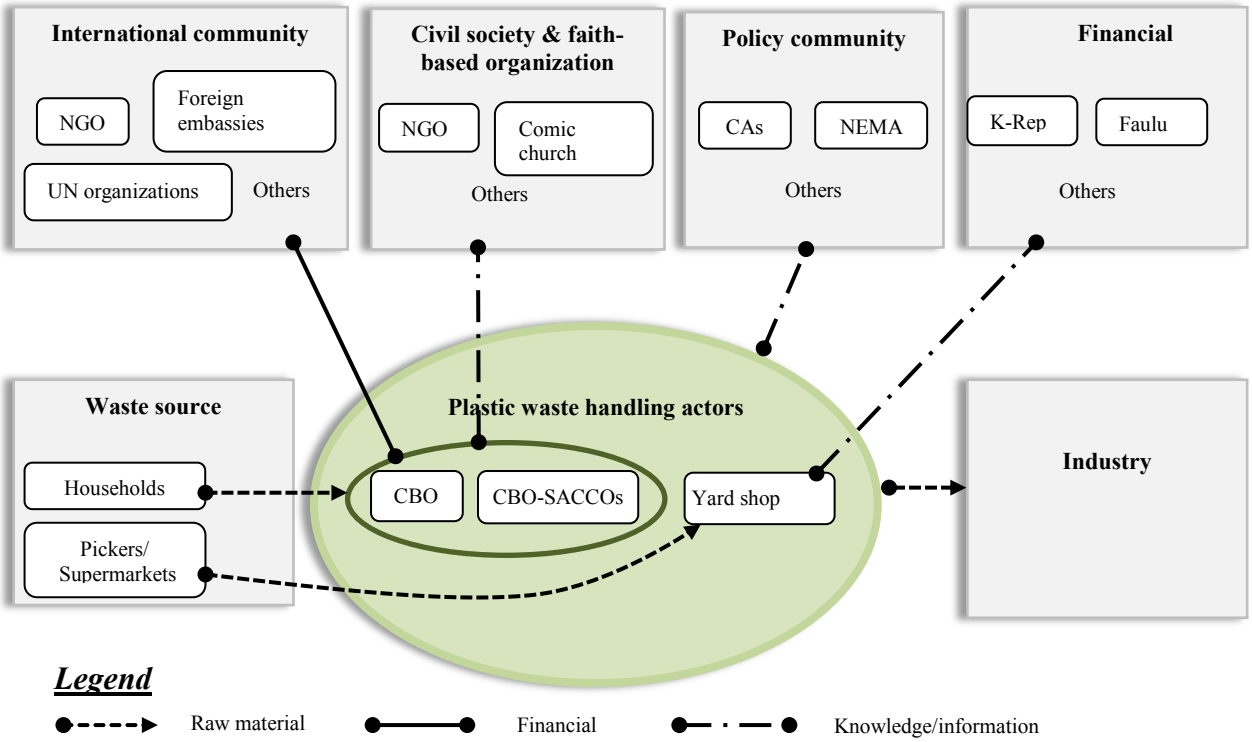

Figure 4-5 Actor network exhibited by the core plastic waste handling actors: Constructed by author

4.4.1 Niche formation of CBOs plastic waste activities

The niche formation of plastic waste activities by CBOs has not proceeded well beyond the experimentation stage. This section explains the failed take off of these CBO activities.

Social Network Composition

The actor network for CBOs comprises of the policy actors, international actors, societal actors, suppliers, industrial actors and, in some CBO cases, CBO-SACCOs. The inclusion of diverse social groups in innovation processes is advocated by transition scholars like Raven and Verbong (2009). They argue that these actors, either through direct or indirect means, influence the direction and also the force and momentum of innovation processes since they bring in different resources to the network.

Since the early 1990s, Kenyan CBOs have evolved from voluntary organizations that focused on welfare issues and environmental cleanliness of informal settlements to broader outfits undertaking waste material recovery activities, including plastics, in major cities of Kenya. Through collaboration with donors and both local and international NGOs, CBOs have been able to acquire financial resources which have been instrumental in equipping them with the required working tools, skills and knowledge for value added activities.[36] However, these donors play especially a strong role in establishing CBOs. Once they stop funding these CBOs, a decrease of CBO activities and functioning can be seen.

City authorities in CBO social networks have provided CBOs with new resources. For example, Riruta Environmental Group is a CBO that engages with environmental activities of the City Council of Nairobi. This CBO is often invited to participate in city environmental programs, including clean-up programs, which exposed the CBO to the city's solid waste management agenda.[37] Riruta Environmental Group is also registered by the City Council of Nairobi as a waste collection CBO in Dagoretti Division of Nairobi, thereby elevating the CBO status on SWM activities. In Nairobi, City Garbage Recyclers, through their collaboration with the city, was allocated a piece of land on a temporary occupational license to conduct their value added activities. The same CBO benefitted from the city through annual invitations to show case their activities at the Nairobi Agricultural Show. Other benefits of CBO collaboration with city authorities relate to learning of the city specific by-laws and involvement in policy dialogues around the enactment of SWM by-laws. In Kisumu for example, Nyalenda Community Development Group was one of the partners that drafted the 2007 Kisumu Municipal Council (KMC) SWM by-laws.

Through participation in the by-law making process, this CBO was able to advocate for inclusion of technical and logistical support from the city for CBO waste recovery and recycling activities. Nyalenda Community Development has benefitted from land allocation for its plastic waste recovery activities and still benefits from free collection and disposal of its unwanted waste. Furthermore, the CBO considered their

[36] Exnora International, an environmental NGO operating in most municipalities in India on waste collection, sorting and composting activities, has provided financial support to Kenyan CBOs.
[37] Interview with Mr. Kere, chairman of Riruta Environmental Group, on 24th March 2010

participation in the by-law making processes as recognition of CBOs in processes traditionally dominated by governments.[38] This example indicates that some city authorities are warming up to align with and include such non-state actors in their SWM operations. The chairperson of Carolina for Kibera in Nairobi saw further possibilities in aligning with the city authorities: "We need to work with the City Council very tightly. This will help people see the importance of what we are doing. The City Council could provide us with identity cards so that people do not think we are after stealing their money."[39] Through CBO-city collaborations, CBOs have gained knowledge, access to decision-making and variably (also monetary) favors, which points to a positive view of city authorities about the potential of CBOs plastic waste activities towards restoring city's environmental status.

Besides the city authorities, CBO networks were enriched by participation of NGOs and national organizations. NGOs have been useful both in financial resources and knowledge. On the side of national organizations, NEMA has conducted a series of training programs, both voluntary and for payments, to CBOs. Such trainings have focused on the provisions of EMCA, 1999. CBO-SACCOs also provided extensive training to CBO members, in terms of technical exposures to recycling, and policy and regulatory knowledge on SWM. Collaboration with CBO-SACCOs raised expectations of members in terms of securing loans and dividend earning. However, these expectations were not often met and economic benefits of SACCO-CBOs networks never became a reality, thereby rendering such networks almost inactive.

CBO collaborations with plastic recycling industries did not offer pronounced economic benefits for CBOs, nor did they result in reliable material flows to industries. In supply chain management, information sharing is crucial since it conveys the user requirements and feedback on user acceptance (Wicks *et al*., 1999). But between CBOs and industries there is lack of information sharing regarding the market situation, as only 20% of the CBOs had shared/received some information on requirements of industries. Without a practice of information sharing between CBOs and industries, it is more difficult for CBOs to understand the needs and requirements of industries concerning quantity and quality of waste demand. CBOs were also disadvantaged in gaining information on market prices of different waste types. Besides information sharing, CBOs also lacked the capacity to sustain daily supply of plastic waste to industries, thus jeopardizing reliable supply and threatening their market position. Moreover, CBOs source plastic waste mainly from informal areas, which results in flimsy plastic waste with low quality (JICA, 2010), further downplaying their competitive position vis-a-vis other suppliers.

[38] Interview with Mr. Ogendo on 12 February 2010.

[39] Interview with Ms. Medina the Chairperson of Carolina for Kibera on 19 December 2009. Carolina for Kibera is one of the CBOs collecting garbage in Kibera slums and also recovers plastic waste materials.

While the social network for CBOs is quite extensive with heterogeneous participants, their networks are devoid of strong and strategic alliances that could facilitate CBOs to push a unified agenda on value added activities on post-consumer plastic waste. CBO networks are too localized in specific city areas, thus limiting their activities to particular localities. Yet plastic waste problems are a widespread, and recycling manufacturers also source from larger areas, making the network position of CBOs not very strong. Regular members meetings of CBOs that are member of SACCOs were becoming scarce after donor resources withdrawal. In all, CBOs are part of a wide social network that together can boost plastic waste collection and further value addition. But in these networks, CBOs lack a powerful position and do not operate collectively.

Shaping and convergence of actor's expectations

CBO-SACCOs, donors, industries and governmental actors, and other social groups are part of the CBOs network. But to what extent do they converge in expectations? Expectations concerning the potential of CBOs activities to get rid of plastic waste from the environment seem to converge amongst the actors involved. Apart from the industries, whose primary motivation is economic relevance of the plastic waste material; other actors belonging to the CBO social network converge in having a wider expectation of CBOs than just delivering at industries. These wider expectations are related to solving plastic waste problems in local communities, job creation for community members, and training of community members. For example, Mr. Ogendo of Nyalenda Community Development Group explains how frequent interaction with the KMC Department of Environment enhanced his understanding of the by-laws, as well as changed his attitude on waste management: "I now know what is required by law. Whenever I see people littering the streets, I encourage them to use the litter bins."[40] Littering of city streets is an offence under the solid waste management by-laws and enforcement is the purview of city enforcement officers.

CBO members encouraging others to obey these by-laws means that expectations of CBOs and KMC (and even national authorities such as NEMA) are beginning to move in a common direction. However, CBO expectations of plastic waste activities are as much related to employment creation and economic income, than to a clean environment. Karanja (2005) found that for CBOs engaged in waste management activities, environmental goals are secondary to livelihood earnings. This combination of environmental and economic expectations converge with those of international donors – either governmental donors or non-state religious organizations and development NGOs. These donors have provided technical and financial assistance to CBOs in the hope that they are better positioned (compared to governmental agencies) to respond to community

[40] Interview with Mr. Ogendo an Official of Nyalenda Community Development Group on 12 February, 2010.

problems, including those related to plastic waste (Karanja *et al*., 2004). At the formation stages of CBOs, donor resources flow in to facilitate a number of activities such as regular consultative meetings of members, payments of other administrative costs, acquisition of tools and equipment and facilitation of trainings. Immediately, CBOs begin to engage in environmental activities that create awareness about their activities and increase their visibility. Consequently, such activities attract the attention of governmental actors with the principle mandate for environmental protection and management. CBOs are able to access important favors such as premises which have been useful in their plastic waste value addition activities.

Notwithstanding these convergences of expectations, it has proved to be difficult for CBOs to sustain these positive and high expectations with respect to environmental performance and economic community development. After donor funding and strong (city and national) governmental support and facilitation fades away, CBOs are unable to keep the momentum of plastic waste collection and value addition, resulting in a slowing down and sometimes even dissolvent of CBO activities in solid waste. Without drastic interventions and collective strategies of the CBOs and the network actors related to them, the future of these niche activities looks poor. Sales of plastic waste material are to guarantee CBOs economic income, but without external funding such sales prove to be inadequate, irregular and inconsistent. The situation is not any different for those CBOs who make final products out of plastic waste.[41]

Learning processes

Strategic niche management scholars emphasize the usefulness of broad learning processes that encompasses multiple dimensions, if the innovation process is to have a breakthrough. The CBOs learning processes have mainly focused on regulatory, policy and environmental effects related to plastic waste management, and to technological upgrading to allow new value-added activities. While there is no uniform platform to coordinate learning activities for CBOs, several learning opportunities involving an array of issues have come on the way of individual CBOs. Such lessons are not widely shared but only benefit individual CBOs or even individual members of CBOs.

Through international exchange programs and other training programs conducted by NGOs and NEMA, CBOs have learnt environmental and societal effects of waste. Such lessons have been useful in changing the framing of plastic as waste, towards one of a resource that should be utilized for conservation of materials and for economic income. CBOs have since been able to engage in waste recovery activities involving almost all types of waste (JICA, 1997; JICA, 2010; Karanja *et al*., 2004) (see Figure 4-1). International exchange programs have also equipped CBOs with technical knowledge to

[41] Interview with Mr. Munywe Chairman of Kayole Environmental Management Association on 15 July 2010. This CBO is based in Embakasi Division, Nairobi.

diversify their plastic value added activities, including final product making. City Garbage Recyclers and other CBOs went to India, organized by Practical Action (a NGO), to be exposed to a number of recycling projects on different waste streams. This changed their view of 'waste as waste' towards 'waste as a resource'.[42] For instance, following this exchange City Garbage Recyclers started composting and Riruta Environmental Group started waste collection activities as a result of learning the possibilities of collaboration with city authorities from Exnora International.[43]

CBOs have learned about policy and legal requirements for operating solid waste management activities. Through policy dialogues with city waste management authorities CBOs have learned operational procedures, policies and legal requirements of city authorities. This greatly facilitated acquiring operational licenses and permits which in a way, helped in gaining recognition and the formalization of waste value addition activities. Hence, it reduced harassment by city law enforcement officers. However, CBOs have learned how to operate on the market and follow user preferences, which are key for a successful economic performance and value added activities on plastic waste. CBOs have not cultivated any credible relationship with market actors that obtain them information on prices, preferred qualities, desirable quantities, etc. The unregulated nature of plastic recycling makes that plastic recycling industry, as the most powerful players in the value chain, control activities and information. But CBOs have also failed to set up profitable business for themselves, where costs and incomes, and return on investments figured in a long term strategy. Many CBOs also focused too little on the quality and state of plastic waste, which is a determining factor in prices and can be improved through diversification of waste supply sources. CBOs rely too often only on waste with lower value, from informal settlements, and with that they are unable to compete with other suppliers to plastic waste recycling industries.

Conclusions on the niche formation of CBOs value addition activities

The niche formation of CBOs value addition activities started as a loose set of social networks of community actors pursuing a general environmental agenda on a voluntary basis. Their activities attracted seed money from donors. With these funding, CBOs started to undertake a series of experiments and learning processes which gradually attracted policy actors and expanded the social network. However, when donors pull out and with limited prospects of continuity of funding, initial high expectations drastically drop and the core network actors diverge into pursuing different agendas. Hence, the niche formation of CBOs has a difficult time in gaining any stability. Despite having had a grasp of how to sort plastic waste and meet infrastructural requirements and SWM

[42] Interview with Mr. Macharia Chairman of City Garbage Recyclers, on 9 November 2008.

[43] Exnora International is an Indian environmental NGO operating in most municipalities on waste collection, sorting and composting activities.

policies, learning and dissemination of learned lessons is limited, especially with respect to markets, profits, and technological advancement.

4.4.2 Niche formation of CBO-SACCOs plastic waste activities

The niche formation around CBO-SACCOs plastic waste activities has not proceeded well beyond any donor funding period. Just like the CBOs, CBO-SACCOs failed to establish viable economic networks and to develop the capacity to function economically viable. Despite being part of a variety of networks, some of which extended abroad, CBO-SACCOs struggle to sustain their value addition activities. Even though CBO-SACCOs have a solid technological infrastructure they have found it difficult to compete on the market of plastic waste recycling and acquire sufficient income to continue functioning. Lessons learnt have been limited and not been properly applied to enhance the growth of those particular SACCOs. This section explains why CBO-SACCOs have been unable to sustain their plastic waste recycling operations.

Social network composition

The actor network in which CBO-SACCOs function involves international community actors, national policy actors, industrial actors, societal group actors including CBOs, and individuals. Except for KIWAMA, the other two CBO-SACCOs studied (namely Bamato Environmental and Sanitation Initiative and Nairobi Plastic Recyclers) cherished financial and technical support of several national and international non-governmental organizations (NGOs). The CBO-SACCO niche formation has been enabled and driven largely by active involvement of various international community organizations and NGOs. Box 4-2 shows the resources that went into – the now almost defunct – Nairobi Plastic Recyclers SACCO. UNEP, UNDP and the French Embassy provided initial financial and technical resources, while Practical Action coordinated learning activities.

Similarly, the Bamato Environmental and Sanitation Initiative SACCO in Kisumu began with financial assistance from Shelter Forum, a national NGO based in Nairobi. The international community actors have facilitated both international and local learning programs and have thus equipped CBO-SACCOs with technical skills, knowledge and information. Financial resources obtained through donors' networks were instrumental in equipping CBO-SACCOs with machines, in facilitating member meetings to disseminate knowledge and strengthen networks, and in paying salaries for officers overseeing operations on behalf of the members. In addition, city and national authorities through their departments of environment and planning have facilitated site allocations for CBO-SACCOs operations and supported them in facilitating permits and licenses. Site facilitation happened for Nairobi Plastic Recyclers SACCO and Bamato Environmental and Sanitation Initiative SACCO. NEMA has been the national institution for training on

waste management regulations, while Practical Action has also conducted in-house training sessions on marketing strategies. Through individual CBO members, CBO-SACCOs have been receiving waste materials, while networks with plastic industries have served as market linkages for CBO-SACCOs plastic waste products. At the industry level, linkages involved different industries all competing for plastic waste material.

Hence, overall, the networks around CBO-SACCOs have been extensive and quite supportive for the establishment and functioning of CBO-SACCOs. But the stronger part of the network with frequent and supportive relations has been centered on policy actors and donors, while the CBO-SACCOs have been weakly integrated in an economic network, which would make their niche activities sustainable after financial support ended. CBO-SACCOs relied too much upon the solid waste management part of its network and niche activities, and too little on the economic plastic production activities.

Shaping and convergence of actor's expectations

Expectations concerning the environmental benefits that are likely to accrue through CBO-SACCOs activities on plastic waste converged among the various actors involved, at least initially when these organizations and their waste collection and value added activities were initiated. There was a major convergence among network actors that CBO-SACCOs were well placed to cope with both the economic and the environmental dimensions of waste recycling. Moreover, there was convergence on the idea that these CBO-SACCOs were less vulnerable than individual CBOs, and thus could withstand periods of lesser economic activities, lower oil (and virgin polymer) prices, or more fierce competition. CBO-SACCOs were also expected to be influential towards city authorities and towards economic actors higher up in the value chain, negotiating favorable conditions, infrastructures and prices. However, due to limited inclusion of economic actors in the networks, it proved hard to keep up high expectations, especially for core actors (individual and CBO members). The CBO-SACCOs did not deliver according to these high and convergent expectations. The failure to sustain CBO-SACCOs plastic waste activities beyond the donor funding period led to major disappointments and downplayed the expectations of many members as well as donor organizations.

While CBO-SACCOs are formed to facilitate financial needs of (individual and CBO) members and therefore are confronted with economic expectations of these members, they pursued the view that through their huge technological capacity of value addition on plastic waste, they are well-placed to serve their members economically and solve environmental problems of plastic waste.[44] Expectations have been high at the initial stages of CBO-SACCOs formation, when they acquired machinery, and were able to demonstrate their capacity and knowledge on handling plastic waste to other actors of the network. These demonstrations served to win confidence on their ability to manage

[44] Interviews with representatives of CBO-SACCOs.

plastic waste and to generate income for their members. For the core actors, being a CBO-SACCOs member implied earnings from dividends, guarantees in selling plastic waste and access to opportunities for training in various aspects of waste management. These promises held their expectations high. Furthermore, the beginning of CBO-SACCOs' plastic waste activities were marked by high outputs and significant economic returns (see Text box 4-2) and members either earned or accumulated shares, which further strengthened their (future) economic expectations. The initial stages were not only marked by high expectations, but members were also very positive. CBOs recounted of how belonging to a consortium improved their competitive advantage over individual CBOs. For instance, a member of a CBO-SACCO in Kisumu explicitly noted that, "Individual collection of plastic waste means selling to brokers while as a co-operative society; we sell waste even to manufacturers." Similarly, the chairman of Riruta Environmental Sanitation, a CBO in Nairobi and a member of Nairobi SACCO remarked, "as a cooperative society, our bargaining power is increased and we are also able to influence city policies and to acquire land."

These high and converging expectations started to dwindle once CBO-SACCO donor funding which facilitated their day to day activities was no longer tenable. International and national donors expected that once CBO-SACCOs acquired sufficient relevant technical trainings, received machinery and equipment, and free land allocation, and developed a position in the plastic waste value chain, their operations should and could continue in a self-sustaining mode as viable parts of functional economic networks. However, due to the fact that CBO-SACCOs remained primarily CBOs and failed to develop sufficiently their economic functions and their economic networks, CBOs-SACCOs were unable to meet these high expectations once outside financial support stopped. There were no operations that enabled CBO-SACCOs to earn the necessary income to cater for their running costs, including electricity bills, machine maintenance costs, water bills, payment of salaries of administrative officers and still guarantee dividend. For instance, when Shelter Forum stopped funding Bamato Environmental and Sanitation Initiative SACCO, payment of salaries also stopped.[45] Furthermore, suppliers of waste could no longer receive their payments and be guaranteed of any other benefit resulting in irregular and decreasing supply of waste materials and problems in fulfilling contracts with manufacturers. Machinery could not run to full capacity or broke down. These problems together diminished expectations in the network around CBO-SACCOs, resulting in a rather rapid dissolvent of these organizations.

[45] Interview with Mr. Odhiambo the Secretary of Bamato Environmental and Sanitation Initiative on 12 February, 2010.

Learning processes

CBO-SACCOs appear to have learnt on a number of dimensions. The learning space has been broader and deeper than that of individual CBOs. Trainings were offered to CBO-SACCO staff on integrated technology, waste management requirements of the respective city authorities, national regulations on solid waste, and marketing of products. Trainings encompassed also international experiences in order to gain an overview of the range of recycling methods, organizational arrangements and technological requirements available internationally. Nairobi Plastic Recyclers SACCO officials, just like those of Riruta Environmental Group (REG), went to Hyderabad and New Delhi, India, in order to learn about the best available technologies and how to successfully engage in plastic recycling initiatives (see Text box 4-2).

Individual CBO-SACCO staff who learned of technologies for recycling and marketing, have used such knowledge to organize demonstration sessions where members came to learn; they also traveled within the country and the East Africa region to provide lectures on procedures and technologies of plastic recycling to create useful products. They also offered information on where affordable machines for value addition could be purchased best and what the technical specificities entailed. This all has been useful in spreading technological knowledge, creating larger opportunities for recycling and reducing the environmental burden of plastic waste. The learning processes on policies and regulatory requirements have enabled CBO-SACCOs and their member organizations to conduct their operations without any fear of harassment by law enforcement officers.

Learning processes have been less strongly focused on longer term business models for CBO-SACCOs and also not for member organizations. Too much emphasis was placed on technological hardware, on the technological characteristics of plastics, existing policies and regulations, and on an organizational model based on membership. Developing a long term profitable business case was not put central in learning, while subsidies were taken for granted and not questioned as a temporary, start-up phenomenon.

Conclusions on niche formation of CBO-SACCO value addition activities

In conclusion, the failure of the CBO-SACCOs to develop an attractive and successful niche formation can be attributed to a lack of focus in the sustainable economics of such niches, in the networks created, in the expectation developed and shared, and in the learning processes. Despite the significant social, technical and (initially) financial capital, the strong convergence of expectations of a large variety of actors engaged with CBO-SACCOs (members, policy-makers, international donors) and the wide networks these CBO-SACCOs were part of, CBO-SACCOs did not manage to develop into a successful niche for the takeoff of plastic waste recycling. Problems started to emerge when donors disengaged from the network, and it then proved that the construction with members, guaranteed prices and concentrated negotiating power with other partners in the plastic

waste recycling chain could no longer be sustained. Besides the three experimental CBO-SACCOs no other new initiatives were developed, preventing any significant take off. Basically, CBO-SACCOs faced the same predicament as CBOs, although the stakes were much higher for CBO-SACCOs whose activities had attracted large technological investment from donor funding and included many member organizations.

4.4.3 Niche formation of yard shop operators' plastic waste activities

The niche formation of yard shop operators' activities on plastic waste recycling appears to have proceeded well, despite limited networking opportunity with city authorities. There are an increasing number of individual entrepreneurs starting waste recovery activities. Expectations of yard shop operators are further continuation and growth and they converge with other economic chain actors. Learning opportunities have been properly utilized for improving their businesses. This section explains the near-successful development of yard shop operators in plastic waste recycling.

Social network composition

The actor network for yard shop operators comprises of waste materials suppliers (pickers, supermarkets, and industries), policy actors (NEMA and city authorities), financial actors, and industrial actors (semi-processors and industries). Yard shop operators, just like CBOs and CBO-SACCOs, have no inter-city social networks. Within their specific cities, they have established informal connections with their colleagues in order to respond to any demand of plastic waste material that may not be within their individual reach for clients. The waste material supply to yard shop operators has evolved from the traditional waste pickers towards supermarket outlets and industries. These new supply networks, which bring in much cleaner waste, have boosted the economic prospects of yard shop operators.[46] Due to these economic benefits and the high demand for plastic waste of industries, value addition activities of yard shop operators have been expanding over the years, with the majority of them developing businesses over the past 10 years.

The success of yard shop network building is largely based on their principal focus on economic networks. Yard shop operators exhibit extensive economic networks for supply of plastic waste material to the plastic production socio-technical system. First, all the three identified socio-technical routes completing the recycling chain (see Chapter 5) receive plastic waste material from yard shop operators. But they also sell to semi-processors of plastic waste. Second, particularly with regard to supplies to conventional recycling industries, an average yard shop operator supplies to a minimum of 3 industries. Characteristic of these networks were the intense activities depicted mainly by daily and

[46] Information received from Mr. Mutua during an interview on 14th February, 2009

weekly sales that kept economic returns high. These economic networks offered good prices to yard shop operators. Information, favors and mutual trust have helped yard shop operators to receive a solid return on their plastic waste from these industries. Through information sharing, yard shop operators were able to know the demand (in terms of quantity and quality) of industries and to develop mechanisms to respond to them. Yard shop operators have also responded to changing demands, for instance through developing relevant infrastructural requirements like constructed open troughs. Through mutual understanding, yard shop operators quite often received cash money in advance from industrial actors in anticipation of their supply at a later date. Others were facilitated by transportation means of industries, which they later paid for. This depicts the investment industrial actors are willing to put in these economic networks in order to reap maximum benefits. High levels of trust between yard shop operators and industrial actors are due to the former's competency, reliability, and adequate capacity. This has, in turn, resulted in strategic alliances between the two parties. This all resembles what Caniëls and Romijn (2008) see as of crucial importance in strategic niche management: "close interaction between actors is essential because important tacit informal and uncodified elements in new knowledge can only be absorbed and shared by means of intensive, indeed direct, communication and learning by doing.

Communication also helps to reduce uncertainty and complexity that are inherent in radical innovation processes". Lin (2001) and Snijders (1999), argue that good innovation performance is a direct consequence of dense contacts in the network, as it is through these connections resources such as information and knowledge flow. According to the literature on niche-regime interactions (Berhout *et al*., 2010), the feedback mechanisms that exist between yard shop operators and industrial actors are fundamental to their innovative performance and growth. Yard shop operators' economic network is not just based on raw material supply in a free market, but includes information and knowledge sharing and mutual trust.

Through advices received from industrial actors, some yard shop operators have sought collaboration with policy authorities and financial actors. NEMA is one such organization which has offered trainings and seminars on environmental provisions, particularly on procedural and regulatory requirements for solid waste recovery activities. As a result, plastic waste recovery activities from these yard shop operators are backed by formal operational licenses. Apart from these instances, where city authorities issued operational licenses, many yard shop operators have not a strong connection with city authorities. This has been a major drawback to their performance as yard shop operators have made sacrifices of paying bribes in order to sustain their economic expectations. Financial organizations (especially micro-credit institutions such as Faulu Kenya and K-Rep) are sometimes part of the yard shop operators' network. Yard shop operators have been able to learn and build basic entrepreneurial management skills through these networks, such as book keeping and accounting.

Shaping and convergence of actors' expectations

Despite the frequent harassments that yard shop operators encounter with some errant enforcement officers of city authorities, expectations of actors within the network of yard shop operators seem to converge towards a common expectation that their plastic waste value addition activities contribute to employment creation, economic prosperity and environmental improvement. NEMA, with the overall national mandate on environment, has particularly been keen in ensuring that relevant environmental knowledge and information was disseminated to improve environmental outcomes of yard shop operators' activities, without necessarily making payments to the organization. City authorities, through their environment departments, have sometimes facilitated operational licenses for yard shops to ensure that their economic activities are conducted within the broader environmental requirements of the city.

Economic expectations remain fundamental in the network of yard shop operators. Such expectations are high as the demand for plastic is higher than what yard shop operators can supply, despite their ever expanding capacity to respond to such demands. Furthermore, the new sources of waste, with better quality, are shaping actor's expectations of greater economic returns. Payments for waste materials are immediate and done in cash by industrialists to yard shop operators and by yard shop operators to pickers. This arrangement is key in sustaining economic expectations without delays in payments. The daily and weekly sales serve to keep such expectations high. Social proximity of economic actors was crucial in fulfilling these economic expectations.

Economic expectations enable yard shop operators to invest in tangible infrastructural facilities. In Nairobi, for example, three yard shop operators who had been in business for about 15 years, had invested in transportation trucks and constructed troughs for cleaning of plastic waste.[47] These investments further shape future economic expectations of yard shop operators. But yard shop operators lack a common forum through which they could represent their common interests and help stimulate newcomers. Yard shop operators do understand the urgent need of a networking forum through which they could share information and (technical) knowledge, represent common interest and negotiate with policy makers and industrialists.

However, future economic expectations may be jeopardized by an unsupportive environment. The premises of yard shop operators are exposed to unpredictable natural (weather) and human hazards (harassment of enforcement officers, bribes, and new infrastructures), a widely shared fear among these businessmen. Furthermore, yard shop operators are not credit worthy given the fact they operated as individuals without any

[47] Pride Street Services, 2001, located on Enterprise Road, Wilzaks Steel, 1995, located on Digo Road and Wato Plastic, 1997, located on Ambira Road.

networking organization. This state of affairs reduces possibilities of major investment and growth of their activities.[48]

Learning processes

Yard shop operators have learnt a number of lessons through a variety of processes. Such lessons mainly focused on markets and how to respond to the demand requirements. Through their close association with industrial actors, yard shop operators have come to learn the favors and seasonality in demand for particular types and volumes of waste. Yard shop operators have used such lessons to engage in aggressive search for additional supply. Many yard shop operators make phone calls in the morning to pickers within their supply network to pass information of requirements.[49] Yard shop operators have learned to become reliable suppliers of plastic waste within the recycling chain, even though demand of industrial actors is still far from being met (see Chapter 5). Yard shop operators have learned the qualities of women in sorting different plastic waste types.[50] Economic lessons have also been learnt from micro-financing organizations (see above).Yard shop operators learnt about regulatory requirements to conduct their activities with city authorities and NEMA licenses/permits, to which a good percentage complies (59%).

Conclusions on the niche formation of yard shop operators' innovation activities

In conclusion, the relatively successful niche formation of yard shop operators is largely based on their strong and integrated economic network, which entails not only material flows but also mutual understanding, sharing of information and knowledge, semi-permanent relations and trust. Lessons learnt by the yard shop operators have been used to enhance and sustain their performance despite having to operate in difficult environmental and enforcement conditions.

4.5 SWM socio-technical regime and innovation activities

The extent to which plastic waste activities of CBOs, CBO-SACCOs and yard shop operators are able to take off and have an impact on plastic waste management depends also on the SWM socio-technical regime. This section discusses the impact a number of SWM regime domains have on facilitating and hampering the development of these innovative activities in plastic waste management. The domains of most interest are regulation, policies and infrastructure, and financial resources.

[48] All yard shop operators interviewed in this study expressed such fear.
[49] Interview with Ms. Njoki, a yard shop operator based at Kijabe Street, Nairobi, on 23rd March, 2009.
[50] Interviews with Mr. Mutau, owner of Brule Yellow Bins on Lunga Lunga Street, Nairobi, on 14 February, 2009, and with Ms. Njoki, a yard shop operator in Kijabe Street, Nairobi, on 23 March, 2009.

4.5.1 SWM regulations and innovation activities

As has been mentioned in Chapter 2, the Local Government Act (CAP 265) and the Public Health Act (CAP 242) form the core of the regulatory framework for SWM. Under these Acts, city authorities enacted by-laws that organize "the duty of containment and effective collection of solid waste". Offences of the Acts and related city by-laws, e.g. dumping waste and littering, are punishable. Most importantly, these regulatory provisions never recognized the material value of waste, as landfilling was practiced as the most suitable disposal of waste, while recycling received hardly any attention.

The enactment of EMCA, 1999, a framework law that regulates the coordination and supervision of environmental activities, brought a new regulatory outlook by recognizing waste material recovery as a key activity in SWM. The NEMA promulgated solid waste management regulations that recognize recycling as a means of solid waste management and gave procedural duty to license waste transporters and other solid waste management facilities (Republic of Kenya, 2006). Based on this law, city authorities have up-dated their solid waste management related by-laws by formalizing working relationship with non-state actors for better SWM services (e.g. City Council of Nairobi, 2007). These developments gave non-state actors the possibility and the formal requirements to operate their value added activities on solid waste. It clearly created a solid waste regime that was no longer only focused on landfilling, but also on recycling and reuse of various kind of waste.

However, actors in the recycling and reuse business still face numerous challenges with these regulatory requirements and are hindered to make an effective contribution to plastic waste material recovery activities. Under the specific city by-laws, non-state waste handling actors, especially yard shop operators, have to register as a business annually at the costs of Ksh. 10,200 (USD 136). In addition all the waste management actors need an operational license of Ksh. 8,500 (USD 113) per year, together with a supervision fee of about Ksh. 2,500 (USD 33) per year, from the city environment department. These formal requirements are expensive for CBOs, CBO-SACCOs and yard shop operators and do no incentivize them to start a new business. Furthermore, implementation and enforcement of these requirements comes with an added burden to these non-state actors. For instance, all vehicles transporting waste should be properly covered to avoid littering while all waste related activities should be conducted in a manner that does not cause nuisance. However, the enforcement of such provisions by city enforcement officers often leads to punishment of vehicle owners, even in cases when they do not litter the environment.[51]

City enforcement officers use these provisions also to punish and harass yard shop operators, forcing them to engage in a game of 'survival of the able', where a number of

[51] Information obtained from Mr. Muthoka, a yard shop operator in Mombasa during an interview on 19th March 2009.

yard shop operators pay significant sums of money – in the range of Ksh. 8,000-10,000 (USD 107-133) per week – as a 'protection fee' to enforcement officers. Officially, they are sentenced for a dumping or littering offence, a penalty which commonly only involves Ksh. 2,000 (USD 27). For yard shop operators, these are huge challenges imposed by the SWM regime, which hampers the development of their plastic waste activities. Monetary coercion and the willingness to pay for taxes within the informal economy is a contemporary phenomenon in Kenya. K'Obonyo *et al*. (1999) and Graham *et al*. (1998), in their study of the informal sector economy in Kenya, found out that owners of informal businesses paid bribes and still were willing to pay for taxes. The solid waste management regulations of 2006 do not provide any tax reprieve to these novel actors. Rather, there are additional procedural and licensing requirements. Initiating what is referred to as 'reprocessing facilities' under this regulation costs Ksh. 3,000 (USD 40), regardless of size and type of the facility. The annual license fee to operate such a facility is Ksh. 40,000 (USD 533). These charges are prohibitive and present significant barriers to the further growth of plastic waste collection and processing activities.

The complex division of tasks and responsibilities in waste management between cities and the national state also creates complications. For example, most yard shop operators and CBOs who sought to operate 'formally' have local city business and waste transportation licenses. NEMA has now started to register them and this is already creating confusion between NEMA and City authorities. In such confusion, many still operate in an environment similar to that of informal entrepreneurs (Baud *et al.,* 2001: 4). As long as this state of affairs continues, the integration of these activities with the formal SWM will be hampered and also affect the non-state actors' capacity to bargain better with plastic producers to whom they sell their post-consumer plastic waste.

Despite their positive contribution to environmental management, and especially to solid waste management, the CBOs, CBO-SACCOs and the yard shop operators have to be incentivized by the EMCA 1999 regulations. While all three actors are aware of NEMA's role in the implementation of EMCA 1999, and have benefited from its trainings on compliance to the Act, they were all bemused by the negative incentives in these provisions. The failure of NEMA to roll out a plan for positive incentives is a setback to the growth of innovation activities. As far as regulations on SWM are concerned, these are not properly formulated, designed and implemented to promote waste recovery activities. The regulations are at the moment marred with multiplicity and prohibitive requirements, and the enforcement of these regulations comes with too much 'creativity' of enforcement inspectors. Overall, this provides hardly any enabling and stimulating environment for the takeoff of new plastic waste recycling activities.

4.5.2 SWM Policies and innovation activities

Several policies have been developed on SWM in Kenya (Ikiara *et al*., 2004a). However, these policies are characterized by incoherency as they are scattered and do not make a coherent substantial contribution to proper management of plastic waste (UNEP, 2005a). These policies are also poorly coordinated within the SWM sector and have not rationalized the potential contribution of both state and non-state actors to SWM.

The national medium term plan (2008-2012) of Kenya Vision 2030 recognizes the problem of solid waste affecting the urban localities, and proposes the development of waste management strategies where youth groups can be engaged mainly in collection of solid waste. This policy is strongly focused on the efficient collection and disposal of solid waste and fails to recognize the potential of material recovery that youth, and especially yard shop operators, are already involved in. As such the plan fails to set the path to an integrated solid waste management system.

Another policy is contained in the Economic Recovery Strategy for Wealth and Employment Creation (2003-2007). It recognizes the dysfunctional state of city authorities and the absence of a waste recycling policy. However, it fails to recognize the already existing actors engaged in the solid waste management sector and to build upon these niches by assigning them responsibilities and facilities. Instead, the Economic Recovery Strategy for Wealth and Employment refers to EMCA (1999) to work on these challenges, again focusing primarily on collection and landfilling. Equally, Sessional Paper No.6 of 1999 on 'Environment and Development' recognizes the need to encourage re-use and recycling of solid waste through economic incentive provisions. In support of this and other policy pronouncements, EMCA provides a legal basis for the realization of various incentives, especially for improved environmental performance. Nonetheless, the implementing authority, NEMA, has not formulated and implemented any incentives, nor a procedure to develop such incentives. The Draft National Solid Waste Management Strategy of 2008 furthermore stipulates a statutory 30% of waste recovery within city jurisdictions by the year 2018, and to progressively recover over 50% of the waste by the year 2030. These targets are in line with the environmental aspirations of Vision 2030. However, the strategy fails to operationalize this into concrete actions and there is no deliberate attempt to coordinate, harmonize and focus activities of all – state and non-state – actors towards the ambitions of sustainable waste management as formulated in this plan.

In conclusion, the SWM policy provisions are still largely centered on the classical approaches of efficient collection and landfilling. In cases where recycling of solid waste is mentioned, they fail to provide a framework and operationalized strategies within which non-state actors are stimulated and incentivized to engage, Hence, these actors, and in fact recycling as such, is moved to the periphery of solid waste planning and policy. This continues to jeopardize the further development and the legitimacy of plastic waste recycling activities.

4.5.3 Infrastructures and innovation activities

Infrastructures are a basic element for the effective realization of both health and environmental goals of any SWM system. Kenya's SWM services are characterized by inadequate infrastructural provision that over the years has systematically deteriorated. Today, there is no provision of centralized waste containers which used to facilitate communal waste collection. This has fundamentally affected the operations of non-state actors whose value addition activities are characterized by informal settings, which not only constrains their operational activities at specific locations, but also make it difficult for their clients to access such locations. Except for a few CBOs and CBO-SACCOs, who through temporary occupational licenses or partnerships got land allocated to them by city authorities, the other actors either paid prohibitive rents to sites which were temporary or, squatted on strips of public land along streets or the riverside.[52] They operated in a provisional structure that exposed their equipment to harsh weather conditions and other unpredictable calamities. Many of them lost their investments and livelihoods during the post-election violence that marred the disputed presidential election of December 2007.

Especially yard shop operators face problems related to space (for storage purposes) and premises (actual site). From the interviews conducted in this study, majority of yard shop operators (63.8%) mentioned space as a major infrastructural challenge. For CBOs, it was logistics (70%) and this was similar with CBO-SACCOs at (67%). Problems with logistical infrastructure, which mainly involved picking, transporting and delivering their waste materials, was a more common challenge among CBOs, as they mainly operated within residential areas and within informal settlements (with less easy access), and have less often easy access to transportation equipment.

One of the necessary requirements for value-added activities in the SWM system is designated worksites which would act as storage areas for waste. This requirement has been identified as being crucial in the growth of the informal sector at large in Kenya (Republic of Kenya, 2005). The to be established National Council for Small Enterprises (NCSE) should coordinate the required reforms including harmonization of trading licenses, initiating legal reforms for the growth of informal activities, promoting access to credit and finance, and enhance access to workplace and security of tenure. Implementation of this policy recommendation has the potential to lift the infrastructural, financial and regulatory conditions of CBOs, CBO-SACCOs and yard shop operators by changing the current unsupportive environment.

As discussed in Chapter 2, SWM services are mainly financed by specific city revenues, with occasional financial flows from the national government. But these finances are basically spent on public and large-scale private collectors, and for landfilling. CBOs, CBO-SACCOs and yard shop operators all mentioned lack of financial

[52] Many CBOs and yard shop operators lacked the privilege of entering into agreements with city authorities for space. They all paid exorbitant charges as rent for their operational bases to *bona fide* owners, whether it were city authorities or private persons.

support as one of the key challenges associated with their operations. There seems to be potential for lending facilities, including funds from government financial devolution structures, such as Youth Enterprise Fund (YEF), Constituency Development Fund (CDF) and the Local Authority Transfer Fund (LATF). Individual yard shop operators were not able to tap from these funds and lack an umbrella organization for collective action to make such credit facilities available. CBOs and CBO-SACCOs could approach these funds, but used them only as subsidies, rather than as credits to be refunded.

Usage of water and electricity are not differentiated to favor recycling businesses, but instead, are supplied on equal basis across the economy. All the three actor categories had high water expenses, with yard shop operators' costs being as high as Ksh. 6,000 (USD 80) per month. Under the current water consumption tariff structure, informal activities are grouped under commercial/industrial category (large consumers), with a cubic meter costs of Ksh. 28 (USD 37 cents).[53] This undifferentiated water tariff lacks sensitivity to enable and stimulate innovation.

In conclusion, policy pronouncements and the existing regulatory measures are positive steps towards a favorable regime for waste material recovery. However, the policies remain merely broad statements and have not been translated into concrete measures that address the needs of CBOs, CBO-SACCOs and yard shop operators. Furthermore, these policies lack financial lending provisions that are flexible and within reach of these actors to enhance their capacity and performance. This reflects findings in the literature on post-consumer waste management, which claims that environmental breakthroughs are far away, mainly due to the inferior technical and administrative capacities of the prevailing regime (UNCHS, 1998; JICA, 1998; UNEP, 2005a).

4.6 Socio-technical landscape and plastic waste activities

In transition theory, landscape variables are seen as potentially providing windows of opportunity for innovations, since some variables might create pressure on the existing socio-technical regimes to yield to such new order. If not, landscape variables just create stability of the existing socio-technical regime. This section explains two landscape variables that have played a role in the triggering off plastic waste recycling activities.

After experiencing moderate economic growth rates in the 1960s and 1970s, Kenya's economic performance has been characterized by erratic growth (Radeny, 2011). Consequently, it failed to offer decent employment opportunities to the increasing population. In particular, youth unemployment is a significant problem. It is noted that 60 per cent of Kenyans are under the age of 35 (Republic of Kenya, 2010a), an estimated 64 per cent of unemployed Kenyans are youth (http://www.africa.sauder.ubc.ca). Most new entrants to the labor force are compelled to choose between working in small-scale

[53] Water tariff structure for 1st June 2009 to 31st May 2010. Regular Tariff Adjustment of Athi Water Services Board (AWSB) under Water Act, 2002.

enterprises or being self-employed. According to the 1999 Micro and Small Scale Enterprises (MSE) baseline survey, the informal sector employed 2.4 million persons which increased to 5.1 million persons in 2002 according to the economic survey of 2003 (Republic of Kenya, 2005). These high levels of youth unemployment drive the search for recycling activities and to add value to waste. Waste material recovery and selling has been attractive to many young people living in cities as a source of gainful employment. In that sense the landscape condition of poor economic growth and large unemployment favors plastic waste recycling of especially waste pickers and yard shop operators.

Second, major urban centers in Kenya are increasingly absorbing poor people due to rural-to-urban migration. This human surge has been building pressure on the SWM services of cities, financially and physically, which resulted in skewed waste collection and disposal services where informal settlements hardly have access to formal city waste services. Generally, waste collection is poor in Kenya's major urban centers with an average daily collection of about 30 per cent (JICA, 2010, Republic of Kenya, 2010b). This favors the involvement of the (migrated) urban poor in waste collection in these informal settlements, and to subsequently use collected waste for material recovery activities. Waste recovery activities within these informal settlements have positive ramifications in offering environmentally friendly solutions to waste problems, including plastics, and creating informal employment.

4.7 Conclusion

This Chapter has analyzed CBOs, CBO-SACCOs and yard shop operators with respect to their innovation activities on plastic waste management. While CBOs and CBO-SACCOs developed through foreign donor support with broader expectations than just making an economic business out of waste, yard shop operators are purely economic actors who view their waste management activities as a security to their employment needs. Yard shop operators have been able to maximize on opportunities for learning to ensure that they sustained viable economic networks. Despite the unsupportive SWM regime, yard shop operators have the drive to ensure their ultimate goal of satisfying industrial actors plastic waste needs were met. In this way, yard shop operators have built some capacity to respond to the environmental challenges of plastic waste.

In contrast to yard shop operators, CBOs and CBO-SACCOs whose broad expectation is to grant greater environmental leverage as well as social security of their members do not appear to have any sustainability agenda once donor funding has stopped. Extensive lessons that these two agents learn are never put to the full development of plastic waste management activities. This limits chances of CBOs and CBO-SACCOs to guarantee a clean environment and to attract industrial actors as credible suppliers of plastic waste.

5 SOCIO-TECHNICAL ROUTES COMPLETING THE PLASTIC RECYCLING CHAIN

5.1 Introduction

Plastic waste recycling is not a recent phenomenon in Kenya. In a survey conducted by Mugambi (2001), over 90 percent of Kenya's plastic manufacturing industries have internal reprocessing capacity for own waste and material rejects. This history of plastic waste recycling dates back to the 1960s. During these early years, virgin polymer using manufacturers already established internal recovery processes for their by-products.

As Kenya implemented a variety of policies at different times in realization of her vision of becoming a newly industrialized country (NIC) by 2020, it is evident that plastic manufacturing is increasingly becoming more diversified in its actors and products than before 1990. The diversification is creating a relationship between plastic production industry and the solid waste management socio-technical system. A number of industries either wholly or in part, produce products from plastic waste materials supplied from solid waste management socio-technical system through a chain of actors: conventional recycling industries, home-grown recycling industries and companies exporting to China.

Conventional recycling industries are industries either producing plastic products based wholly on post-consumer plastic waste or on a mixture of virgin raw material and post-consumer plastic waste. Their products mimic those produced from virgin raw materials by conventional plastic producers. Thanks to their 'good' quality products they have secured a relatively big market share (33%) (calculated from Figure 2-5 in Chapter 2) in the plastic manufacturing sub-sector. Their security in the market place is also attributable to their production capacity which is comparable to those of mainstream plastic production industries. Over time, actors of this route have relied on waste pickers (Wilson *et al*., 2009; Medina, 2000) and waste arising from their own production processes (Mugambi, 2001) as their main sources of plastic waste.

However, with increased demand at the local market and the desire to offer more variety in the market, the 1990s marked the entrance of completely new entrepreneurs to the plastic manufacturing sub-sector. The so-called *home-grown industries* are an alternative route to post-consumer plastic waste recycling in Kenya. This actor category produces diverse products largely for local consumption from 'raw plastic wastes' with hardly any value addition (-sorting, separating and cleaning).

Towards 2000 when trade licensing requirements and foreign exchange controls were abolished (Ndung'u, 2000; Were *et al*., 2002) allowing Kenya's goods to access regional and other overseas markets, a third entrant to the trail of post-consumer plastic waste recycling emerged in the form of *companies exporting semi-processed plastic waste to China*. The core business of the actors is semi-processing and export of Polyethylene Terephthalate (PET) flakes to China which are used in the Chinese textile

industry (Kuczenski and Geyer, 2010). This export route emerged in 2000 and coincides with the ever expanding global market opportunities and the search of business opportunities outside the almost saturated plastic manufacturing sub-sector in Kenya.

Semi-processors increase quality and reduce the volume of post-consumer plastic waste along the recycling chain. Semi-processing is not new in the plastic manufacturing sub-sector. Since the 1980s, other industrial entrepreneurs have been mediating the flow of post-consumer plastic waste from the SWM socio-technical system to plastic manufacturing sub-sector. The novelty to the approach of semi-processors is the value addition through technology of granulation and shredding of post-consumer plastic waste. Through value addition, semi-processors are mediators between actors at the SWM socio-technical system and the socio-technical routes of conventional recycling industries, home-grown industries and exporters to the Chinese market.

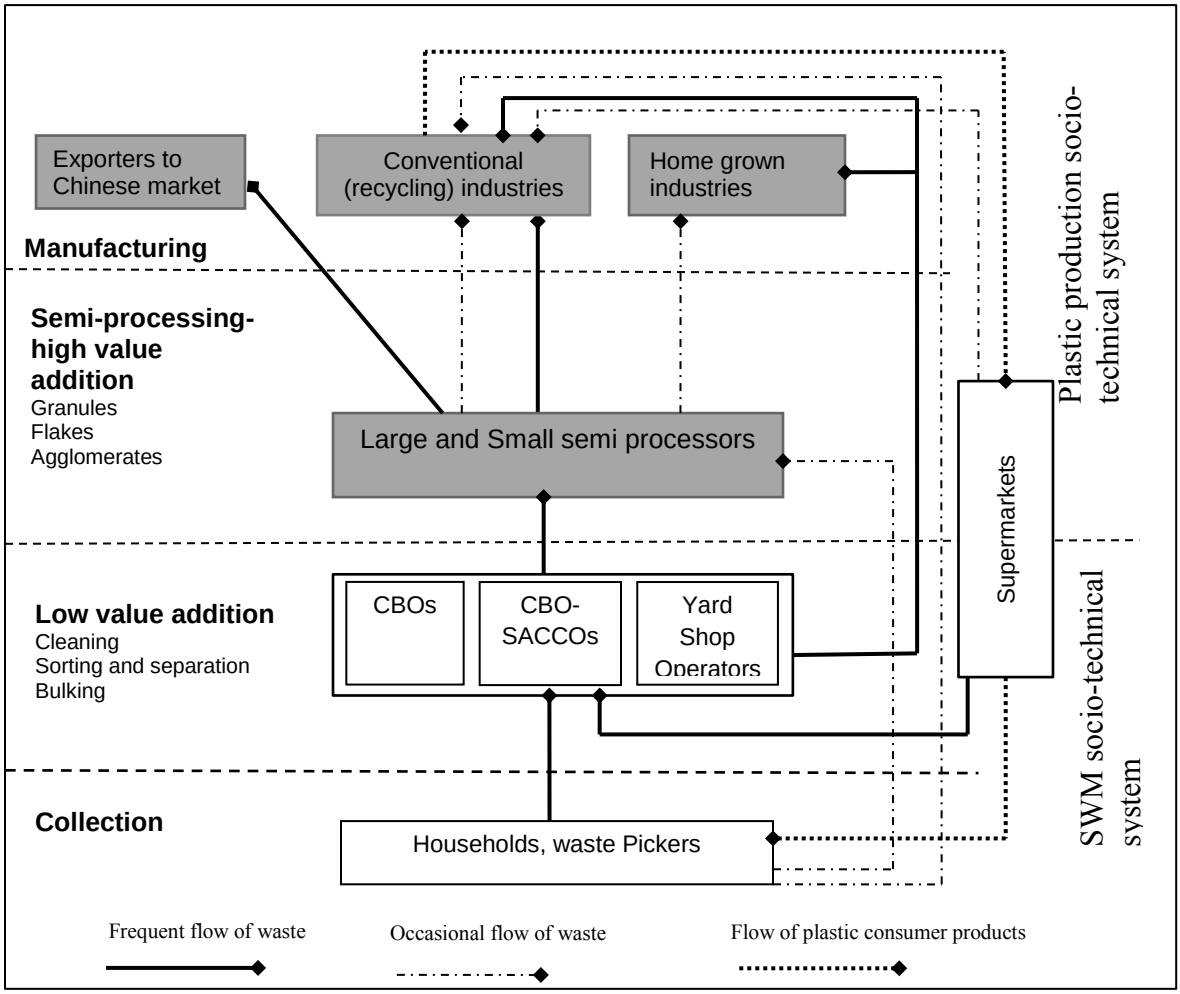

Figure 5-1 Actors embedded in plastic production, retail, consumption, and recycling activities-highlighting actors around plastic waste recycling innovations (constructed by author)

This chapter first presents the operations of semi-processors, followed by an evaluation of their intermediary role. The chapter then presents operations via the three socio-technical routes and analyses each within the framework of strategic niche management. An assessment of the impact of the plastic production socio-technical regime on the socio-technical routes is then done, followed by an evaluation of the landscape variables as they present opportunities or hindrances to plastic waste recycling. Key emphasis is placed on the assessment of the three 'Manufacturing' actor categories (see Figure 5-1) and suitability of their activities for sustainable post-consumer plastic recycling. The activities of the actor categories are referred to as three socio-technical routes completing post-consumer plastic recycling.

5.2 Semi-processors

This section presents the operational features of semi processers and an assessment of their potential intermediary role in directing the post-consumer waste flow between the actors of the SWM socio-technical system and the three socio-technical routes of plastic waste processing.

5.2.1 Operational features of semi-processors

As demand for post-consumer plastic waste becomes high through competition in the plastic production socio-technical system and the opening up of new markets at the international level, semi-processors have emerged at the fringe of the plastic manufacturing sub-sector with new value addition technologies, as previously used only by conventional recycling industries.

The first (large) semi-processor to emerge in 1982 was an industrial entrepreneur buying plastic waste from street and dump waste pickers. According to Mr. Nitin Shah, the Managing Director of Rainbow Plastics, the long distance his suppliers walked from Dandora dump site (source of waste) to the industrial area (his office location) compelled him to initiate a plastic collection programme at the dump site[54]. Through this initiative, pickers at the dump site gathered post-consumer plastic waste, which was later collected and delivered by the company trucks to the industrial area. The company, which at the moment has a monthly handling capacity of 200 tons of waste material, has established a broad base of collection with about 30% primary waste from industries and about 70% from yard shop operators as there is no direct linkage anymore with pickers.[55]

[54] Information obtained through an interview conducted on 05/03/2009 with Mr. Nitin Shah, Managing Director of Rainbow Plastics located in Nairobi. Dandora is the only designated solid waste disposal site in the City of Nairobi.

[55] Information obtained during an interview with Mr. Nitin Shah, Managing Director of Rainbow Plastics on 05/03/2009.

The majority of semi-processors work at small-scale. Each of the 7 interviewed semi-processors agrees that there is a continuously increasing demand for their waste material especially at the local market. Similarly, semi-processors agree that they have a unique position within the recycling chain. Unlike yard shop operators, who only execute/make limited value addition, such as cleaning and bulking, or CBOs and CBO-SACCOs, who failed to sustain technological value addition activities (see Chapter 4), semi-processors have demonstrated their technological capacity in the recycling chain and as such add value to plastic waste.

The bedrock of semi-processing activities is in Nairobi's industrial zones. Small-scale semi-processors squat at the back yard of main industrial enterprises, while large-scale actors are part of the mainstream manufacturing sub-sector. The common activities of semi-processors in the recycling chain entail the separation of post-consumer plastic waste by density and colour; washing, grinding, agglomerating and drying. Large scale semi-processors engage also in palletizing. Through these activities, semi-processors reduce the volume of post-consumer plastic waste, supplying material to actors of the plastic production socio-technical system in a more convenient state. They also resolve the needs of yard shop operators and CBOs (see Chapter 4), particularly through their transportation and storage facilities. Semi-processors have their own transport means with large and well secured operational sites. As such semi-processors have secured a position within the recycling chain that is reordering traditional relationships between the pickers and manufacturers, which for a long time characterized the post-consumer plastic waste recycling (Wilson *et al*., 2009). Very few pickers still have direct supply linkages of waste material with conventional plastic waste manufacturers.

Table 5-1 Operational features of semi-processors

Actor	***Average post-consumer plastic waste/month (tones)***	***Type of technology us***	***Final product***	***No. of employees***	***Unit selling price/Kg (Ksh.)***
Small scale semi-processor[56]	20-30	Granulation, shredding, agglomeration, manual cutting	Granules, agglomerates	5-10	25-35 (US$ 0.33-0.47)
Large scale semi-processor[57]	140-200	Granulation, washing machine, extrusion, palletizing	Granules, flakes	10-50	25-55 (0.33-0.73)

Source: Constructed by author from fieldwork data.

[56] The operational definition of small-scale semi-processors means: - operators whose monthly product output is less than 50 tons and employs less than 10 persons.

[57] The operational definition of large-scale semi-processors means: - operators whose monthly product output is over 50 tons and employs over 10 persons.

Table 5-1 shows the technologies semi-processors apply in the course of their operations. While large-scale semi-processors operate with imported machines which are brand new or second hand, small-scale semi-processors operate with locally fabricated ones. Semi-processors operate on a 24 hour basis. This trend of operation subjected machines to frequent break downs (especially those of small-scale semi-processors) resulting in high maintenance costs.[58]

Large and small semi-processors operate with both permanent and non-permanent employees on a 24 hour shift basis. Permanent employees are mainly on the production line operating machines, while non-permanent employees engage in further sorting and washing, particularly in cases of small-scale semi-processors who perform manual washing. Engagement of women in sorting was observed amongst semi-processors just like in the case of yard shop operators. Semi-processors reported seasonal variations in demand for waste materials with low demand being recorded during wet periods. Plastic waste materials tend to accumulate grit and sand when it rains and if not properly washed, a lot of impurities would remain in semi-processed waste material. However, high-density polyethylene stands out as the plastic waste type with high and consistent demand.

Local technical institutions, including Kenya Polytechnic, Nairobi Technical Institute and Mombasa Polytechnic have been useful in training technicians operating semi-processing machines. [59] Any further skill development takes place via on-the-job training. There are clear differences between large-scale and small-scale semi-processors including the number of employees (see Table 5-1). Small-scale semi-processors operate grinders with production capacities ranging between 30 kg to 50 kg per hour and agglomerators of 40 kg per hour, large-scale semi-processors work with grinders of larger capacities ranging from 70 kg to 200 kg per hour. This is more efficient and it results in a large output in comparison to small-scale ones.

Semi-processors show diversity in their preferred supply routes of waste materials, from both yard shop operators and CBOs as discussed in Chapter 4. However, yard shop operators are the dominant suppliers. A few instances exist where large semi-processors receive waste from manufacturing industries. Some variations were observed in terms of the market outlet of semi-processors. Large-scale semi-processors only supply to conventional recycling industries and the Chinese market, while small-scale semi-processors supply largely to conventional recycling industries and to a limited extent, to home-grown industries.

Regardless of their variations in handling capacity and number of people employed, large and small-scale semi processors are subjected to the same regulatory and compliance requirements applied in the wider plastic manufacturing sector.

[58] Information obtained from Mr. Kuria of Time Plastics during an interview on 17th September 2009
[59] Information obtained during interviews with operators at different times.

5.2.2 Semi-processors as intermediary actors

Having outlined the operational characteristics of semi-processors, this section evaluates their intermediation role in the flow of post-consumer plastic waste within the recycling chain.

Recent literature on waste recycling in developing countries largely focuses on the role of informal sector actors in the solid waste management socio-technical system (Ali, 1997; Furedy, 1999; Wilson *et al.*, 2006; Wilson *et al*., 2009). Hardly any study has been made of the value addition activities of various actors along the recycling chain up to the final manufacturing. Often, waste pickers and itinerant waste buyers have been identified as the only suppliers of waste to the industry (Nzeadibe, 2009; Fahmi and Sutton, 2006; Agunwamba, 2003; Medina, 1997). However, in Kenya, semi-processors have emerged with activities that had been conducted by mainstream recycling industries in the past. They have secured a market position through technological transformation of post-consumer plastic waste materials, according to the requirements of plastic production socio-technical actors.

Semi-processors mediate waste material between actors of the SWM socio-technical system and those of the plastic production socio-technical system. In this regard, they are a critical link in the flow of plastic waste material to three socio-technical routes: conventional recycling industries, home-grown recycling industries and exporters to the Chinese market.

How do semi-processors maintain their position in the plastic recycling chain? To begin with, the value addition activities of semi-processors result in dramatic volume reduction and better quality of post-consumer plastic waste. As a result, the waste material has a higher unit value in the recycling chain compared to the value gained by actors at the SWM socio-technical system (see Table 5-1 and Table 4-2).

A second feature supporting the intermediation role is that semi-processors are located at close proximity to manufacturers. This has a profound effect on transport expenses, which was traditionally regarded as a fundamental barrier to effective performance of the SWM socio-technical system. Despite the close proximity of semi-processors to industries, they have acquired transport vehicles to deliver materials to manufacturing actors. In chapter four, yard shop operators who emerge as promising link with the plastic production socio-technical system bemoaned transportation costs associated with their operations and even paid large sums of money whenever industries offered them transport alternatives. Equally, CBO and CBO-SACCOs cite transport as the major barrier to their effective performance. Semi-processors with their location in Nairobi are able to respond to transport needs of yard shop operators and CBOs and conveniently meet the material demands of manufacturing actors.

Third, semi-processors operate as formal establishments with compliance requirements such as city authority's business permits and annual environmental audits that are demanded by NEMA. This official status guards their operations against any

possible hostility or harassment from law enforcement officers. Semi-processors have also benefited from the transfer of knowledge from or facilitated by government agencies, because they are easy to be identified as legal entities. For instance, Wasteward Enterprises, a small scale semi-processor on several occasions received technical support from KIRDI for the repair of their grinding machines.[60]

Fourth, semi-processors are flexible in their operations as they operate on a 24 hour shift. The flexibility in operations enables them to respond to the demand of manufacturing actors and further win their confidence in the recycling chain. This is unlike the innovation actors at the SWM socio-technical system who only operate during the day as a result of insecurity associated with informal areas.

Lastly, semi-processors can handle large quantities of plastic waste at a given time in comparison to innovation actors discussed in Chapter 4 of this thesis. Because of their capacity, they are able to respond better to the ever expanding demand of manufacturing actors. As a result of these features, their waste materials fetch better prices: Ksh. 25 (USD 0.33) per kg in comparison to innovation actors at the SWM socio-technical system who only sell up-to Ksh. 18 (USD 0.24) per kg of waste material (see Table 5-1 and Table 4-2).

Despite the intermediary role semi-processors play, a number of challenges stand on their way in maintaining this crucial role in the recycling chain. First, the majority of semi-processors operate at a small scale. This implies their output and related economies of scale are low as compared to actors at the manufacturing level (see Table 5-1 and Table 5-2). Yet they are subjected to compliance requirements similar to those for manufacturers of plastic products. This does not differentiate them from manufacturers whose products are sold for between 2-4 times more. For this reason, they face unfair competition. Second, majority of semi-processors (small scale) operate with locally fabricated machines that have poor performance which is typical for new inventions. This situation is likely to jeopardize their expectations and further expose them to failure of meeting demand by manufacturers. Thus the inadequate technological capacity of semi-processors calls for up-grading of their machines if they are to meet their expectations and further respond to the needs of manufacturing actors.

Third, activities of semi-processing actors are limited to Nairobi only and they need to link to the entire four major cities. The skewed physical location disadvantages them to effectively respond to post-consumer plastic waste spread all over Kenya's major cities.

Fourth, even though machines of semi-processors are operated by trained personnel from local technical institutions, improved functioning of machines especially for small-scale semi-processors needed a structured collaboration with institutions of higher learning like local universities and technical institutes. However, interviews

[60] Revealed by Moses Mukangali, the Director of Wasteward Enterprises based in Nairobi's industrial area along Lunga Lunga Street during an interview on 23rd June, 2009.

conducted with semi-processors revealed the absence of such collaborations, except for one processor. Moreover, the processor only interacted out of own interest and need, without any structured sectoral arrangement. The absence of the drive to institutionalize deliberate collaborations to enhance technical performance is likely to compromise semi-processors' effective role of intermediation, as expansion of their current output is not easily feasible.

Fifth, semi-processors do not pay cash in advance or on delivery of waste materials but instead, issue cheques which in most cases mature into cash after 7 days.[61] Given that actors at the SWM socio-technical system are used to cash payments to fulfill financial obligations, they are likely to by-pass semi-processors and supply directly to manufacturing actors. In order for semi-processors to effectively play their intermediary role, they would have to adapt their payment system to be in tandem with the needs of their suppliers of waste material.

Sixth, semi-processers operate as individual entities and lack a common umbrella organization through which the ideas can converge, share experiences, represent common interests and further facilitate engagement with other relevant organizations. This puts in doubt their effectiveness to control the flow of post-consumer plastic waste as there is no shared vision among semi-processors. Lastly, except for the large-scale semi-processors who have greater capacity for meeting demand of post-consumer plastic waste of home-grown industries and exports abroad, small-scale semi-processors have limited capacity for handling plastic waste.

In conclusion, semi-processors have displayed the technological capacity to perform higher value addition activities along plastic waste recycling chain thus qualifying their intermediation role. However, their effectiveness to this course is still confronted with a number of challenges which still facilitate direct flow of post-consumer waste material from SWM socio-technical system to the plastic production socio-technical system.

5.3 Socio-technical routes completing plastic waste recycling

Having assessed the intermediary role of semi-processors, this section presents the operations of actors of three socio-technical routes namely conventional recycling industries, home-grown recycling industries and companies exporting to China. Also presented in this section is an evaluation of internal niche processes of the routes. The routes which have evolved at different time periods complete the recycling chain in such a way that actors identified for the routes compete for access to plastic waste. Table 5-2 presents the operational features of the routes.

[61] According to Mr. Otieno of December waste services (a yard shop operator), some of the cheque payments still bounces. Mr. Otieno was interviewed on 17th November, 2010 when he underscored the advantages associated with direct supply to actors of the three socio-technical routes.

Table 5-2 Operational features of 3 socio-technical routes of plastic recycling

Socio-technical route sampled	*Average PCPW[62] handled/ month (tones)*	*Type of technology used*	*Final product*	*No. of industries interviewed*	*No. of employees per company*	*Unit selling price in Ksh/Kg of product*
Conventional recycling industries	300-600	Extrusion, film, injection and blow moldings	Containers, basins, tanks, packaging bags, film sheeting, chairs	7	110-210	95-120 (USD 1.27-1.60)
Home-grown recycling industries	90-110	Extrusion, agglomeration, granulation, shredding.	Fencing poles, twines, benches, flower pots, roofing tiles	2	10-16	70-75 (USD 0.93-1.00)
Export to China	160	Washing machines, separators, extrusion, palletizing	Flakes	1	100	45-55 (USD 0.60-0.73)

Source: Constructed by author from fieldwork data.

5.3.1 Operations of conventional recycling industries route

Conventional recycling industries have existed for as long as mainstream plastic manufacturing industries have existed. Hence as long as they used their own waste materials or received waste material through inter-industry exchange it was difficult to differentiate them from industries producing from virgin raw materials. Due to the costs of virgin raw materials and government friendly policies to promote growth of local industry, plastic recycling industries have developed into a sizeable proportion of the plastic manufacturing sub-sector.

Table 5-3 Development of conventional recycling industries

Number of Conventional recycling industries		
Year of establishment	Mixed polymer industries	Wholly post-consumer waste industries
1967-1976	4	Nil
1977-1986	9	2
1987-1996	17	5
1997-2008	29	7

Source: Constructed by author using data abridged from database of Ministry of Industrialization (2008) and survey data by KNCPC (2006).

[62] PCPW means, post-consumer plastic waste.

Table 5-3 shows the development of conventional recycling industries which have been on an increasing trend since 1967. Those industries producing from mixed raw material dominate the development. Table 5-2 further shows the dominance of conventional recycling industries route, compared to the other two routes, both in terms of production output and number of people employed. Traditionally known to rely on pickers for their post-consumer plastic waste, conventional recycling industries rely now on a broad base of raw material supplies. Raw material is supplied by CBOs, CBO-SACCOs and yard shop operators (discussed in Chapter 4), as well as semi-processors. Also instances where pickers by-pass other actors along the recycling chain and directly deliver to them still exist. Nevertheless, yard shop operators and semi-processors are the principle suppliers of raw materials to conventional recycling industries.

To control waste flows in the recycling chain, conventional recycling industries have developed informal arrangements with semi-processors, almost similar to those with yard shop operators. Conventional recycling industries have secured agglomeration and grinding machines for small-scale semi-processors. This arrangement was found at Premier Industries Limited, whose production wholly relies on post-consumer plastic waste and handled up to 600 tonnes of material per month.[63] The exemplary case of machine-support based relationship is not unique to Premier Industries Limited alone. It was also found at Hi-Plast Limited, another manufacturer whose production is based on both virgin and waste materials, with a monthly capacity of 400 tonnes of products.[64] This kind of relationship, on the one hand, is meant to secure undisrupted supply of waste material, and on the other, demonstrate additional investment conventional recycling industries have in the supply chain. By identifying particular semi-processors who are frequent suppliers, and offering technical support without any contractual agreement, conventional recycling industries trust that their supply would be ensured at given prices amidst competing demand for plastic waste materials. This is however, not the case, as semi-processors supply to other actors whenever they get better price offers from them for their waste materials.[65]

Chapter 2 provided figures on the temporal growth of the plastic production industry based on raw material used (see Figure 2-1). Even though the plastic industry inclines to favour virgin raw materials, post-consumer plastic waste is increasingly becoming a preferred choice. Table 5-3 further confirms the trend. This preference is only possible with reliable supply and distribution networks. Conventional recycling actors are reaching out to new sources to secure waste material supply while their products are sold both in the local and regional markets. Traditional local market

[63] Revelation by Mr. Dhiraj Dhodhia, the Managing Director of Premier Industries Limited during an interview conducted on 12th July, 2010.
[64] Information obtained during an interview with Mr. Mbarua, the Technical advisor to Hi-Plast Limited on 23rd June, 2009.
[65] Revelation by Mr. Dhiraj Dhodhia, the Managing Director of Premier Industries Limited during an interview conducted on 12th July, 2010.

destinations for conventional recycling industries products are also becoming new sources of waste materials. Premier Industries Limited, who distributes its products up-to Tanzania and Uganda, sources additional waste materials from smaller towns of Isebania and Busia neighbouring Tanzania and Uganda, respectively. Generally, conventional recycling industries conduct their own product distribution to market destinations although this study found one industry-Hi-Plast Limited which occasionally employed services of intermediary actors for distribution.[66]

When asked what motivates them to produce plastic products out of waste, all interviewees prioritized the higher profits, and mentioned environmental cleanliness as a secondary benefit. The motivation of conventional recycling industries towards involvement in plastic waste recycling is manifested in the kind of investments and innovations they are involved in. Many conventional recycling industries have dug boreholes and recycle waste water in an effort to avert high costs associated with water use while also addressing their excess water needs. Interviewed plastic recycling industry managers indicate that returns on investments circle are especially high on up-to date machines. Furthermore the implementation of policies to promote industrial development, for instance through zero tax ratings on technology imports has made it possible to import new technologies, which results in cost effective production and thus shorter periods for return of investment.

Despite having access to the latest technologies, conventional recycling industries still have some challenges in their operations. For example, an interview with Mr. Vimal Shah the operations manager of Sun plast Limited revealed that post-consumer plastic waste can only be reprocessed up-to four times, after which it loses material value.[67] According to Mr. Shah of Premier Industries Limited, up-to 20% of post-consumer plastic waste is lost as impurities during manufacturing. This is mainly in the form of grit, soil and sand. The losses are particularly high with semi-processed waste material, hence there is a preference for yard shop operators' waste material which is only separated and washed but obtained in 'whole'.[68] Even though production processes of conventional recycling industries appear to face some challenges, at face value their products hardly present any difference with those produced from virgin polymer materials and can be considered cheap. Table 5-2 shows the cost of a kilogram of wholly post-consumer waste product Ksh. 95-120 (USD 1.3- 1.6) at the market place compared to that of virgin polymer at between Ksh. 165-178 (USD 2.2- 3.4)[69]. This in disregard to electricity costs

[66] Information obtained during an interview with Mr. Mbarua, the Technical advisor to Hi-Plast Limited on 23rd June, 2009.
[67] Information obtained during an interview with on 17th November, 2010.
[68] Mr. Shah is the floor and personnel manager at Premier Industries Limited. He was interviewed on 16th November, 2010.
[69] Interview with Mr. Soni, the operations and personnel manager of Afro Plast Limited, a manufacturer using virgin raw materials. He was interviewed on 17th November, 2010.

which is highlighted as being high in recycling production processes.[70] A survey done by KNCPC indicates that products from post-consumer waste material take the form of film plastic bags, water tanks/containers, jerry cans and fencing posts and are mostly in black colour (Kenya National Cleaner Production Centre, 2006). See also Photo Image 5-1.

Photo Image 5-1 Products of conventional recycling industries at Premier industries and Kenpoly industries (Photo series by Leah Oyake-Ombis)

Conventional recycling industries operate with standard technologies and display comparable production output, just like the mainstream plastic manufacturing industries producing with virgin polymers (KNCPC, 2006). Technologies applied are mainly from India, China and Taiwan. The technical support for this route is mainly done by expatriates coming from India and sometimes from the countries of origin of technologies applied in production. It is not clear how industries hire expatriates but given that the majority of plastic manufacturing companies are family businesses owned by Kenyans of Asian origin, such expatriates tend to come as extended family members especially from India. Normally, expatriates work side by side with local technicians who after a period of learning, take over the operations and maintenance of the machines. For example, Mr. Mahesh the Managing Director of Hi-Plast Limited, a plastic recycling industry established in 2003 confirms the adoption of this strategy. The company's three local technicians are working alongside two professionals from India in order to impart appropriate skills and knowledge relating to application and maintenance of blow technologies.[71] In most cases such foreign experts go back after a 5 year period. Other industries like Kenpoly with close to 30 machine units employ such experts as employees alongside their local technicians. From the interviewees, local technicians who are key in machine operations have been trained from institutions such as Kenya Polytechnic and Nairobi Technical Institute. It was evident that local technical personnel rotates from one industry to the other mainly in search for better paying jobs. However, through this trend,

[70] Confirmation made by the researcher on 17th November 2010 at Nakumatt holding and Uchumi supermarkets.
[71] Information obtained during a follow up interview on 15th August, 2009.

it is possible for such technicians to transfer their know-how to other industries thus popularize the knowledge on diverse technologies existing within the industry.

Even though interactions of conventional recycling industries with city authorities is not structured and can be considered minimal, city authorities as regulators and planners of the urban space are crucial in the operations of conventional recycling industries. City authorities facilitate operations of conventional recycling industries through issuance of annual business permits and development approvals. For example, according to Nairobi city council by-laws, construction of bore-holes is not permitted. However, some conventional recycling industries have been authorized to operate such facilities within the city's jurisdiction. Such decisions besides being given other considerations are also based on the significance of activities of conventional recycling to the city's economic growth. Other government institutions have also been instrumental in the operations of conventional recycling industries especially with regards to compliance requirements. Conventional recycling industries interact with NEMA and the Ministry of Labour and KEBS to obtain various licenses formalizing their operations. As a NEMA requirement, conventional recycling industries have to conduct environmental audits and submit reports to NEMA.

In most cases, audit reports are related to management of any waste arising from production and by submitting such reports to NEMA; conventional recycling industries have been able to receive advises on how to develop environmental management plans to facilitate their compliance with environmental standards. A number of conventional recycling industries are members of the KAM as this is the organization that highlights and lobbies its interests with government. Issues such as lack of incentives, high taxes, inconsistent government policies, and cost of utilities have been consistently on the KAM agenda as constraining to the growth and performance of conventional recycling industries (KAM, 2006). Through KAM, conventional recycling industries have been able to access information on the East African Community (EAC) regional market thereby facilitating their choices as relates to market destinations. Collaboration with KAM has been instrumental in facilitating conventional recycling industries internalize energy saving audits and cleaner production processes since energy is one such compulsory production input that determines optimal performance.

In conclusion, operations of conventional recycling industries have evolved to a level where it is able to adequately respond to the challenges of plastic waste in the environment. In this respect, conventional recycling industries have up-to date technology, an elaborate raw material supply network, an ever expanding consumer network and a broad view on the future of the plastic recycling sub-sector.

Niche formation of conventional recycling industries socio-technical route

The niche formation of conventional recycling socio-technical route appears to be successful as the route has been able to attract a constituency of economic network actors

from both the demand and supply side. Furthermore activities of manufactures on the demand side of the economic network display high and mature technological sophistication which is even comparable to those of mainstream plastic manufacturing industries (KNCPC, 2006). Figure 2-1 and Table **5-3** show a consistent growth of the route in terms of manufacturing actors. This section presents an analysis of the niche development of conventional recycling industries socio-technical route using the three tenets of SNM theory of: social network composition, shaping of expectations and learning processes.

Social network composition

It is evident that the success of niche formation for conventional recycling industries socio-technical route is based on the large social network building of manufacturers as well as the ever expanding network for material supply. These two actor groups of economic network have been instrumental in shaping the niche formation even though SNM scholars call for more heterogeneity of actors' participation in niche formation (Schot and Geels, 2008). The social network that has emerged over the last four decades of niche development for conventional recycling industries includes several manufacturers, distributors, waste material suppliers including semi-processors, yard shop operators, CBOs, CBO-SACCOs and pickers and KAM.

In the first decade of the niche formation there were only a few manufacturers who used internal waste materials from their cuttings and rejects together with virgin polymers to produce plastic products. Plastic recycling technology had not become popular since the period was also marked with restrictions on technology imports (see Chapter 2). However, the subsequent three decades have seen an increased experimentation diversifying into two streams of production. As Kenya adopted free entry into production with zero rating taxation policy on manufacturing technologies around 1980, a constituency of conventional recycling industries with enormous capacity for production was building up (see Table 5-2 and Table 5-3). More industries have been registered using either purely post-consumer plastic waste or a mixture of post-consumer plastic waste and virgin raw material. This growth in numbers is supported by the outcome of a field interview by the researcher[72] that found out seven conventional recycling industries (see Table 5-2). Actors of conventional recycling industries have been able to produce almost similar products like those produced by conventional plastic manufacturers but at a more competitive price further enhancing their growth. Products of conventional recycling industries have received similar social acceptance by consumers just like plastic products made of virgin materials. Conventional recycling industries products are sold both at the local and regional markets thereby increasing visibility of such products and further causing their diffusion into the consumer market. Furthermore

[72] Interviews conducted between, 24th August 2008 to 17th November, 2010.

technologies used by conventional recycling industries are similar to those used in the wider plastic manufacturing sub-sector. It is therefore possible that with fluctuations on prices of virgin polymers, some mainstream plastic manufacturing industries have been able to convert their operations into production from post-consumer plastic waste.

Unlike 20 years ago when waste pickers were the dominant suppliers of waste material to conventional recycling industries, the supply network is increasingly getting diverse. Conventional recycling industries are engaging in strategic games to gain an edge for waste supply over actors of the other two socio-technical routes. They are also reaching out to new destinations further broadening the network. New actors like yard shop operators, CBOs, CBO-SACCOs and semi-processors are taking over control of material supply when direct linkages between conventional recycling industries and pickers is diminishing. The main reason is that plastic waste is becoming a more competitive business with high expectations from industries. This state of affairs is demonstrated by the ever increasing new industries that get registered (see Figure 2-1, Chapter 2). According to Sunil of Hala Industries, challenges exist in meeting their raw material demand since the same suppliers also supply to PIL their neighbour.[73] Through their material supply networks, conventional recycling industries are able to access local raw materials which are cheap since they do not attract any duty or foreign exchange. Further still, such broad base for raw material supply is able to improve conventional recycling industries economies of scale resulting in high returns in their product sales. The emergence of new supply actors is slowly creating an alignment of actors' activities along the recycling chain. Different levels can be distinguished by certain value addition activities with the picker being lowest in the chain.

The niche development of conventional recycling socio-technical route has immensely benefited from manufacturers who are members of KAM. The organization (KAM) contributes to the network with knowledge about market situation and cleaner and efficient ways of production especially in relation to energy saving.[74]

Shaping of expectations

Expectations of participating and potential actors in conventional recycling industries social network seem to converge that this route hold great potential in solving environmental problems related to plastic waste although economic benefits appear to be the overriding factor particularly for manufacturers and suppliers of plastic waste. For actors who were interviewed, environmental motives are secondary as they mainly

[73] Mr. Sunil Shah is the Director of Hala industries. He was interviewed on 15th August 2009. Hala industries produces plastic shopping bags and has a monthly capacity of 600 tons with 115 employees.

[74] Information obtained from Mr. Dhiraj Dhodhia, the Managing Director of Premier Industries Limited during an interview conducted on 12th July, 2010 and from, Mr. Mbarua, the Technical advisor to Hi-Plast Limited on 23rd June, 2009.

mentioned economic benefits with environmental motives being second. However, manufacturers whose plastic recycling activities have evolved from usage of internal waste (generally regarded as less contaminated as compared to the plastic sourced from municipal waste stream), unanimously concur that their activities are responsible for restoration of the environment. This positive view is shared amongst governmental actors who are responsible for legitimizing operations of conventional recycling industries and who have alluded to recycling of waste as a strategy for good environmental management (see Appendices 1 and 2). The same positive view is also held by KAM who makes efforts to facilitate relevant knowledge for effective operations of conventional recycling industries. The huge and growing quantities of plastic wastes that conventional recycling industries handle monthly continued to raise expectations amongst them (see Table 5-2 and Table 5-3). Expectations of manufacturers are high and positive and have stabilized overtime because they have been in operations well over four decades since the introduction of plastic material into the Kenyan market. The positive expectations among conventional recycling industries are due to quick returns to investment and profits[75].

According to Kantaria of Elgon Plastics, return to investment is normally realized between 2-5 years for new machines.[76] Conventional recycling industries also have a secure market position for their products which has resulted in huge investment in technology and other infrastructural needs. Hence their expectations are based on tangible outputs. Conventional recycling industries have conveniently been producing products which are reliable and have been standardized just like products of mainstream plastic manufacturers. Table 5-2 shows that a kilogram of plastic product of conventional recycling industries fetches a higher price in comparison to those of the other two socio-technical routes but it is still less expensive than those of mainstream manufacturers using virgin materials. Besides the well-structured and elaborate local market for products of conventional recycling industries, such products have also secured a market position within the East African region and other COMESA markets.[77] These extended market linkages cause for high economic benefits expectations for actors of the socio-technical route.

Positive expectations of conventional recycling industries are also based on the additional strategies they have been able to devise to gain a large supply network for raw materials. Lower international oil prices are expected to lower the demand for plastic waste material by manufacturers since the cost of virgin polymers would generally turn low as well. This appears not to be the case as conventional recycling industries has grown without interruption. Expectations on the plausibility of conventional recycling industries for plastic waste management is even expected to go higher at least in the recent time given the political turmoil facing the Middle East region where much of the

[75] Information obtained during interviews with industrial representatives on different dates
[76] Mr. Kantaria is the Managing Director of Elgon Plastics. He was interviewed on 17th November, 2010.
[77] Information obtained during interviews with representatives of conventional recycling industries on different dates.

world's crude oil comes from. Furthermore, the massive technological, logistical and other infrastructural investments of conventional recycling industries show that the route has matured and confirms actor's long term view of their place within the wider plastic manufacturing sub-sector.

On the other hand, expectations of actors within the supply chain are not consistently high. Such expectations are intermittently affected by the international polymer prices and the quality of waste material. Manufacturers offered lower prices whenever prices of respective virgin polymers went low at the international market.[78] Still, lower prices than anticipated by suppliers were expected whenever plastic waste materials supplied to manufacturers are not well sorted or contain impurities.

At the moment, there is no labeling of plastic products as made of post-consumer waste. This may be a missed opportunity in shaping expectations for the conventional recycling industries route. Literature on innovations (Ram and Jagdish, 1989) and sustainable consumption (Albach *et al*., 2010) hold that well-informed and conscious consumers are more likely to consume products they consider as friendly to the environment. If such a development were to happen, it would further shape expectations for the conventional recycling route as desirable for plastic waste management.

Learning processes

Learning as a dimension of niche formation should take several dimensions if the niche is to successfully take off (Geels, 2004a; Geels, 2005a; Geels and Schot, 2007). The two main actors (plastic manufacturers and raw material suppliers) have learnt a number of lessons.

Starting with manufacturers, while there is no inter-firm collaboration amongst conventional recycling industries technical lessons have over the years been acquired through direct importation of international expatriate knowledge. Also through learning by doing, some technical lessons on operations and maintenance have been learnt at firm level. However, diffusion of such lessons within the wider manufacturing sub-sector has been mainly done through employee transfers. Additional lessons on enhancement of technical performance have also evolved through other organizations. Through KAM, conventional recycling industries have been able to learn how to internalize cleaner production techniques for energy and other industrial inputs as well as on the dynamics of the regional market. Industries on their own are able to analyze energy flows in production systems and take corrective measures thereby increasing their chances of survival in the market.

Other techno-economic lessons include the extent of impurities associated with post-consumer plastic waste, requiring extra infrastructural investment.

[78] Information obtained during an interview with Mr. Karume of Pride Street, a yard shop operator based in Lunga Lunga Street, Nairobi on 17th November, 2010.

Conventional recycling industries have learned that the increasing demand and competition for plastic waste requires them to evolve new strategies if they are to become the most preferred route for completing the recycling chain. They have since broadened their raw material supply network with preference of waste material from particular suppliers. Conventional recycling industries have also learnt market survival tactics if to compete in the market place with mainstream manufacturers. In this respect, conventional recycling industries employ varied strategies. For those who produce with a mixture of virgin raw material and post-consumer plastic waste, the strategy is to hide the dull colour commonly associated with comingled plastic waste material. They either use colouring resin or apply mixing ratios that result in appealing colours. In the case of actors who produce purely on post-consumer waste, only black pigmentation is used. These lessons have enabled conventional recycling industries to consolidate their technical capacity in order to compete favourably with mainstream plastic manufacturers. Conventional recycling industries have learned the importance of operating with formal requirements such as city authorities' licenses and other government permits. By conforming to these requirements, conventional recycling industries are embedding themselves within the wider plastic manufacturing sub-sector.

Conformity with government requirements cautions them against any victimization and harassment by law enforcement agencies. Other conventional recycling industries have started to broaden the scope of the recycling agenda by initiating other experiments. Hi-Plast Limited has been instrumental in the development of Green Africa Limited, a company which has been its major distributor of plastic bags in Nairobi, but at the moment produces fencing poles from comingled waste. Hi-Plast Limited donated an extrusion machine which is being used to create and accumulate new knowledge for plastic waste recycling. Through these varieties of lessons, conventional recycling industries have been able to develop coping strategies thereby broadening their vision as far as plastic waste recycling activities are concerned. On the other hand, only yard shop operators who have emerged as the dominant suppliers within the recycling chain (see Chapter 4) have been able to learn on the demand requirement of conventional recycling industries. Yard shop operators are conversant with the quality, quantities and type of plastic waste demanded by conventional recycling industries. They have developed a close but informal relationship with conventional recycling industries which make them share information hence creating some level of social proximity (trust) between them. Yard shop operators therefore stand out as the nucleus of the material supply in this socio-technical route.

Conclusions on niche formation and desirability of conventional recycling socio-technical route

In conclusion and in reference to the three dimensions of SNM, conventional recycling industry as a socio-technical route is a successful niche development. The route has

evolved from a small niche of mainstream plastic manufacturers to a large constituency of manufacturers within the wider plastic manufacturing sub-sector. The actor network for conventional recycling industries route is broad, with a diversity of manufacturers displaying big handling capacities for waste materials, an expanded material supply network and a still expanding market for consumption of finished products. Through international flow of knowledge (expatriates), the conventional recycling industries route has consolidated relevant, broad and sound technological base supported by qualified technical support. There is convergence of participation and potential actors' expectations that the conventional recycling industries route is adequate and has the potential to solve environmental problems of plastic waste. This conviction shapes actor's future expectations and guides their learning processes particularly of the main actors on the supply and demand sides of the route.

Varieties of lessons have been and continue to be learnt particularly by actors within the supply chain network thereby broadening their vision of the plastic recycling sub-sector. Actors like manufacturers are starting to question the extent to which they can maintain status quo and are engaging in other experimentations in order to acquire further knowledge on other techniques of recycling. For example, Hi-Plast Limited has started to promote activities of other actors experimenting with other recycling routes. Because of the huge investment conventional recycling industry has put in place, they are reflexive about their future place in the plastic manufacturing sub-sector.

As a route for completing the recycling chain, conventional recycling industries have proved to handle huge quantities of plastic waste yet their capacity is still underutilized. The route presents an elaborate and well- organized network of suppliers for waste materials which extends to capture waste materials even from other up-coming small towns. Conventional recycling industry makes a significant contribution to employment creation in Kenya despite a lack of a clear differentiation of the plastic manufacturing sub-sector to ascertain a distinctive contribution of different streams of manufacturing. The ever expanding demand for plastic waste coupled with their strength to employ, are testimonies to the influence of conventional recycling industries. The situation is the same with their contribution to economic development as conventional recycling industries have a share of both local and regional markets for their products. However, some barriers still stand on their way to effective containment of plastic waste. Importantly, limitations exist as to the variety of products which can be made out of 'whole' post-consumer plastic waste. Another setback is the inability to receive enough waste materials while the market demand is expanding.

5.3.2 Operations of home-grown recycling industries route

The definition of home-grown industry as used in this study springs from two characteristics: final product and mechanical sophistication. Home-grown recycling

industries produce from comingled post-consumer plastic waste and apply machines that are re-modeled and use locally fabricated moulds produced by Jua Kali Industry.[79] Normally, extrusion machines are elongated and fixed on moulds to produce particular sizes and shapes of final product. The most important products of the two industries studied (Green Africa Limited and Devani Limited) are solid hard-plastic poles. Other streams of products such as twines, bollards, flower pots and plastic lumber for benches are also emerging.

This study only found two home-grown plastic recycling industries, namely Devani Ramji Haribhai Limited (hereafter referred to as Devani Limited) established in 1990 and Green Africa Limited established in 2007. Both are located in Nairobi. At the time of the study, Devani Limited had assembled machines comprising of 5 grinders and 6 extruders. Two grinders were locally fabricated while the other grinders and extruders were imported as second hand from Taiwan. Green Africa Limited had a grinder, agglomerator and an extruder. Except for the extruder which was a donation by Hi-Plast Limited (see section 5.3.1), the other machines are locally fabricated by the Jua Kali artisans.[80] According to Devani Limited, second hand machines and locally fabricated machines are much cheaper than brand new ones, hence the decision to investment in second hand machines.[81]

The two manufacturers view their involvement in plastic waste recycling as a business that has the potential to also make a contribution to the environment and in fact, operate with all the necessary compliance requirements. However, another motivation is the desire to solve an environmental problem created by plastic waste particularly littering.[82] This conviction is further re-enforced by their unique approach to manufacturing. Home-grown recycling industries use 'whole' waste that is not sorted into different plastic waste types nor washed. This is in disregard to the fact that plastic waste from municipal waste streams present diversity in densities, polymer type and contain high levels of contamination which are known to be problematic in recycling processes (Davis and Song, 2006; Nomaguchi, 2002; Nettravali and Chabba, 2003). Such products would not have attained any uniformity in their chemical composition. Nonetheless, home-grown recycling industries are in constant consultation with a number of technical organizations to facilitate speedy standardization and ensure conformity of their products without having to go through KAM. Devani Limited collaborates with University of Nairobi, Department of Architecture and Building Science which has in many occasions examined his products for thermal and environmental comfort. KEBS has also certified

[79] Jua kali is a Kiswahili word used in the informal sector to denote bracing in the harsh sun.
[80] Jua Kali artisans are technical persons working in the informal sector usually their products and services are cheaper than the formally registered engineering firms.
[81] Information obtained during an interview with Mr. Mohammed the operations manager of R.H. Devani Limited on 24th April 2009.
[82] Information obtained during interviews with Mr. Githinji, the General Manager of Green Africa Limited and from Mr. Mohammed, the Operations Manager of R.H. Devani Limted on 16th and 24th April, 2009 respectively.

fencing posts for consumption, while Ministry of Roads and Public Works has performed tests on fencing posts for its density and crushing strength properties. NEMA has provided a certification of fencing post as an icon of environmental friendliness. However, home-grown recycling industries have not become members of KAM, a situation which could be attributed to their limited turn overs.

In terms of waste material, Devani Limited for a long time relied on pickers and industries until recently that yard shop operators have taken over the supply. Green Africa Limited is supplied by yard shop operators as the main supplier. Sometimes semi-processors supply but only in situations of high demand and when yard shop operators are unable to cope with it.[83]

Unlike conventional recycling industries, actors of this route are yet to develop an 'almost-official' arrangement with yard shop operators that would guarantee them reliable supply of waste materials. Nevertheless, they have developed an own approach for supply. Representatives of home-grown recycling industries pay regular visits to yard shop operators' premises on which occasion they would negotiate and agree on terms of delivery such as transport arrangement, costs related to different types of waste and modes of payment. As a result of this constant interaction, there has evolved a sense of commitment on behalf of yard shop operators to ensure deliveries of waste material to home-grown recycling industries. Through shuttling from one yard shop site to the other, home-grown recycling industries have secured their supply network that is trusted, as was confirmed by Josephat a yard shop operator.[84] Given that home-grown industries do not have own collection vehicles, they always hire transport for the yard shop operators whenever they need it. See Photo Image 5-2.

Photo Image 5-2 Off-loading comingled plastic waste and storage at Green Africa Limited (Photo series by Bas van Vliet)

[83] They would only resort to small-scale semi-processors in cases of acute shortage of supply from yard shop operators. Waste materials from semi-processors are costly since they are sorted and making of home-grown products does not require sorting and cleaning.

[84] During an interview with Josephat of Nairobi Waste Papers on 15th August 2009, he attested to the fact that, he would wait for Green Africa Limited to pick their portion of waste upon which, he would sell the remainder to any other buyer.

However, home-grown recycling industries still handle less waste in comparison to the other two routes (see Table 5-2). They hold the view that the government should devolve funds to city authorities, who should in turn facilitate formal waste collection sites within the divisions to be operated by yard shop operators. Only this way, home-grown recycling industries would trust that a level field would be provided for equal access to plastic waste by the three socio-technical routes. The current problems with the shortage of supply of waste materials make home-grown industries to engage in batch production.

During this survey, it was revealed that Green Africa Limited produce only 60 posts per month. The low production is further blamed on inadequate and inefficient machines which keep on overheating even though a water cooling system was installed. However, it is possible that impurities associated with 'whole' plastic waste can also cause inefficiency in production as frequent break downs of machines are experienced resulting in high expenditures for maintenance. For example, Green Africa spends between Ksh. 30 000 to Ksh. 50 000, (USD 400-667) per month on average in maintenance of the three machines it uses.[85] Costs related to electricity usage are also bemoaned by home-grown recycling industries. In collaboration with NEMA, home-grown recycling industries have repeatedly written letters petitioning the Ministry of Energy and Finance to offer energy concessions. They are convinced that their strategy towards plastic waste management can be a quick win and raise the government's profile given the current situation of plastic waste and the complete absence of citizen's participation in waste separation. Photo Image 5-3 shows the process of making fencing posts while Photo Image 5-4 shows the products.

Photo Image 5-3 Extrusion of fencing post in a mould and water cooling system at Green Africa Limited (Photo by Bas van Vliet)

[85] Information obtained during an interview with Mr. Githinji the General Manager of Green Africa Limited on 16th April, 2009.

Products of home-grown recycling industries are not yet in the market place but consumed through informal networks and only by those familiar with such networks. The Kenya Wildlife Services recently used a total of 20,000 plastic posts from both Devani Limited and Green Africa Limited to secure a 2,000 square kilometers area of the Aberdare forest. Aberdare forest is one of Kenya's important water catchment areas, currently under threat by human encroachment. Both entrepreneurs interviewed [86]concur that one post of 9 feet by 5 inches takes about 17 kg of waste material. At their current rate of production of 60 posts per day, the two actors needed about 167 days to meet the demand for fencing Aberdare. Deducing from this case, home-grown recycling industries' current capacity is inadequate despite the products starting to penetrate other sectors which is likely to raise expectations for use of such products in other application domains.

Photo Image 5-4 Fencing posts at Green Africa Limited (Photo by Peter Ohon)

Niche formation of home-grown recycling industries socio-technical route

The niche formation around these home-grown industrial activities has only been partially successful: so far there are only two industrial actors using commingled plastic waste as a resource and they struggle with collecting enough plastic waste, high maintenance costs and with meeting the demand for their specific products. Yet there is huge potential for this kind of industry as commingled plastic waste is abundantly available in Kenya, and the demand for the kind of products that can be made from it appears to be huge. The question is why the uptake of this industry has not emerged as could be expected from the positive supply and demand conditions mentioned above. This section will present explanations for the only partially successful niche formation by exploring the 3 dimensions mentioned in SNM literature (Verbong *et al*., 2010): social network composition, shaping of expectations and learning processes.

[86] Information obtained during an interview with Mr. Githinji, the General Manager of Green Africa International Limited and from Mr. Mohammed, the Operations Manager of R.H. devani Limted on 16th and 24th April, 2009 respectively.

Social network composition

One of the explanations for the so far meager niche formation is that the social network building around home-grown plastic recycling industries shows a number of gaps in the economic network of actors (supply of waste material and demand of products), governmental actor network (policy and technical support) as well as in the societal actor network (support of NGOs).

The actor network for home-grown industries route comprises of only 2 manufacturers as the dominant actors; yard shop operators, semi-processors, waste pickers at the supply side; University of Nairobi, NEMA, Ministry of Roads and Public Works and KEBS as technical support actors and a few mainly institutional clients for the fencing posts. The two industries, namely Devani Limited established in 1990 and Green Africa Limited established in 2007, are both located in Nairobi.

A main problem in terms of network building is that unlike conventional recycling industries, the dominant actors (manufacturers) of this route are yet to develop solid arrangements with waste handlers that would guarantee them a more reliable supply of waste materials. Devani Limited for a long time relied on pickers and industries until recently that yard shop operators have taken over the supply of waste material for home-grown recycling industries with occasional supply from semi-processors.[87] However the struggles home-grown recycling industries have to undergo to ensure such supplies is not sustainable and may not be attractive to other potential manufacturers. Representatives of home-grown recycling industries have to make physical visits to secure their waste material supply. This restricts the source of waste materials for home-grown industries to Nairobi unlike conventional recycling industries which are predominantly located in Nairobi but receive waste materials from yard shop operators located in major cities and other upcoming small towns. Furthermore lack of efficient and readily available technologies does not make the route attractive to potential manufacturers and it is likely the reason for the route's slow take off.

Despite home-grown being a local concept, its technology development has not received necessary support. A visit to Kariobangi Light Industries, commonly known as the hub for fabrication of Jua Kali machinery, revealed an extensive development of grinding machines but not the elongated extruders commonly used for making fencing posts.[88] This technology is essential for all products made from commingled plastic waste however its development for home-grown products has not been taken upon a larger scale. Generally, minimal collaboration exists between industries, universities and technical institutions (Republic of Kenya, 2005). Even though KIRDI's mission is to build technological capacity within industries for Kenya's economic development, the

[87] They would only resort to small-scale semi-processors in cases of acute shortage of supply from yard shop operators. Waste materials from semi-processors are costly since they are sorted and making of home-grown products does not require sorting and cleaning.

[88] The researcher visited Kariobangi Light Industries located in Nairobi's Eastland area on 17th April, 2009.

plastic recycling industry is not a priority at the moment as technology incubation centers that KIRDI has created so far are only for leather and agricultural products (KIRDI, 2007). Furthermore no linkages have been fostered between the Jua Kali industry, universities and research institution in a bid to facilitate exchange of technical knowledge that would kick off home-grown recycling activities as an independent industrial unit.

Another potentially relevant societal actor to the home-grown recycling industries route but who is so far absent is Practical Action, an international NGO with offices in Kenya. The organization whose goal is to promote development of appropriate technologies in response to poverty challenges aligns its activities with community organizations categorized as 'poor'. Practical Action has been facilitating technical needs of CBOs in a bid to equip them with necessary skills to enable them respond to the needs of plastic recycling industries (Environmental Sanitation, 2005). Lack of collaboration of home-grown recycling industries with Practical Action is therefore a missed opportunity to tap in from the long standing international experience of Practical Action with plastic waste recycling technologies. This would have enhanced technical learning necessary to boost performance of the improvised but ingenious technologies.

Apart from the small, restrictive and instable actor network at the supply side, also the products of home-grown recycling industries are consumed by only a few actors through informally built networks. According to one entrepreneur, Kenya Wildlife Services remains the major client since the company started producing fencing poles.[89] Other clients remain individual farmers[90]. Unlike the market situation of the other socio-technical routes, products of home-grown recycling industries are yet to face diffusion at the wider market place. In response to the question as to why home-grown do not have a defined distribution network or marketing strategy for their products, one entrepreneur mused: "we fear advertising what we do because this place will be over flooded with customers and we are not able to provide for so many people!"[91] . In the same vein, the other entrepreneur confirms absence of storage facility on lack of stocks for keeping. He went further to say, "We hardly have any stock to keep here anyway, we always have orders even three months in advance. The main problem is getting enough waste to enable us meet the demands of our clients".[92]

It is still uncertain if poor output and performance of home-grown technology is related to a lack of material homogeneity and physical impurities inherent in commingled plastic waste. But the lack of a social network with societal and institutional actors on this matter, added with the so far limited supply and demand networks is definitely a drawback to the improvement on efficacy of home-grown technology. In fact,

[89] Information obtained during an interview with Mr. Githinji, the General Manager of Green Africa International Limited on 16th April, 2009.
[90] http://webarazafarmer.com/ accessed: Date
[91] Information obtained during an interview with Mr. Githinji, the General Manager of Green Africa International Limited on 16th April, 2009.
[92] Information obtained during an interview with Mr. Mohammed the operations manager of R.H. Devani Limited on 24th April 2009.

manufacturing actors are now producing by trial and error, and incurring difficulties in matching supply and demand as well as huge expenses in maintenance of production technology.

Shaping and convergence of actor's expectations

The expectations concerning the environmental benefits of this route of plastic waste recycling seem to converge among the various actors involved. However, due to the limited economic network currently involved in this route, it is hard for the core actors to keep up high economic expectations for the future of this route. Moreover, expectations about the future of this route are vague or absent.

While economic benefits remain a key expectation especially amongst the manufacturers and suppliers, home-grown recycling industries route have been presented as novel and a potential to solve contemporary environmental problems of plastic waste (Waste Digest, 2006). However it is still premature to make a specific conclusion about these expectations as experience with products of home-grown recycling industries is still too brief for expectations to stabilize. The high expectations that the two manufacturers have are based on the short-term applicability of their products in some specific sectoral domains. However, their current production where they only can make 60 posts per day cannot sustain such expectations. Deducing from this example, home-grown recycling industries' current capacity is inadequate to respond to the plastic waste situation in Kenya. The current problems with the shortage of supply of waste material do not help them to have a positive expectation of the future. Furthermore legitimization of various performance properties and provision of waste collection infrastructure and subsidies would be necessary to retain high expectations amongst home-grown recycling pioneers. It is only recently in 2002 and 2007 respectively that fencing posts, the predominant product of home-grown recycling industries received certifications of KEBS and the Ministry of Roads and Public Works.[93]

Learning processes

Learning as a dimension of niche formation refers not only to traditional techno-economic learning, but also to user preferences, symbolic meanings, industry and policy networks and societal and environmental benefits of the new technologies (Coenen *et al.*, 2010). Only partially such learning processes have occurred in this route of home-grown plastic recycling, as will be shown below.

The two home-grown industries actors have only learnt a few techno-economic lessons. First, that they can produce unique and suitable plastic products without the recycling 'rituals' of sorting and washing. Sorting and washing of commingled waste is

[93] TRE No D 6362 and of 2002 and Paid Mr. Number 7570222 of 13/02/2007

the most expensive aspect of post-consumer plastic waste recycling (Andrady and Neal, 2009; Hopewell *et al*., 2009; Furedy, 1990). Home-grown recycling industries have been able to negate the process and still offer competitive products (see Table 5-2). Second, home-grown recycling industries have learnt that locally re-modeled extrusion machines are ineffective and keep on overheating. They have so far installed a self-made water cooling system to counter this effect[94].

Another lesson learnt is how to cope with their disadvantaged position in the market place. The stiff competition for waste material makes them operate with the limited supply networks. Nonetheless, they appreciate the high demand for plastic waste materials and have learnt that it is only through establishment of waste collection points by city authorities that are accessible to all on equal terms that would ensure a more coordinated recycling industry.

Even though home-grown recycling industries have learnt of the ineffectiveness of the machine they use, for which they have developed coping measures like water cooling systems for the overheating extruders, important technical lessons that can enhance output have not been taken up during the 20 years after the first industrial actor emerged.

Lastly there is a lack of adequate learning on the possible variety of products that can be made by 'whole' post-consumer plastic. There are trials on products such as bollards and flower pots. However, lack of adequate technical capacity may deter their possibilities of ever being marketed as products of home-grown route. Much more experimentation and learning about appropriate and efficient technologies will still be needed for the current home-grown recycling industries activities and their future diversification of products.

Conclusion on niche formation of home-grown recycling industries route

When viewed in light of the three tenets of the SNM the outcome on niche formation of the home-grown recycling industry route is rather mixed. On the one hand, expectations are converging among the few economic and governmental actors that home-grown innovation route provides a suitable solution to the current plastic waste problem since the route amasses all types of plastic waste and uses them in whatever state they are sourced to make products. On the other hand, there are still major weaknesses. Expectations of the two manufacturers are driven by short-term performance and wishful thinking. These may not be representative for how the route would perform in future. There is hardly any growth, in terms of new industries, suppliers or clients or enhanced output except for trials on a few products. Technical uncertainties still exist as the technology applied still lack the inputs of different strands of science necessary to

[94] Information obtained during an interview with Mr. Lawrence, the operations and logistics manager of Green Africa Limited on 24th November, 2008.

improve its performance and win the confidence of the existing manufacturers and further entice potential investors. The route as a niche is still very much in its formative stage. Hardly is there any feedback learning mechanism between home-grown recycling industries actors and consumers, a crucial ingredient to facilitate further improvement of performance of products like posts which have a great potential in replacing wooden posts in fencing.

However, home-grown route as a strategy for management of plastic waste has still some potential. The strength of the route lies on the ability of its actors to use different types of plastic waste in their dirty state to make new plastic products. This portends great savings in the management of plastic waste. The route is appropriate in the Kenyan situation given the existing waste management practices where hardly any waste separation is conducted by generators. However, as a stand-alone strategy for plastic waste management, niche formation has been hampered due to limited societal, governmental and economic network building, low economic expectations and scattered, let alone second order learning about appropriate production technologies and markets.

5.3.3 Operations of a company exporting to China

The Chinese export market route is a recent phenomenon. It started as an initiative of Green Loop International Limited, a hitherto conventional recycling industry manufacturing polythene packaging bags based in Nairobi in 2003. The route targets the Chinese textile industry that relies on flakes of PET waste as raw material. According to Mr. Jai Shah the Managing Director, his motivation to venture into this route was a result of the highly competitive market environment for plastic packaging bags in Kenya which he felt was not tenable.[95] The actor is a large semi-processor and has assembled a variety of technologies comprising of washing machines, conveyor belt, waste separator, gridding and shredder machines and extrusion machines (see Photo Image 5-5). Green Loop International has elaborate technology and skilled manpower which has been acquired in a similar manner like conventional recycling industry actors given its background. Mr. Jai Shah reckons that the first 5 years of his exports to China was marked by high demand that saw the company extend its waste supply network beyond Nairobi to include other cities and small towns. The returns were promising compelling the company to operate with a 24 hour shift.

[95] Revealed during an interview on 24rd November, 2008

Photo Image 5-5 PET waste and associated recycling machinery at Green Loop International (Photo series by Leah Oyake-Ombis)

At the time of this study, Green Loop International was the only company involved in the export of PET flakes. It exports about 160 tons per month which is far more than what home-grown industries handle. However, the company's capacity is comparable to that of the majority of the dominant conventional plastic manufacturing industries and conventional recycling industries (KAM, 2006; Mugambi, 2001). Just like companies of home-grown recycling route, yard shop operators are the dominant suppliers of waste materials to Green Loop International. The company has developed a relationship with particular yard shop operators where the industry sends its vehicles for collection of waste materials. Costs related to transport are always recovered upon payments made to yard shop operators mostly in the form of cash. In terms of its products export to China, Green Loop International has not diversified its networks, but only deals with one client in China. Transactions related to exports between Green Loop and the recipient company in China is through written contract and payments guaranteed through a Letter of Credit (LC).

At the local scene, export of plastic waste materials to China is unique to the extent that it specializes on PET waste material. However, consumption of PET plastic polymer materials is still low in Kenya compared to other types of plastic polymers (Chapter 2, Figure 2-4). This is likely to affect increased exportation. Furthermore PET waste is not a major environmental pollutant as many PET bottles are re-used, thus limiting their return to the environment. It is only until recently that a few industries are starting to manufacture PET products locally. Before, PET was imported into the country in the form of PET bottles mainly. [96] However, Green Loop International does not face any local competition nor is adversely affected by price fluctuations at the local market. At the international market, PET virgin polymers fetches higher prices compared to other

[96] Information obtained during an interview with Mr. Chiraq Soni, operation's manager of Afro Plastics (K) Limited on 16th November, 2010.

polymers of PP and PE. [97] This explains the surge for PET waste material market in China which has a large textile industry. Nonetheless, the local market situation would not change even if PET polymer prices were to go low at the international market as it happens sometime.

Despite the high promises export of flakes materials to China provoked at the initial stages, the entrepreneur admits that a number of challenges exist. By the time of this interview, Green Loop International was still unable to meet the demand for the flakes material by its client. However, failure to meet demand for waste material is a common condition facing the whole recycling industry in Kenya. Besides, a major challenge relating to quality demand results in incurring losses.[98] PET flakes materials were either returned or offered lower prices than expected. Losses were attributed to claims of supplying sub-standard goods as opposed to those spelled out in the contract or even in the LCs. At the time of this interview, these unpredictable developments had reduced the company's operating hours to 8 with waste supply sources only confined within Nairobi. Furthermore, the management was contemplating venturing into production of fencing posts. [99] When asked why his flakes materials have not been certified locally before export, the owner remarked lack of existence of standards for semi-processed plastic waste materials.

According to Jaffee (2003) and Republic of Kenya, (2008a), other than horticulture and the Fish industry, Kenya has not established the quality, standards and conformity assessment system that is comprehensive enough to support diversification of her products into new export markets both at the regional and international levels. It is therefore difficult to ascertain when claims of sub-standards goods are true or false. However, in an attempt to adequately respond to quality requirements especially those related to physical contamination, Green Loop International has dug a water borehole at a cost of Ksh. 2.5 million (USD 33,333) for intensive washing. Besides, it has also installed a waste water treatment facility (see Photo Image 5-6) which enables the company to re-use its waste water. These developments have to some extent, reduced occurrences of complaints about product quality but not solved the problem completely.[100]

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[97] The Plastemart database for March 1, 2009 places international prices for PET bottles, LDPE film and PP injection at 1000 USD, 985USD and 855USD respectively (http://www.plastemart.com/intl_graph.asp?...mtl_id=14; visited on March 30, 2010)

[98] Revelation by Mr. Jai Shah, Managing Director of Green Loop International during an interview on 24th November, 2008. The information was again, confirmed during a follow up interview on 19th November, 2010.

[99] Information obtained from Mr. Jai Shah, Managing Director of Green Loop International during an interview on 24th November, 2008.

[100] Information obtained from Mr. Jai Shah, Managing Director of Green Loop International during a follow up interview on 13th April, 2010.

Photo Image 5-6 Part of the waste water treatment facility at Green Loop International (Photo by Leah Oyake-Ombis)

Although the company's operations have been enabled by acquiring the operational licenses from relevant government organizations, limited interactions still exist. Despite the huge amounts of money paid to city authorities and other government department in the form of licenses, no useful advice has come forth in aid of their challenges.[101] For example, Green Loop International is of the view that if waste separation can be encouraged at household level, the company is likely to overcome challenges associated with quality of its export materials. Still, the company is aware of the existence of the EMCA, 1999 however, the manager is oblivious of its incentive provision which aims to promote recycling of waste materials. Even if the company was to be aware, procedures for administration of such incentives are still unclear and not in the public domain.

Manufacturing industries have found KAM a useful platform to pursue enabling policies with the government in order to enhance their productivity output and access to markets. Green Loop International is not a member of KAM. Although it may not attract a lot of attention, membership to KAM has the possibility of initiating discussions with the government on how to establish regulatory instruments necessary in enhancing their products competitiveness at the international market. According to Mr. Jai Shah, electricity costs is still a major barrier to their successful operations and is an important area where he feels the government should intervene in if plastic waste recycling is to be pursued as a sustainable strategy for management of the environment.[102]

Operations of Green Loop International as far as plastic waste management is concerned remain a unique adventure. However, conformity requirements remain a drawback to its positioning in the market place.

[101] Revelation by Mr. Jai Shah, Managing Director of Green Loop International during an interview on 24th November, 2008.
[102] Information obtained during an interview on 24th November, 2008.

Niche formation of Chinese export market socio-technical route

The niche formation for the Chinese export market for flakes materials potentially presents a unique opportunity to plastic waste recycling but has so far not been successful. After close to ten years of experimentation, only one exporter can be identified with difficulties in sustaining the market demand leave alone finding new markets. Expectations are mixed with hardly any credible learning opportunities to advance the export agenda. This section presents explanations as to why such an exclusive niche that specializes only in a particular waste type not common to the local recycling industries could not take off. The explanations are coined around the three SNM concepts of social network composition, shaping of expectations and actor learning processes in order to understand the failure.

Social network composition

The social network building around the Chinese export market is deficient of participation of governmental organizations, private lobbying organizations, producers' network, users' networks, suppliers and societal groups. The actor network for Chinese export route comprise of one exporter as the producer, one recipient as the user and a few yard shop operators as suppliers.

Only Green Loop International which had accumulated an elaborate technological infrastructure from previous plastic manufacturing activities remains an exporter even after close to 10 years of experimentation. Green Loop International had pre-empted a better market opportunity by specializing its operations on a particular waste type and locating a market abroad for its products as the plastic recycling industry was registering more newcomers thus increasing competition within the traditional markets. However, exporting semi-processed PET to China has not been able to attract more exporters because of a number of reasons. The Kenya Government formulated the National Exports Strategy (NES) to improve competitiveness of the manufacturing sector. NES aimed at strengthening some related institutions; and regulations on quality and safety of fish products which has improved conformity to international standards (Republic of Kenya, 2008a). However, the plastic manufacturing sub-sector particularly relating to export of semi-processed waste materials is not a priority at the moment hence no standards exist for semi-processed waste materials.

Experience with Green Loop International indicates that difficulties exist as long as semi-processed waste materials are not able to meet Chinese quality standards. Lack of local verification and certification of standards to meet international standards, does not provide a conducive environment likely to attract other potential exporters. Furthermore, export of goods always comes with extra costs related to foreign exchange. As long as exporters are not able to forecast substantial economic returns by undertaking such

adventures, it is not possible that many industries would risk their investments especially in such an unstable economy like Kenya (KIPPRA, 2009). According to the Managing Director, the demand for PET waste by his client in China is also not consistent but whenever it comes, in most cases, the company is not able to cope with it thus limiting his exports to one client. [103] The economic network does not grow in terms of waste material suppliers.

Despite having developed a ' special relationship' with a few yard operators, not many yard shop operators like trading in PET waste since they consider it scarce and do not fetch good money in comparison to other waste types (Table **4-2**). Other waste suppliers such as CBOs and CBO-SACCOs are not part of the supply network as they tend to chart a different trajectory for plastic waste recycling. Some CBOs supply waste material to CBO-SACCOs while CBO-SACCOs also tend to engage in semi-processing to gain higher economic value (see Chapter 4). Furthermore, a social group like Practical Action finds creation of linkages between CBOs and local industries manufacturing final plastic products more sustainable in management of plastic waste and a better strategy for Kenya as far as employment creation is concerned (Waste Digest, 2006). Practical Action was at the forefront to ensure that Nairobi Plastic Recycling SACCO makes final products such as cloth hangers.

The social network of export to China still suffered another setback by lack of KAM's participation which could have facilitated a flow of knowledge and information necessary to enhance competitiveness. KAM's mission is to encourage formulation, enactment and administration of sound policies within the manufacturing sector by lobbying the government in order to improve business environment.[104] Other government organizations such as NEMA and KEBS are not part of the export network. However, recent developments involving these organizations indicate their commitment towards promotion of plastic waste recycling. NEMA for example, has legislated on plastic waste recycling as a strategy for plastic waste management (Republic of Kenya, 2006), while KEBS has developed a standard for plastic material allowing for production and consumption in Kenya (Kenya Bureau of Standards, 2007). These developments remain generally applied without the urgency to consider particular needs of the differentiated routes and actors.

Shaping and convergence of actor's expectations

For close to 10 years of experimentation, expectations of participating and potential actors to the export market network have not been shaped, let alone converged towards a common direction. Green Loop International who is the pioneer to the route had high expectations particularly on the route's economic returns given the special nature of the

[103] Information obtained during an interview with Mr. Jai Shah, Managing Director of Green Loop on 24th November, 2008.
[104] http://www.kam.co.ke

waste material. Such expectations were based mainly on the short-term favorable returns. However, uncertainties associated with the market coupled with the reluctance to supply PET waste materials have not resulted in high expectations for the future market. In fact the only exporter is not certain of the future as he envisions waste separation at source would be needed to guarantee a future market. At the moment, city authorities do not encourage any household waste separation[105]. Positive expectations by the exporter are still jeopardized by other recycling industries who have not found it a viable business to engage in. Others like home-grown recycling industries have embraced a more aggressive approach to recycling. As discussed in section 5.2, they use all waste types in their comingled form. In principle, other actors' expectations converge on generic plastic waste recycling as a strategy for environmental management. However such generality in expectations has not been supportive in shaping expectations of the exporter or other potential exporters given that the route requires a totally different set of policies.

Learning processes

Hardly any learning processes to enable improvements in niche performance could be observed in the Chinese export route. What had been learned before the Chinese export route emerged was how to meet user demand. In this respect, Green Loop International learnt two lessons. The exporter learnt about quality expectations at the international market for PET flakes materials. In this regard, Green Loop International has instituted own water infrastructure to wash physical contamination from plastic waste. Green Loop International still learnt about the high competition that characterizes the demand side of plastic waste recycling despite having coined a niche on PET waste which only appeared to have a few customers.[106] The company has developed own networks for supply of waste materials. However, these lessons still remain inadequate to guarantee the future of export of flakes material to China as there is increasing local competition for waste materials.

Conclusions on niche formation and desirability of Chinese export socio-technical route

In conclusion and in reference to the three dimensions of SNM, the Chinese export socio-technical route has not proceeded well and may not be regarded as a successful niche development. The niche which started close to 10 years ago has remained stagnant with one exporter without attracting additional exporters. Similarly, there is no penetration of

[105] Information obtained from Directors of Environment from City Council of Nairobi, Mombasa Municipal Council, Kisumu Municipal Council and Nakuru Municipal Council during interviews at different days.

[106] Data obtained from Ministry of Industrialization,(2008) and KNCPC, (2006) only show Green Loop Internation as the only company involved with PET waste. Also interview with the Managing Director on 24th November, 2008 indicate that a few yard shop operators engage in buying and selling of PET waste.

the exporter's products to Chinese export market to create further branching in users. The waste supply network has rapidly shrunk from a wider geographical setting that involved major urban centers to localized city setting with a few suppliers who are not very enthusiastic about pursuing supply of just PET waste. Furthermore, the social network lacks participation of governmental actors with existing technology not being adequate to meet the market demand in terms of quality. There is lack of convergence of current and potential actors' expectations. Opportunities to shape actor's expectations especially exporters were missed out. One of the missed opportunities is membership of KAM. KAM functions as a platform which could have facilitated learning processes thus shaping of actors expectations. Knowledge gaps concerning markets, networks of supply and processing technology still exist and lessons learnt on these issues remain inadequate.

As a route for management of plastic waste in Kenya, export of PET flakes materials to China is inadequate as it targets a particular plastic waste stream whose consumption is still minimal and does not pose any serious environmental challenge at the moment. Export of PET flakes to China can just be viewed as being complementary to the existing two routes. Home-grown recycling industries are still few and lack adequate technological capacity and second, conventional recycling routes have also developed special preference for other waste than PET. However, there is need for establishment of a local quality assessment for PET flakes materials in anticipation of increased consumption of PET in Kenya that may make Kenyan textile industry consider PET flakes materials as a source for fibre making.

5.4 Plastic production socio-technical regime and socio-technical routes

The MLP on transition emphasizes the importance of interactions and the co-evolution of niche innovations with the various elements of the regime. The MLP on transition rests on the premise that niches can be supported by the incumbent regime to cause changes and bring a transition further. The development and further diffusion of the three socio-technical routes depend on the supportiveness of the plastic production socio-technical regime which is anchored in the wider manufacturing sub-sector in Kenya. The dimensions of the plastic production socio-technical regime have been defined in Chapter 3. This section presents the policy, regulatory and utilities domains as important elements of the plastic production socio-technical regime whose dynamic developments are crucial to the performance of the three socio-technical routes.

5.5 Policies domain and implications for the socio-technical routes

As has been discussed in Chapter 2 of this thesis, Kenya has enacted a number of favourable policies to facilitate the manufacturing sector as key to its economic development. Such policies have been broad and not specific to the plastic production

sub-sector (Ronge and Nyangito, 2000). Nevertheless, they have been instrumental in facilitating access for the plastic production sub-sector to manufacturing technologies. The zero rating taxation on imported technologies is an incentive and has acted as a push factor and could explain the current diversification of production resulting in the different socio-technical routes. According to Mr. Ndolo of Star Plast industry, absence of taxation of imported machines benefits them twofold: First, there is efficient production due to availability of latest technologies and second, there are short periods of investment returns resulting in steady growth in the sub-sector.[107]

The government's commitment to participation in regional trade arrangements (RTAs) has reduced trade barriers within the East Africa region. By removing tariff and non-tariff barriers among member countries, Kenya's industrial exports have access to a wider market which results into exploitation of economies of scale and attraction of further foreign investment into the country (Republic of Kenya, 1996). This policy has stimulated much growth within the conventional recycling industries. For a number of decades, plastic bag production was never regulated and manufacturers produced all kinds of bags including those of less than 10 micron thickness commonly known for their littering of the environment. However, arising from the policy instruments for management of plastic bags (KIPPRA, 2006) and the subsequent amendment to the Finance Act of 2007, only bags of 20 micron and above are to be produced in Kenya. Furthermore, an excise duty at the rate of 50% of excisable value is charged on plastic shopping bags payable by the manufacturer. These regulatory measures are likely to be windows of opportunity for the development of plastic waste recycling in Kenya and for the conventional recycling route in particular as it has a long history for recycling backed by an elaborate network of internal waste material supply.

In general, the plastic production sub-sector has benefited from a number of programmes under the liberalization policy. The Kenya Investment Act of 2006 which provides a 'one-stop-shop' for licensing and registration of business has effectively reduced the bureaucratic procedures that hamper investment flows through increased time spent in the registration process. Furthermore, the NES has been instrumental in deepening the existing traditional markets and supporting expansion of Kenyan products into new markets segments (Republic of Kenya, 2008a). This has positively influenced the growth of the conventional recycling route where its products have gained access to the East Africa region and COMESA markets. However, the NES has been slow to recognize the differentiation of the plastic manufacturing sub-sector that calls for urgent attention in the development of regulations on quality and safety of its products. The implication of this has been a poor up-take of semi-processed plastic waste materials at

[107] Information obtained during an interview on 19th November, 2010 with the operations manager of Star Plast Limited, a virgin producing industry based in Nairobi. Investment cost of a brand new extrusion machine with a capacity of 2 tons per day is re-pays itself within a two year period.

the international market, which negatively affects the overall diversification of the industry's products.

The National Industrialization Policy which was formulated in 2008 to help fast track the realization of Kenya Vision 2030 has not been sensitive to the unique requirements of the plastic production sub-sector. The policy recognizes innovations as being central in meeting the rapidly changing consumer needs and standards. It further proposes to intensify innovations in priority segments of the manufacturing sector and commit to develop capacity in order to meet international standard requirements (Republic of Kenya, 2008a). For example, plastic manufacturing sub-sector has been listed as requiring up-grading some of its products through collaboration of the industry and public institutions such as KEBS and KIRDI. This policy framework has the potential to create a wide diversification of the plastic manufacturing sub-sector if products of home-grown industry and export of semi-processed waste materials could be picked as potential innovations for further development. Such a move would enable fast-tracking of standardization of plastic waste products which so far have not obtained any credible certification in order to access both local and international markets. Such a move would be a big incentive in the promotion of both exports of waste materials to China and competitive market access to home-grown recycling industries' products.

5.6 Regulatory domain and implications for the socio-technical routes

Despite the positive promise in the establishment of a one-stop-shop to facilitate business establishment as contained in the Kenya Investment Act of 2006, the multiplicity of compliance requirements by the government is a potential barrier to the smooth operations of actors in plastic manufacturing sub-sector. Its impact is particularly negative to the newly emerging routes of home-grown recycling industries and the Chinese export market. Generally, manufacturing actors have to contend with multiple entry requirements in order to start businesses and operation. Requirements include a license from the KEBS, NEMA and the respective city authorities' licenses. Licensing fee from NEMA, currently standing at Ksh. 40,000 (USD 533) per annum is too high in the perspective of the actors interviewed. Besides, one still has to pay for Local Authority Single Business Permit amounting to Ksh. 70,000 (USD 933) per year. There is also an annual Audit and Occupational Health and Safety fee of Ksh. 60,000 (USD 800) paid to the Ministry of Labour per annum. Further, these actors submit a levy at 0.2% of their total earning to the KEBS. The multiplicity of these license requirements in the first place calls for urgent harmonization and second, their rationalization to make them affordable and effective to plastic manufacturers whose raw material is post-consumer waste.[108]

[108] Findings obtained from respective actor routes' representatives and semi-processors during interviews conducted on different days.

5.6.1 Utilities domain and implications for the socio-technical routes

Electricity

Kenya records high percentage of production loss (9.3) due to power outages in comparison to countries like China (1.8), Uganda (6.3) and Zambia (4.5) (KAM, 2006). Kenya power is heavily hydro-based and in times when the country experiences drought as it often happens, there are power shortages which compels the monopoly distributor-Kenya Power and Lighting Company to ratio power consumption. Overall, this state of affairs makes manufacturing in Kenya uncompetitive. The tariffs applied by the electricity supply sector are not facilitating the growth of the plastic production sub-sector in general. Its impact is bemoaned by actors across the four streams of manufacturing (conventional manufacturers, conventional recycling, home-grown recycling and export to Chinese market). Interviews with representatives of industries indicate variation of electricity per unit cost of production amongst actors. While a number of factors including state of technology and costs of water contribute to cost of production, the findings contained in Table 5-4 confirm high energy input in manufacturing processes involving post-consumer plastic waste as raw material. Manufactures generally cite electricity among the top most serious constraints they face. Costs on electricity usage is a fundamental barrier to the growth of home-grown recycling industries which have also not gained credible technological stand to engage in mass production of plastic waste products.

Table 5-4 Comparative electricity usage based on raw material usage

Industry	***Production process***	***Amount of production in tones per month***	***Average electricity cost in Ksh. per month***	***Approximate cost in Ksh. electricity per kilo of product***
Afro-Plastics	Virgin	160	500,000 (USD 6,667)	3.1 (USD 0.041)
Hi-Plast (*conventional recycling industry*)	Virgin + post-consumer plastic waste	400	1,200,000 (USD 16,000)	4.0 (USD 0.053)
Premier (*conventional recycling industry*)	Post-consumer plastic waste	600	2,800,000 (USD 37,333)	4.7 (USD 0.063)

Source: Constructed with data obtained from fieldwork.

Water

Water is another input crucial in shaping the development of the conventional recycling industries and Chinese export routes. Costs of water present challenges to the growth of

these routes. For instance, Hi-Plast spends Ksh. 600 000 (USD 8000) on water per month against a monthly production capacity of 400 tons. Green Loop International Limited and Premier Industries have constructed their own water boreholes to caution them against high costs of water use.[109] A number of scholars have faulted feedstock recycling as recovery option for plastic waste in municipal solid waste streams citing high costs associated with cleaning and processing (Hyde and Kremer, 1999; Furedy, 1990). In the perspectives of the representatives of the plastic manufacturing sub-sector, expenses related to water and electricity still stand on their way to successful development. [110]

Apart from a few favourable policy measures for the development of the plastic manufacturing sub-sector, this section has assessed that the situation regarding other regime dimensions including regulatory and utilities are barriers to the successful development of the various socio-technical routes to blend well with the existing production based on virgin raw materials.

5.7 Socio-technical landscape factors on socio-technical routes

Different landscape variables have impacted differently on the development of innovation activities on plastic waste management. At the national level, lack of financial support especially to the newly emerging and small-scale home-grown industries and other possible small-scale exporters to China may limit chances of their development. Kenya's manufacturing sector is liberalized and only manufacturers with sound financial, technological and market networks can survive in such a competitive environment.

During the import substitution period discussed in Chapter 2, a number of financial institutions were established to promote industrialization. For example, the Development Finance Company of Kenya gave out loans to industries which used locally available raw materials to create employment and increase foreign earnings for which the government was the guarantor (Gachino, 2009). However, with declining economic performance, government gradually rescinded its role and such institutions have since become banks with lending interest rates which do not provide any incentive to the manufacturing industry. This situation does not provide a level playing ground to the new manufacturers. However, the main landscape variable for use of post-consumer plastic waste in the manufacture of plastic products revolves around international polymer prices.

Kenya wholly depends on imports of virgin plastic polymers mainly from Middle East countries (KAM, 2006). The global oil prices become a major factor to contend with in the plastic production sector. The benchmark Brent crude oil prices have been rising

[109] Revelation on different expenditure lines was obtained through interviews with responsible officers of respective PCPW manufacturing industries.

[110] Revealed by Damaris Kimilu the Corporate Affairs Officer in charge of taxation on, 14th December 2009.

from USD 25 per barrel in 2003, to USD 63 in 2006 and USD 80 in 2010.[111] This rise is expected to even escalate given the fragile political situation facing the Middle East region. The international oil prices have overtime acted as the push factor creating demand for post-consumer plastic waste by manufacturers. However, this demand is likely to change in future given the discovery of oil in Uganda and the current government plans to import oil from Sudan. These developments which have been widely circulated to the public through press articles (e.g., The Standard, January 2012: 23)[112] are likely to make transportation of crude oil cheaper resulting in cheap raw material that may drastically shift trends and development of the plastic manufacturing sub-sector. In such a case, deliberate government policies setting out an agenda for management of plastic waste would be required to sustain and further facilitate the up-take of plastic waste materials by plastic manufacturing industry.

Kenya's position in the regional markets of (COMESA) and the East African Community (EAC) is another favorable landscape factor encouraging the use of post-consumer plastic waste by manufacturing industries. According to a report by Kenya Association of Manufacturers (KAM, 2006), Kenya's exports make more than 40% of the intra-COMESA exports and in 2004, the plastic production sector accounted for 1.9% of export revenues from manufacturing. In order to sustain the current or claim a bigger market share, the plastic production sub-sector must explore alternative sources of raw material that would result in cheaper production.

5.8 Conclusion

Throughout this chapter, the focus has been to examine two issues. One, the extent to which semi-processors can intermediate the flow of post-consumer plastic waste and two, the potential and suitability of the three socio-technical routes of conventional recycling industries, home-grown recycling industries and Chinese export market for the completion of post-consumer plastic waste recycling.

The semi-processors have been able to display their unique value addition to post-consumer plastic waste that places them at a higher level in comparison to the non-state actors at the SWM-socio-technical system in the recycling chain. However, their intermediation role is jeopardized by the way they operate their economic networks. Their payment arrangement for plastic waste does not allow for continuous interactions with their suppliers in the recycling chain. This hampers direct flow of waste material from SWM-socio-technical system to the socio-technical routes completing the recycling. Furthermore semi-processors have still not evolved to demonstrate adequate capacity

[111] http://www.eia.doe.gov/emeu/steo/pub/contents.html, visited on 10th September 2010.
[112] Kenyan Prime Minister on a mission to South Sudan to negotiate a deal which would see South Sudan oil exported to the export terminal along Red Sea coast through Lamu port in Kenya.

necessary to marshal all the plastic waste generated from all the four cities as they are only present in Nairobi.

In regards to the three socio-technical routes completing recycling, the picture that evolves from this analysis points to the conclusion that plastic waste recycling in Kenya has evolved from periods when only a few mainstream plastic manufacturing industries performed own internal waste re-use to a large recycling sub-sector with three distinct categories of industries. These categories, here referred to as routes, are complementary to each other in terms of plastic waste management and ecological contribution to the environment while for waste as raw material, they are competitive. The contextual landscape variable of the products market, the unfavourable international prices for virgin raw materials and the consistent development of favourable manufacturing policies have played a fundamental role in technology access for the overall recycling sub-sector.

The niche analysis of the three routes shows that despite the unique orientation and varied socio-economic advantages of each individual route, conventional recycling industries route emerges as most successful in completing the recycling route for the management of plastic waste. Conventional recycling industries route has evolved with a systematic growth in manufactures with an expansive network for waste material supply with a viable and secure market for its variety of products both within Kenya and the East African region. The route has evolved to accumulate large technological capacity only comparable to that of mainstream plastic manufactures while also making substantial contribution to employment creation for the Kenyan people. While this study only focused on the four major cities of Kenya, the waste material gathering network of conventional recycling industries is reaching out to other urban centers with similar problems of plastic waste. This trend demonstrate the vigour and desire to which conventional recycling industries actors would want to address the social and environmental problems associated with plastic waste. The long history for conventional recycling industries in recycling activities has made them become familiar with some of the common problems facing different actors along the recycling chain. In this respect, they have evolved suitable arrangement build on trust to sustain activities within the recycling chain. The social network of conventional recycling industries actors with KAM has resulted in market penetration as well as in building appropriate knowledge in enhancing technical performance of actors.

The niche analysis of home-grown recycling industries depicts a lack of well-developed technological niche and reliable waste material supply networks while the product market also remains informal. Hardly is there any growth in terms of manufacturers while they continue to handle limited amounts of waste materials. On the other hand, home grown recycling route offers a resilient and pragmatic solution for post-consumer plastic waste. Nonetheless, the scope of home growth application also still presents a lot of uncertainties to its application for plastic waste management.

The niche analysis of Chinese export route presents a niche struggling to take off. However, lack of appropriate institutionalized standards hampers effective take off and subsequent market penetration. Most SNM studies have always depicted national bias where their studies have mostly been within the national context. The development of Chinese export market particularly for the product market has taken an international route which has brought in new knowledge as far as market dynamics are concerned. Furthermore, Chinese export route is unique in its waste stream by specializing only in PET wastes in Kenya.

In conclusion, different actors at different levels and scales at the plastic production socio-technical system are aiding plastic waste recycling with a diversity of challenges yet they present potentials in jointly responding to plastic waste management problems in Kenya. Studies that have been done towards efforts of understanding plastic waste recycling have only echoed policy requirements in response to conditions of the SWM socio-technical system. However, the diverse and special nature of manufacturers at the plastic production socio-technical system calls for a embracing policy options that take cognizance of the special needs of industrial plastic waste handling actors including semi-processors.

6 SUBSTITUTION OF PLASTIC BY BIODEGRADABLE PLASTIC: THE CASE OF SHOPPING BAGS

6.1 Introduction

Since the discovery of synthetic polymers in the middle of the 19th century, a wide range of materials that were traditionally used in packaging (including metal, glass, paper, pulp-based materials and wood) have increasingly, been replaced by plastics. Blown films of Polyethylene have found their use in the form of plastic packaging bags. Worldwide, and increasingly so in developing countries like Kenya, supermarkets, fast food outlets, retail stores and open air markets issue plastic bags to their customers and in most cases for single use only.

Generally, plastic materials offer a number of advantages over other conventional packaging materials. Advantages of plastic materials include excellent mechanical properties, chemical and biological inertness, low costs, and high energy effectiveness (Roy *et al*., 2011; Albach *et al*., 2010; Davis and Song, 2006). Plastic bags stand out for their excellent fitness for use, resource efficiency and low price. They can be and are produced in many shapes, sizes, materials and are light in weight (Ramaswamy and Sharma, 2011).

The extensive use of plastic bags has led to the accumulation of plastic waste in the environment with far reaching consequences. According to Waste Watch (2003), packaging is the main source of waste plastics in municipal waste streams (Barnes *et al*., 2009). Plastic bags present a number of challenges to the environment. They are resistant to biodegradation and cause long-time pollution (Barnes *et al*., 2009). According to Halden (2010) they present a risk to human life. Plastic bags cause aesthetic pollution (Didyk *et al*., 2000) and pollute oceans (Koch and Calafat, 2009), soil (Brinton, 2005), livestock (Singh, 2005; Ramaswamy and Sharma, 2011), and wildlife (Gregory, 2009). Because of these ramifications and the unprecedented use of plastic bags, countries across the world have implemented a variety of policy measures in managing plastic wastes, including a ban on the production of certain plastics (UNEP, 2005b; Luís and Spínola, 2010), levying taxes, placing mandatory recycling targets to be achieved (Luís and Spínola, 2010; Hyde *et al*., 2001; Blum, 2010; Harder and Woodard, 2007) and adoption of anti-plastic bag campaigns (UNEP, 2005b).

In Kenya, over eight million plastic shopping bags are given out every month by supermarkets and two times as many from petty and small scale trading activities in the informal sector (UNEP, 2005a). About 4000 tons of single use plastic bags are produced monthly with an estimated 2000 tons ending up in the municipal waste streams. Half of this produced quantity of plastic bags has a thickness of less than 15 micron, and it is these bags that cause inadvertent litter and pose challenges to recycling (*ibid*). An alternative packaging bag, commonly referred to as biodegradable plastic bag, has emerged as a potential strategy in the management of plastic bag waste in Kenya. This

novel development came amidst relentless lobbying efforts by plastic bag manufacturers to re-negotiate a suddenly imposed governmental Directive on minimum thickness of plastic bags (in 2007) that was largely perceived as being negative to the growth of the plastic industry (Deloitte Kenya, 2007).

This chapter analyzes the development and implementation of biodegradable plastic bags as an emerging preventive innovation in the management of plastic waste in Kenya. Figure 6.1 situates the main actor categories that are involved in what I will call the niche innovation of biodegradable packaging bags. Section 6.2 describes and analyzes the scholarly debate on biodegradable packaging bags, highlighting its state of development and salient bottlenecks in its usage. Section 6.3 presents the plastic bag policy that (among other things), led to the introduction of biodegradable plastic bags in Kenya. Section 6.4 provides an account of biodegradable plastic bag development and implementation in Kenya, outlining the production, retailing by supermarkets, and its consumption by households as highlighted in Figure 6-1. Section 6.5 contains a strategic niche management analysis of the production and retail of biodegradable plastic bags, followed by an analysis of the regime and landscape dynamics related to the introduction of biodegradable plastic bags. Section 6.7 concludes on the case of biodegradable plastic bags as a material substitution innovation in plastic waste management.

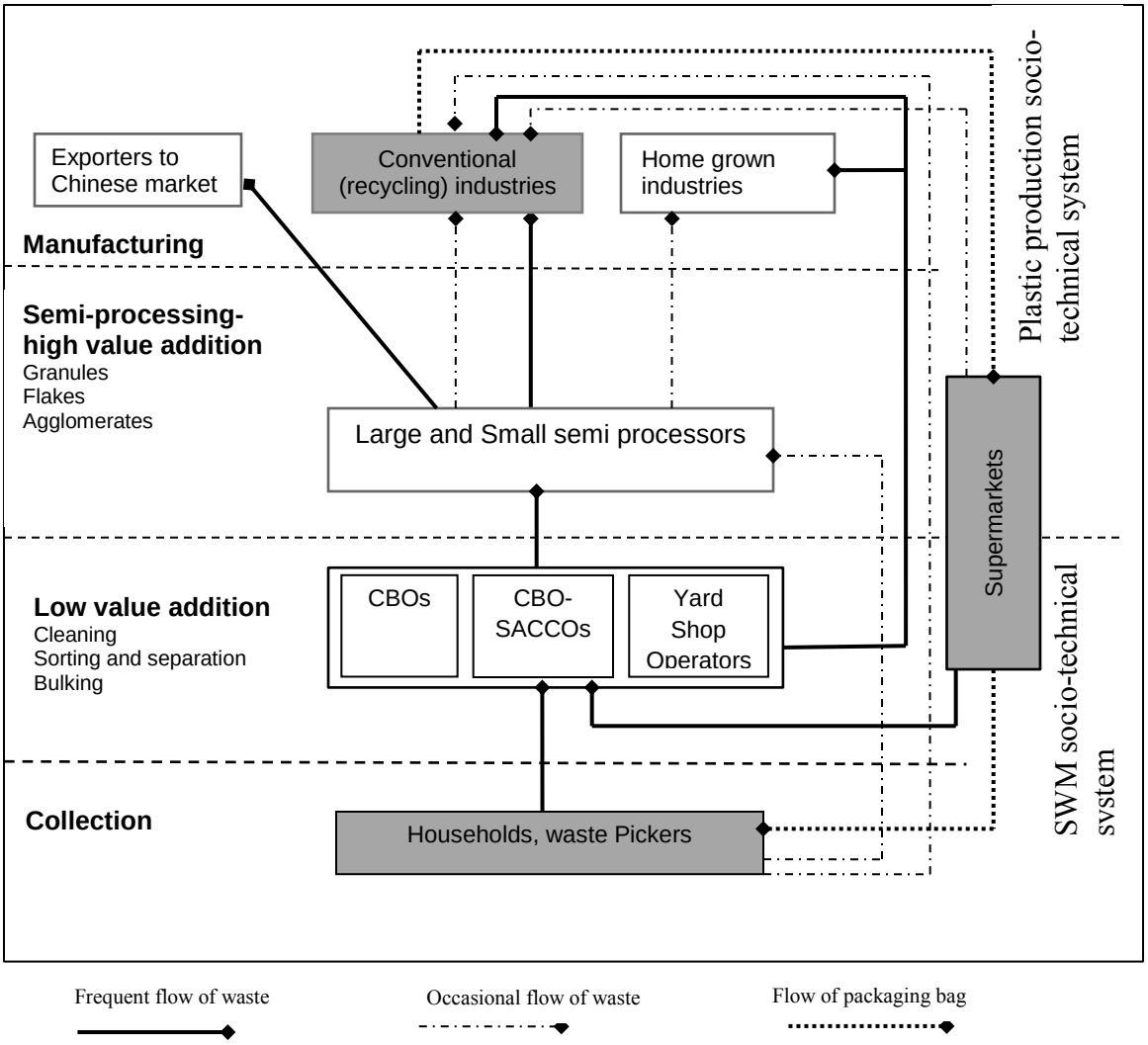

Figure 6-1 Actors embedded in plastic production, retail, consumption, and recycling activities-highlighting actors around plastic prevention innovation (Constructed by author)

6.2 Global scholarly debates on biodegradable plastic packaging

Following the limited success of recycling plastic packaging waste, the beginning of 2000 ushered in an additional concept to the integrated approach to solid waste management. The concept of redesign or material substitution (Hopewell *et al*., 2009) broadens the scope of the integrated approach to waste management. Within the framework of material substitutions, attention shifts towards the use of alternatives for conventional plastic packaging materials. Besides paper and other conventionally used packaging, plastics that are easily biodegradable were seen as a more environment-friendly alternative to conventional plastic packaging.

Biodegradable plastic packaging are made from materials broadly classified into *biodegradable polymers* and *biopolymers,* depending on whether the dominating ingredient is a synthetic oil-based polymer or a biologically derived polymer (Davis and Song, 2006; Song *et al*., 2009). The former are known to be synthetic polymers, which either have certain degrees of inherent biodegradability (Brody and Marsh, 1997; Smith, 2005) or contain chemically modified plastics to assist in the biodegradation process (Bastioli *et al*., 1994). Biopolymers are naturally occurring long-chain molecules and include cellulose, polysaccharides and proteins. Biodegradable polymer materials will reduce the need for synthetic polymer production, and thus reduce pollution. According to Leaversuch (2002) and KNCPC (2006), biodegradable plastic materials can degrade in 60 to 180 days when being placed in a standard composting environment, with a range of 90 per cent to 60 per cent decomposition of the artifact.

According to Orhan and Büyükgüngör (2000) and Kolybaba *et al*. (2003), there has been a marked increase of interest in biodegradable materials for use in packaging, agriculture, medicine, and other areas. Nayak (1999) highlights four major markets for biodegradable materials: food packaging, non-food packaging, personal and health care disposal, and consumer goods. After initial pilots with bio-plastics production in 1990, the use of biodegradable plastic materials as substitutes for conventional plastics in the packaging sector is slowly gaining prominence in a number of developed countries (Song *et al.,* 2009). Many governments – especially within Europe, North America and to some extent China – have introduced initiatives to encourage research and development of bio-based polymers (Kolybaba *et al*., 2003; Grigat *et al*., 1998; Chau and Yu, 1999). For instance, BASF, a world leader in the chemical and plastic industry, has worked on the development of biodegradable plastic materials based on polyester and starch (Fomin, 2001). A variety of blends have been formulated and have been tried on full scale production (Jacobsen *et al.*, 2000; Drumright *et al*., 2000; Petersen *et al*., 2001; Lim *et al*., 2008; Murariu *et al*., 2008; Gang and Aimin, 2008; Song *et al*., 2009; Nampoothiri *et al*., 2010).

Due to the absence of comparable functionalities with petrochemical-based plastics, until 2000 worldwide production of biodegradable plastics had not reached industrial and commercial scale.[113] But after that, considerable progress has been made in terms of functionalities, and subsequent production and application. However, current world levels of production are around 350,000 tones (*Bioplastics*, 07/08; Song *et al*., 2009). This production level is less than 0.2 per cent of the production of petrochemical-based plastics, which reached over 260 million tons in 2005 (Miller, 2005). Starch, commonly derived from agricultural feedstock of wheat, corn, rice, beans, and potatoes (Chandra and Rustgi, 1998; Bastioli, 1998; Salmoral *et al*., 2000; Martin *et al*., 2001), has been widely used in making biodegradable polymers. Despite extensive research into the development of biodegradable plastic materials, a couple of barriers still stand in the way

[113] http://www.european-bioplastics.org; www.bioplastics24.com.

to their full use as substitutes to conventional plastic packaging. First, depending on the amount of degradable material that constitutes the raw material, the tear strength of biodegradable packaging bags is low compared to their petrochemical counter parts. Second, biodegradable plastics have also a high rate of water absorption, which contributes to poor substitution up till now (Gupta and Sharma, 2010). Studies indicate that when starch material is used in the production of biodegradable plastic bags, the final product – despite having similar strength as bags made from conventional plastic polymers – still is sensitive to ambient moisture (Janssen and Mościcki, 2006). This can only be overcome by coating or lubrication, which requires an extra extrusion step during manufacturing of biodegradable plastic bags, a factor that increases costs of production (ibid). Third, problems increase with increasing surface to volume ratio of the final product like, for instance, films (Janssen and Mościcki, 2006). Proponents of biodegradable packaging bags have also recognized the low technological capacities of most of the developing countries on biodegradable materials (Nhamo, 2008). Lastly, Miller (2005) and Petersen *et al*. (1999) also mention that bio-plastic polymers are still not cost effective. The costs of most bio plastic polymers fall in the range of 2-5 Euros per kg, compared to approximately 1.2 Euros per kg for the major petrochemical polymers.

According to Liu (2006), poor performance and relatively high costs of production, compared with conventional plastics, gives major restrictions to widespread use of biodegradable plastic products. A few supermarkets have tried to offer biodegradable plastic bags for shopping. For example, Tesco and the Co-op, both leading supermarkets in the UK, in 2002 tried to provide their shoppers with biodegradable plastic bags in an effort to reduce plastic waste taken to landfills. A contested debate ensued after introduction of the bags on the biodegradability status, which compelled the supermarkets to abandon the project. Claims were that the bags were not 100% biodegradable as emphasized by the supermarkets.[114]

Such not fully resolved technical and economic issues limit the potential of biodegradable plastics in the current global consumption of plastic bag packaging. Nonetheless, these uncertainties are not unusual for new innovations and have not hindered the emergence of biodegradable plastic bags within the Kenyan consumption space. The next section details the backgrounds and policies that led to the emergence of biodegradable plastic bags in Kenya.

6.3 Kenyan plastic bag policies and its consequences

The plastic bag manufacturing sub-sector in Kenya forms a sizeable proportion of the plastic manufacturing sector. For quite a long time it produced mainly bags of 10 micron

[114] http://www.edie.net/news/news_story.asp?id=5953

thickness and less. There are over 30 plastic bag manufacturers in Kenya, with a combined capital investment worth over Ksh. 5.8 billion (USD 77.3million) and employment up to 9,000 people, both directly and indirectly (Hi-Plast Ltd, 2007). The massive contribution of the sub-sector to the country's economy and the important role plastic bags play in people's daily life came together with massive use and the accumulation of plastic waste in the environment. This has attracted significant public criticism, leading to a wide spectrum of responses from society.

In 2003, UNEP facilitated a technical working group to develop policy instruments, to be piloted in Nairobi, for the management of plastic bag waste. The technical working group comprised of key stakeholders related to the production and environmental problems of plastic bags, namely KEBS, KAM, NEMA and the KIPPRA. Lessons learnt from the pilot in Nairobi were to inform the development of a national policy to handle the waste problems from plastic bags.

After almost four years of consultations, negotiations and learning from best practices from both developed and developing countries, this technical working group had developed two sets of policy packages. The first set of policy measures included the launching of an aggressive public awareness creation and anti-litter campaign; the development of an effective recycling system; support for the improvement of a waste disposal system; the introduction of a voluntary code of practice for retailers; and the introduction of a minimum thickness standard of 20 micron for plastic bags used for shopping. The second set of policy measures contained the adoption of an advanced minimum thickness standard of 30 micron by the manufacturers; the introduction of a levy charged on plastic bags; and the support by the government for the development of alternatives to petrochemical–based carrier bags (KIPPRA, 2006). The policy packages were to be implemented in two phases. The first set of policy instruments were to be implemented immediately, followed after two years by the second set based on lessons learnt with implementation of the first package. To assist the policy implementation, a Plastics Management Fund (PMF) was to be created and managed by a committee comprising of representatives of the various stakeholders. The fund was to attract voluntary contributions from industry, government and other well-wishers.

Plastic bag manufacturers had just begun implementing the 20 micron standard gazetted by KEBS, when the Minister for Finance overruled the negotiated plastic bag policy package and issued a stringent and judicious proposal for the management of plastic bags. During the 2007/08 budget speech, the Minister announced an immediate ban on manufacturing of plastic bags of less than 30 micron thickness and further proposed an excise duty of 120% on plastic bags to take effect in January 2008. The 2007/08 Directive on plastic bags came as a shock and disappointment to stakeholders, given the competing interests they had compromised and efforts made to build consensus on the two sets of plastic bag policies, which were still in a pilot phase. According to KAM, the Minister betrayed the spirit of consultation in policy making and failed to pre-

empt the ramifications of such unilateral decisions.[115] As a representative of one of the plastic production companies (Hi-Plast Ltd) recounted, the directive compelled manufacturers to abruptly upgrade their production technologies, resulting into a series of consequences. Foremost, manufacturers had to incur an unexpected investment in order to stay in business. As not all manufacturers were able to comply, enterprise closures resulted in job losses[116]. Another immediate and significant impact of the Minister's 2007/08 Directive on plastic bags related to the consumer economy. Because plastic manufacturers transferred the financial burden of the excise duty to consumers, prices for all plastic carrier bags increased, resulting in an upsurge of prices of basic commodities such as salt, sugar, bread and milk (Hi-Plast Ltd, 2007).

Table 6-1 Plastic bag policy implications on two commonly used plastic carrier bags.

Carrier bag size	*9"*15", per 1000 bags (Ksh.)*	*7"*12", per 1000 bags (Ksh.)*	*% cost increase compared to 10 micron bags*
Cost at 10 micron thickness	284	177	-
Cost at 20 micron thickness	569	354	100%
Cost at 30 micron thickness	854	531	200%
Cost at 30 micron with 120% excise duty	1878	1168	560%

Source: Constructed using both oral and written information obtained from East African Plastics Association on the flimsy packaging bags used at kiosks and open air markets.

Table 6-1 compares costs and percentage increase of costs of two commonly used plastic carrier bags, compared to a standard 10 micron thick plastic bag. Implementation of the 20 micron plastic bag was a huge sacrifice for manufacturers as production costs went up by 100%. However, total compliance with the Minister's Directive escalated costs close to six fold (Table 6-1). The costs are largely passed on to consumers. However, manufacturers also had additional costs following the directive, as already manufactured bags of less than 30 micron thickness had to be destroyed and recycled. Moreover, demand for plastic bags decreased as consumers tended to reuse bags, since the bags of 30 micron thickness were more durable. This led the chairman of East African Plastics Association, who was also the chief executive officer of Hi-Plast group of companies, together with other manufacturers to start a youth campaign to recover all plastic bags within Nairobi's environment in support of plastic waste recycling.[117]

[115] Interview with Ms. Kimilu, Corporate Affairs Officer in charge of taxation on 8 February, 2009.
[116] Interview with Mr. Mahesh Dodhia, Chief Executive Officer of Hi-Plast Ltd, on 15 December, 2008.
[117] Interview with Mr. Chege, of Practical Action, on 23 May, 2009. Practical Action was one of the NGOs charged with the mandate to locate youth groups and link them with plastic recycling companies.

Lobbying for better plastic bag policies

Massive investments in the plastic bag sub-sector to meet the ban on manufacturing plastic bags of less than 30 micron thickness and the excise duty of 120%, and the slow pace for phasing out heavy machinery, led plastic bag manufacturers to negotiate with the government. Engaging in consultative dialogue was likely to bring greater benefit to both sides, as the government would achieve economic stability, while industries would not incur losses. In April 2008 just before the Finance Minister read the budget for the year 2008/09 in June, the chairman of the East African Plastics Association submitted a proposal to the Minister to review the 2007/08 Directive on plastic bags. The proposal, entitled "Getting the plastic industry back on a sustained growth for enhanced investments, employment and poverty reduction" (East African Plastic Association, 2008), contained a number of recommendations for consideration by the government.

One such recommendation was to share the 120% excise duty (which was mainly borne by plastic shopping bag manufacturers) with manufactures of other plastic materials meant for commercial use, like plastic sheets used in horticulture and the building industry. This proposal was mainly aimed to lower taxes that can be levied on plastic shopping bags, which directly impacted on prices of basic commodities. Also recommended was a substitution of the ad valorem excise duty of 120% with a specific excise/levy of USD 20 per ton on all imported raw materials for the manufacturing of plastic bags. The levy was to be remitted to a Solid Waste Management Fund, established by legislation, for financing and funding solid waste management related programmes. The Solid Waste Management Fund had a broader scope as compared to the Plastic Management Fund earlier proposed by stakeholders. This Solid Waste Management Fund was to be managed by key stakeholders, including industry representatives, city authorities and other government institutions. Manufacturers also wanted an immediate legislative amendment to allow plastic bag manufacturers to manufacture bags of at least 14 microns thickness to be in conformity with what they referred to as 'international best practice'.[118] However, such a demand on legislative amendment by manufacturers did not come immediately.

While anticipating the possible long term impacts of the Minister's 2007/08 Directive on plastic bags on their investment, a number of plastic bag manufacturers started to explore alternatives of using their processing installations to produce biodegradable plastic bags.

[118] Information obtained during an interview with Mr. Suresh, the chairman of environmental committee of KAM on 6th February, 2009.

6.4 Development of biodegradable plastic bags packaging in Kenya

6.4.1 Production of biodegradable plastic bags in Kenya

In 2007 Packaging Industries Limited (PIL) started the production of biodegradable plastic bags to be used as shopping bags. The drive behind the venture was the unprecedented government pressure on plastic bag manufacturers to upgrade their production processes in order to contribute to less plastic littering and better environmental management.[119] PIL is a mainstream plastic bag manufacturing company whose operations started in 1978 based on imported virgin polymer materials of Linear Low Density Polyethylene (LLDPE). However, towards 2000 the company started to expand its production to include plastic waste materials. PIL produces plastic shopping bags, plastic sheets and other plastic bags used in primary packaging[120] of commonly used items such as sugar, salt and rice. PIL is the pioneer manufacturer of biodegradable plastic bags and imports raw material for this from South Africa. So far, the Company only produces three different sizes of biodegradable plastic bags and supplies bags on demand to Nakumatt holding, a major supermarket retail outlet in Kenya.

The production of biodegradable plastic bags started in the anticipation that the market would eventually shift in favor of biodegradable plastic bags given the rigorous measures the government had put in place to manage conventional plastic bag production.[121] But PIL has also other (non-biodegradable) plastics interests and, as a member of KAM, supported also the lobbying efforts towards lifting the stringent policy measures on conventional plastic bag manufacturing. The company has not fully gone into production of biodegradable plastic bags and quite often uses intermittently the same extrusion machines for conventional plastic bags and for biodegradable plastic bags production.

The biodegradable bags produced by PIL only carry the retailer's logo. No additional information is displayed on the bags, for instance to communicate the bag's properties and environmental benefits to potential customers and consumers. The life span or degradability of biodegradable plastic bags depends on the ratio and nature of biologically derived material to petro-chemical polymers used in the production process (Bismarck *et al*., 2002). However, the exact nature of biopolymers used and the typical ratio applied in production is not disclosed on the Kenyan biodegradable bags.[122] Displaying information on the bag, including its environmental benefits, could show the company's technological advancement as well as inform consumers and influence their daily shopping routine. While PIL did not provide reasons for not taking such disclosure

[119] Interview with Mr. Benju, Operations Manager of PIL, on 15 December, 2009
[120] Primary packaging sometimes referred to as sales packaging is the wrapping or a container of the product as a sales unit and is handled by the consumer.
[121] Interview with Mr. Benju, Operations Manager of PIL, on 15 December, 2009.
[122] Interview with Mr. Benju, Operations Manager of PIL, on 15 December, 2009.

steps, it is likely related to doubts ventilated by a number of authors on the appropriateness of some biodegradable plastic bags offered for sale (WRAP, 2007; Song *et al*., 2009), and the fear of PIL to be a target of such accusations.

Despite the lack of adequate information and labeling on the bag, the start of production of the bags raised much enthusiasm in Kenya. During the first weeks of production a large number of curious manufacturers asked for information at PIL's premises regarding the details of biodegradable plastic bag production. However, as time progressed, prospects of further dissemination of this new technology and product started to become illusive. Through KAM, plastic bag manufacturers had managed to avert further implementation of the Minister's 2007/08 Directive on plastic bags. The government, through Kenya Gazette Supplement No.82 (Republic of Kenya, 2009), lifted the ban on production of plastic bags of less than 30 micron thickness and replaced it with a ban on less than 20 micron thickness, and it reduced the excise duty from 120% to 50%. The new Directive took effect after the 2009/2010 budget reading in June 2009 and this, according to PIL, has put the further expansion of biodegradable plastic bags production to a halt.[123]

6.4.2 Sale of biodegradable packaging bags

Supermarkets are increasingly becoming the preferred locations for shopping by the Kenyan urban middle class. In this context, supermarkets have become major agents as far as plastic pollution is concerned. Together with other formal and informal outlets, supermarkets release millions of plastic bags every day, most of which end up in the environment. On a different front, supermarkets are the only points where biodegradable plastic bags have been sold as substitutes to plastic shopping bags. Even though Kenya has four major supermarkets chains only Nakumatt holding sells biodegradable plastic bags. Nakumatt holding has 19 outlets spread disproportionately in cities of Nairobi, Mombasa, and Kisumu, with Nairobi having the largest share (11 outlets).

[123] Interview with Mr. Benju, Operations Manager of PIL, on 15 December, 2009.

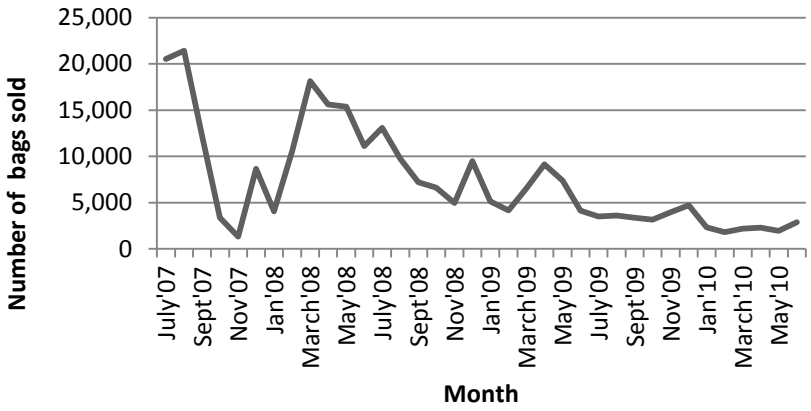

Figure 6-2 Trend in the sale of biodegradable packaging bags (constructed with monthly sales data obtained from Nakumatt holding)

Figure 6-2 demonstrates the inconsistent trend in sales of biodegradable plastic bags since the Minister's policy directive for plastic bag management. Sales picked up in July, 2007 upon introduction of the ban on production of plastic bags of less than 30 micron thickness. They suddenly dropped a few months after the introduction. Nonetheless, the ban has not been that important in the decreasing sales, but was used by the company as such. The further decline is related to levels of demand, since Nakumatt holding stocked too many bags while very few bags were being bought by consumers.

Generally, sales were marked by high optimism and eagerness by consumers at the start, just like production. However, this enthusiasm did not sustain beyond the first three months. The bags were sold in three different sizes with costs at Ksh. 30, 45 and 70 (USD 0.4, 0.6, and 0.9) per bag respectively. The selling continued to show a steady decline over the entire period. When consumption of biodegradable plastic bags is compared to the freely issued plastic bags, huge disparities exist. For the entire period that biodegradable plastic bags was sold in Nakumatt holding (see Figure 6-2), sales varied between 1329 and 20,521 bags per month. This means, for every one biodegradable plastic bag sold, between 300-5,000 plastic bags, are issued for free to shoppers. This disparity shows how it may be difficult to convince Kenyan urban shoppers to change their shopping routines and further commit resources to buy biodegradable plastic bags as an effort to conserve the environment. Further compounding the problem, is the fact that, Nakumatt holding together with other supermarkets still issued free plastic bags as well as other retail shops (including open air markets), which sell them at Ksh. 2-20 (USD 0.03-0.3) for a variety of sizes. At Nakumatt, biodegradable plastic bags are displayed at shelves and/or hanged on stands in between shelves, where they look just like any other commodity item on sale. There was no special marketing strategy to elicit changing consumer behavior with respect to packaging.

The placement of the bags did not relate to other packaging materials and thus created no competitive environment with conventional plastic bags issued (for free) at payment counters. The lack of strategic positioning of biodegradable plastic bags did not seduce consumers to make informed choices about their packaging behavior. According to Nakumatt holding, the bags were placed together with other saleable items since they have to be paid for.[124] The responsibility towards dissemination of biodegradable plastic bag is put at consumers, rather than at the retailers, as costs are fully and directly transferred to the consumers. Government organizations have not been involved in setting unit prices for the bags, or subsidizing biodegradable bags, much to the regret of the retailer. "The government for over three years has collected huge amounts in taxation of plastic carrier bags production. Such funds should be re-invested to support the existing alternatives or be used to initiate research on other alternatives including sisal bags".[12] Supermarkets take no responsibility in increasing the adoption of biodegradable plastic bags, beyond selling it to willing buyers at Nakumatt. As at 2011, Nakumatt holding was no longer placing orders and PIL stopped production of biodegradable plastic bags.

6.4.3 Consumer perspectives and practices with biodegradable plastic bag

The perceptions of consumers of biodegradable plastic bags and the extent to which the new artifact elicit change in shopping practices have a profound bearing on its take-off. Table 6-1 presents surveys on households in the four cities and on consumers leaving Nakumatt supermarkets who had bought the bags at least once in their shopping practices.

More than half of all Kenyan urban consumers shopping at supermarkets are aware of the existence of biodegradable packaging bags. But, only 24.5% of the supermarket consumers shopped from Nakumatt holding (see Table 6-2) and hence were actually exposed to such bags. Hence, other sources of information, including sharing information with friends and colleagues and media reporting, have been instrumental in knowledge about biodegradable plastic bags. Awareness levels are dependent on education and income of consumers.

[124] Interview with Mr. Atul Shah, Chief Executive of Nakumatt holding, on 14 July, 2010.

Table 6-2 Perception and practices of households and consumers on biodegradable plastic bags

Variable	*Households in the four cities (N= 1206)*	*Consumers intercepted at Nakumatt holding exits in Nairobi (N=25)*
Supermarket visited		
Nakumatt holding	24.5%	
Ukwala	8.8%	
Tuskys	19.1%	
Uchumi	17.0%	
Others	30.6%	
Type of packaging exposed to at the supermarket		
Paper/carton	5.8%	
Plastic bag/paper	0.6%	
Plastic bag	92.1%	
Biodegradable bags	1.6%	
Aware of existence of biodegradable plastic bag		
Yes	50.9%	
No	49.1%	
Price of biodegradable plastic bag		
Cheap	1.6%	4%
Fair	17.9%	16%
Expensive	53.9%	80%
N/A	26.6%	
Use of bio-degradable plastic bag while shopping		
Always carry		20%
Not always		80%
Motivation to buy biodegradable plastic bag		
Smart/good		28%
Strong/durable		12%
Capacity		28%
Environmental friendly		32%

Sources: Household survey executed between 25th October and 17th November, 2008; street interviews with consumers at Nakumatt holding supermarket exists between 8th and 29th June, 2010.

The chi-square statistics show a significant relationship between knowledge on biodegradable plastic bags on the one hand, and education and income at the other (ρ= 0.036 and ρ= 0.000, respectively). There is a low usage of biodegradable plastic bags, also among those with high incomes and high levels of education. Only 1.6% of the supermarket shoppers have ever bought a biodegradable plastic bag. A number of reasons accounts for the low adoption. To begin with, there is a general opinion that

biodegradable plastic bags are expensive especially when one has to make a choice between them and the freely offered conventional plastic bags (see Table 6-2). The cost of the smallest size bag is equivalent to that of a 400g piece of bread.[125] Second, limited choices exist in bag sizes. Only three sizes were offered, yet conventional plastic bags are offered in a larger variety of sizes. Thirdly, the use of biodegradable bags would mean a significant change of consumer shopping practices and routines, which can only come with time. As it is now, consumers have only had a brief experience as production has stopped. Fourthly, exposure to and experience with biodegradable bags was only for a small part of the consumers: only those shopping at Nakumatt holding supermarkets.

For those who bought the bag, experiences have not been very favourable. Results from face to face interviews at Nakumatt holding supermarket show that only 20% of consumers who had bought the bags remembered to bring it along whenever they went shopping or for any other use (Table 6-2). This is a further confirmation that traditions and routines of consumers are potential barriers to the introduction and adoption of biodegradable bags. Consumers need to change existing routine behavior and change it into a new form of routine behavior, as they have to switch to carrying their own bags while going shopping (Gilg *et al.,* 2005). At the moment, this behavior is not included in the Kenyan urban shopping culture. Some interviewed consumers (32%) mentioned environmental friendliness as a motivating factor for buying biodegradable plastic bags, but it seems a different thing to also change their shopping practice accordingly.

6.5 Biodegradable plastic bag niche formation

From the previous sections, it became clear that biodegradable plastic bag niche formation has failed to take off as an innovation for prevention of plastic bag waste in Kenya. This section presents explanations as to why there was lack of niche formation for the biodegradable plastic bag production and sales by exploring the three dimensions of social network formation, shaping and convergence of expectations and learning processes.

6.5.1 Social network composition

One of the explanations for lack of niche formation and further expansion is that there is lack of social network building among governmental actors (for policy, and technical support), producers, consumers, and other societal actor (private lobby organizations, media and NGOs).During the brief period that biodegradable plastic bags were tried in Kenya, the economic actor network consisted of only one external supplier of raw

[125] Information obtained by the researcher on 17th November 2009 during a spot check on common commodity items prices from Nakumatt holding supermarket.

material, one manufacturer as the front runner, one retailer and a limited number of consumers.

PIL was the only producer of biodegradable plastic bags until the ban on the production of plastic bags thinner than 30 microns was lifted. Even as PIL ventured into production, the company remained skeptical and counted on two horses, and did not go an extra mile to establish a well-developed technological niche. On the side of PIL, environmental benefits were never strongly envisioned and used in marketing; the company especially pre-empted a possible market opportunity in favour of biodegradable plastic bags. The low market absorption of biodegradable plastic bags coupled with additional production requirements explains the lack of continued experimentation by PIL. Prospects of good monetary returns were not forthcoming due to the inadequate distribution network for sales of biodegradable plastic bags and the limited efforts in marketing. Nakumatt holding, a traditional consumer of plastic bags from PIL was the only retail outlet for biodegradable plastic bags during the entire period.[126] Furthermore, consumer demand for biodegradable plastic bags was too low and never consistent as it was based on too little positive functional value a biodegradable plastic bag could offer against conventional throw-away plastic bags. Not many consumers could forgo their routines of being provided with free bags on such a short interval and further make financial sacrifices to buy biodegradable plastic bags just as they did to other commodity items. The supermarket did not engage in any ambitious sales and marketing strategy that would provide adequate information and advantages of biodegradable plastic bags in order to boost its sales. Because of the low consumer demand (see Table 6-2), sales at Nakumatt holding were meager to stimulate further production by PIL, nor could such sales attract other potential manufacturers to invest in biodegradable plastic production and broaden the network.

Besides failure to amass economic networks necessary to sustain the flow of biodegradable plastic bags from production to consumption, the development of biodegradable plastics as a niche was deprived of participation of other important network actors necessary to facilitate increased adoption. PIL is a member of KAM, but KAM's position remained heavily inclined towards supporting conventional plastic bag manufacturing and continued to be one of the key actors propagating sustainable plastic waste management through recycling as a management priority, rather than substitution (see section 6.3). KAM is of the view that plastic bag manufacturing is good for the country's economic growth as long as the bags produced can be recycled for better environmental management. In addition, some crucial policy actors were missing in biodegradable plastic bag niche development. For example, NEMA and the Ministry of Finance could have developed an administrative structure that would roll out fiscal incentives to the benefit of the industrial pioneer. It is noted that Section 57 (2) of the EMCA, 1999 provides for fiscal incentives in the form of tax rebates to industries that

[126] Interview with Mr. Benju, Operations Manager of PIL, on 15 December, 2009.

invest in plants, equipment and machinery for pollution control (Republic of Kenya, 2000). This provision created an opportunity for NEMA to support biodegradable bags if it was proven that these bags contributed to pollution control and litter nuisance related to plastic bag waste. City authorities, as principle waste operators at the center of waste management, also have not been part of the niche development network. Their priority remained to fulfill the primary duty of efficient waste collection and disposal, rather than contributing to prevention of plastic waste. In fact, the city authorities' waste management plans emphasize plastic waste recycling (JICA, 2010). Lastly, research organizations such as KEBS, KIRDI and universities were absent as actors in the niche development for biodegradable plastic bags, while misconceptions on its functionality continued amongst important Kenyan actors. This prevented learning and knowledge building on and legitimacy for biodegradable plastic bags as a packaging alternative.

Societal actors such as environmental NGOs and media could have provided support and capacity to disseminate information about biodegradable plastic bags. However, prominent NGOs like Practical Action[127] have been mainly instrumental in facilitating local technology development especially shredding and grinding machines for plastic waste recycling (Waste Digest, 2006), but have not engaged in biodegradable plastics. This is related to the fact that such NGOs see plastic waste as an opportunity for poverty alleviation for community groups lacking employment opportunities, and only in second instance as an environmental issue in need for prevention. Equally, the media has been featuring mainly programmes related to plastic waste recycling, and less so to substitution or prevention.[128]

6.5.2 Shaping and convergence of expectations

With the exception of the start-up and initial introduction period of the biodegradable plastic bag, there are hardly any major positive economic or environmental expectations that can be distilled from the core actors actually or potentially participating in the niche formation of biodegradable plastic bags. Expectations of the potential actors to the network (governmental institutions, city authorities, NGOs and the media) are in support of recycling rather than substitution. Furthermore due to its poor economic performance, economic expectations of the core actors involved in biodegradable plastic bag production and sale declined rapidly, up to the moment that all activities came to a stop at a very early period of its experimentation.

[127] Practical Action works with poor communities mainly in the developing world to develop appropriate technologies in sanitation and other societal sectors (http://practicalaction.org).

[128] An article by Gahika Weru titled, "*Waste not, want not: how to squeeze money out of garbage*", highlight how Nairobi City continue to choke under plastic waste while recycling machines lie idle (Sunday Nation, May 2008.

PIL and Nakumatt holding only shared economic benefit expectations in the beginning. For PIL, securing a market for biodegradable plastic bags with their traditional client for plastic bags –Nakumatt holding, with a demand of over 8 million bags a month – was a market opportunity. Equally for Nakumatt holding, being the largest supermarket with 19 branches in big towns, prospects of consumer demand looked high. Such expectations were prompted by the ban on production of plastic bags with less than 30 microns thickness, making them anticipate a niche market for an alternative to throw-away plastic bags. However, such economic expectations did not hold high even before the ban was lifted, as there was no appropriate strategy for the introduction of biodegradable plastic bag in a market that was already inclined in favor other products for packaging (such as plastic bags), resulting in poor sales and low returns. In the first place, PIL was not very sure and fully dedicated to full production of biodegradable plastic bags. The company did not dedicate any particular production line that would increase production of biodegradable plastic bags in anticipation of tangible economic returns. Second, Nakumatt holding failed to adopt a competitive strategy similar to that for throw-away plastic bags where, consumers have to encounter them at the counter for free. The lack of strategic positioning of the two economic actors depicts dearth of positive expectations and full support, even though economic motives triggered initially their involvement.

These hesitations of the main actors complicated the entrance of new producers and retailers in this niche innovation, as expected economic benefits were perceived to be too high. PIL, as a front runner lacked a strategic vision on the niche development that could serve as an exemplary technology and hence be able to attract other industrial actors to participate in production process that could further broaden the diffusion and shape expectations. Furthermore KAM, which could have provided a platform for learning, hold different expectations, in favor of plastic waste management rather than material substitution of prevention of plastic waste. According to them, manufacturing industries can pursue their economic agenda through plastic bag manufacturing as long as plastic waste recycling is enhanced in order to meet environmental goals.

Expectations of other potential actors converge at recycling of plastic bag waste as a feasible environmental solution, rather than substituting them with biodegradable plastic bags. NEMA has gazetted waste management regulations which highlight plastic recycling for management of solid waste (Republic of Kenya, 2006). Nairobi City Council has developed a bio-waste composting policy (City Council of Nairobi, 2002), however, it is not explicit about the composting of biodegradable plastics. The Ministry of Industrialization has formulated an industrial development policy that emphasizes plastic waste recycling by industries (Republic of Kenya, 2008a), while KEBS has also gazetted standards for production of conventional plastic bags (KEBS, 2007), not for the biodegradable ones. Lastly, informal waste operators like waste pickers, CBOs, CBO-SACCOs and yard shop operators have a stake in recycling of plastic waste. Any substitute to plastic waste that reduces their economic expectations is not a welcomed

idea (Kuria and Muasya, 2010). The local media have also contributed to the shaping of expectations that plastic waste recycling is a more sustainable environmental management strategy than plastic substitution.[129]

6.5.3 Learning processes

Hardly any useful lesson about biodegradable plastic bags has been passed from the actors involved in the niche to other potential network actors. PIL learnt that biodegradable plastic bags can be produced using the same technical units as conventional plastic bags. This enabled the manufacturer to produce biodegradable plastic bags without necessarily investing in new machinery. However, this useful knowledge remained under the purview of PIL as it was never shared amongst plastic bag producers despite a few 'curious' manufacturers having visited PIL just at the beginning of its production.[130] KAM, who could have functioned as a platform for other manufacturers to learn about this technology and consequently accelerated the production of biodegradable plastic bags, hold a different view about the ability to replace the dominant plastic packaging bag. Furthermore, before PIL introduced biodegradable plastic bags into the market through Nakumatt holding, there was no major information campaign in the public domain about the bag. Through Nakumatt holding, a good proportion of Kenyan urban consumers have become aware of the existence of biodegradable plastic bags, despite only a few having had first-hand experience with it through purchases (see Table 6-2). Just being aware was not enough to make them change their habits or facilitate them share it in such a way that more consumers would subscribe to it. Consumers did learn about costs associated with consumption of biodegradable plastic bag. But this lesson has not been helpful for the niche formation, in the sense that it was rather a barrier in the uptake of biodegradable plastic bags as long as other packaging materials were offered for free.

Knowledge gaps at consumers are still apparent and hinder further niche formation. As essential intermediaries in the diffusion of biodegradable plastic bags, neither PIL nor Nakumatt holding have taken the opportunity of displaying environmental information on the bags to consumers. Therefore, consumers were not educated and motivated to evaluate any benefits of the bag and to make conscious decisions based on such benefits. For the few consumers who had encounters with

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[129] An article by Joseph Murimi, titled "Dream to tame plastic waste comes of age*",* highlights how there is huge demand for plastic waste and Kenyans cannot satisfy such demands (*The Standard,* April 2008, P.11). Gahika Weru, with his article titled "Waste not, want not: how to squeeze money out of garbage", highlight how Nairobi City continues to choke under plastic waste while recycling machines lie idle (*Sunday Nation*, May 2008).

[130] Interview with Mr. Benju, Operations Manager of PIL, on 15 December, 2009. Manufacturers like Complast and Uni-plast visited PIL, as they are all located on Lunga Lunga Street.

biodegradable plastic bags, knowledge of the bag is basically about its functional properties such as durability and re-usability, but not on environmental benefits.

The 2007/08 Ministerial Directive on plastic bags was yet another reminder of the challenges posed by plastic pollution. The development has not triggered concern of stakeholders to engage in learning processes that would approve of a possible substitute material, whose consumption could reverse the current trend of plastic bag usage. The media did not utilize the bad publicity on plastic bags to highlight possible substitutes to throw-away plastic bags including biodegradable plastic bags. Even environmental NGOs appeared to have no relevant knowledge that was shared to highlight positive aspects of alternatives to throw-away plastic bags for packaging, including biodegradable plastic bags. On the contrary, they are knowledgeable on using conventional plastic waste as a resource. [131]

6.5.4 Conclusion on niche formation of biodegradable plastic bag

In conclusion, and in accordance to the three tenets of the SNM highlighted at beginning of this section, the niche formation of biodegradable plastic bags failed to take off for a number of reasons. There was only one experiment involving only a few actors within the economic network. There was no formation of a well-defined technological niche and not even a viable market niche. Within the economic network, there was insufficient experimentation both at production and retailing. Learning hardly took place and the niche formation was marred with diverse expectations. Governmental actors, who should legislate on environmental practices, and KAM who supports manufacturers in innovation, were absent in the network while their expectations converged on a different strategy for management of plastic waste. It is therefore possible to conclude that there was no alignment of actors' expectations, neither on environmental nor on economic dimensions of biodegradable bags. Knowledge gaps and lack of engagement in learning processes presented limited opportunities for experimentation and diffusion of this innovative technology.

6.6 Socio-technical regimes for biodegradable plastic bags

The focus of this section is on Kenya's prevailing plastic production and solid waste management regimes, since their orientation and functioning affect any future possibilities of using biodegradable plastic bags as a substitute to plastic bag packaging. This analysis starts with the plastic production regime and then proceeds to the solid

[131] For example, Kayole Environmental Management Association, based in Nairobi, has been conducting environmental trainings on waste recycling in East Africa. The NGO focuses on training youth and women groups to earn income by making sellable items such as pillows, hats and hand bags from plastic waste (Interview with Mr. Munywe, chairman of KEMA, on 27 January, 2009).

waste management regime, highlighting the key dimensions that influence the development and diffusion of biodegradable plastic bags.

6.6.1 Plastic production socio-technical regime and biodegradable plastic bags

As indicated in chapter 2 and chapter 5, the plastic production regime has consistently registered an upward trend in its growth, both in terms of product output and technologies used. In this growth, it is also evident that without a packaging policy or an institution to regulate packaging, plastic bag consumption has been on the rise. Furthermore, in the history of plastic development in Kenya, policies that were developed largely emphasized its contribution to economic development as part of the wider manufacturing sector (KAM, 2006). Kenyan consumers have overwhelmingly adopted plastic bags in their daily lives. From a household survey conducted during this field research, 92.1 per cent of Kenya's urban consumers prefer plastic bags as packaging their shopping (see Table 6-2). This state of affairs does not create much room for any alternative packaging, especially when supermarkets continue to issue them for free while open air markets also sell them at low prices.

The 2007/08 Directive on plastic bags was the first policy measure to address the consequences of littering plastic bags in the environment and to outline possible strategies for its sustainable management. However, due to power games that characterize policy making in Kenya, implementation of such strategies have become illusive. Successful petitioning of the government by KAM has thwarted measures contained in the Directive. A statement of the Vice-President's in July, 2007 further put into doubt the government's commitment towards implementation of measures following the 2007/08 directive on plastic bags. While issuing a ministerial statement in parliament on behalf of Local Government Minister, the Vice-President cautioned city authorities to go slow in their enforcement of the Directive, which prohibited production of particular thickness of plastic bags (The People Daily, 26 July, 2007). This was the first step to avert further production of biodegradable plastic bags by PIL.

The unsupportive environment that characterizes the plastic production regime was still evident in the lack of follow up by the government of a policy package that promoted environmentally friendly packaging. The follow up of two measures was crucial in support of biodegradable plastic bag development: introduction of the plastic bag levy and a subsidy provision for existing and potential manufacturers of alternative packaging bags. If appropriately applied, the introduction of a plastic bag levy would reduce usage of plastic bags and further induce interest in research for alternatives. Furthermore funds collected from such taxes could be channeled directly to research organizations and industry to steer research and development on biodegradables, given that Kenya does not have any reliable technical or research infrastructure for packaging, leave alone alternative packaging. A subsidy system in support of current and future

production for cost-effective alternative bio-based plastic bags might at least facilitate consumer behavior change and create demand for consumption.

At the moment, biodegradable plastic bags are too expensive and they are not subsidized. As a new trajectory with no local knowledge, biodegradable plastic bags development required a constituency of policy and technical support actors coordinating their varied resources. For example, if its development would engage collaboration of the manufacturer with NEMA and the Ministry of Finance charged with incentives facilitation, it would have opened a window of opportunity for negotiation and development of a subsidy system necessary for cost-effective production and introduction of biodegradable plastic bags. Such an incentive program would have served as a protection and stimulus for biodegradable plastic bags introduction in the market, reducing the stiff competition currently mounted by free plastic bag packaging. An interview with the Director Compliance and Enforcement at NEMA confirms a dearth of urgency within the government to support the development of alternative materials for conventional plastic bags. NEMA continues to emphasize priority for programmes that enable city authorities realizing high plastic recycling rates.[132] These intentions of NEMA are supported by steps the organization has taken since the enactment of EMCA (1999). NEMA has rolled out training programmes in support of informal actors to comply with recycling requirements as established in solid waste management regulations of 2006. The same position is held by Practical Action, an NGO which was listed as a lead stakeholder in pursuance of alternatives to plastic bags under the technical stakeholders' arrangement. The NGO activities have been visible in supporting plastic recycling initiatives of informal waste actors.

The Ministry of Industrialization has recognized the need for a more integrated strategy for waste management. The National Industrialization Policy of 2008 proposes to promote incentives for investment in waste recycling plants and in production of natural fiber bags such as cotton in all 47 counties by 2030. This is a positive step towards the realization of provision of alternative packaging materials. However, institutional arrangements to define the nature and roll out of such incentive programmes have not been set.

The KNCPC has come up with a proposal for a measure of degradability as ranging from 90 per cent to 60 percent decomposition of plastic material within 60 to 180 days when placed in a standard composting environment (KNCPC, 2006). However, these proposed parameters have not been utilized in the development of biodegradable plastic bags. The standards are used as a first step towards a technical guidance in the development, production and use of biodegradable plastic bags. At the moment there is no institutional infrastructure and collaboration for effective promotion and support of biodegradable plastic bags development, as confirmed in interviews with representatives

[132] Interview with Mr. Langwen on 18 February, 2010.

of KEBS[133] and KIRDI[134]. Despite KEBS being a member of the technical team that formulated the plastic bag policy, it has only developed one standard for plastic bag manufacturing since then (KEBS, 2007), heavily in support of plastic waste re-use and recycling. KIRDI also only promotes technology development for particular materials, mainly foodstuff, textile and leather. These commodities are central in the current government development policy which emphasizes food security for its people (Gitu, 2004) and security of export market advantage over Kenya's regional neighbours like Uganda and Tanzania (KAM, 2006). KIRDI gives no technological support for the development of alternative packaging materials.[22] Efforts of other actors within the plastic production socio-technical regime, like universities, are also in support of plastic waste recycling. For example, Jomo Kenyatta University has fabricated a plastic washing machine for the Nairobi Plastic Waste recycling SACCO.[135] Lack of R&D support for packaging alternatives fails to create room for novel alternatives to emerge.

The plastic production socio-technical regime offers limited opportunities for bio-based or other alternative packaging materials to throw-away plastics in Kenya. Production actors are entrenched in their practices supported by a highly developed technological infrastructure and high demand for throw-away plastic products. The rather incoherent, unstable and shifting policy governmental directives in favour of the status quo are also unfavourable for development of bio-degradable plastic bags. This state of affairs only confirms the reluctant position taken by the government towards a new innovative development. It is therefore highly unlikely that the government would soon spearhead the development of relevant regulations and provide technical and economic support needed for the emerging biodegradable packaging trajectory to take off.

6.6.2 Solid waste management socio-technical regime and biodegradable plastic bags

Developments that have taken place within the solid waste management regime are far from embracing the introduction of biodegradable plastic bags as a strategy for integrated plastic waste management. Here the activities of local and national authorities are being addressed.

The National Environment Council (NEC), which is charged with policy formulation and the definition of national environmental goals and objectives, has not come forth with disposal policy goals that would trigger city authorities to enact by-laws to control waste types destined for disposal sites. Equally, the Standards and Enforcement Review Committee, established under EMCA, has limited scope in its mandate. The

[133] Interview with Mr. Ombok, Manager Chemical Standards, on 16 November 2010.
[134] Interview with Mr. Moturi , Deputy Director in charge of technical services at KIRDI, on 6 May, 2009.
[135] Information obtained during an interview with Mr. Awiti, the Technical Officer of Nairobi Plastic recycling SACCO on 23rd July, 2009.

committee is charged with the responsibility of providing advice on environmental standards, which cover methods of disposal, transportation, segregation and destruction of waste. So far, the committee has only developed a general waste management regulation (Republic of Kenya, 2006). Under this regulation, waste re-use and recycling is regarded as a cleaner production method in the management of plastic waste. No policies or regulations on material substitution have been formulated.

Kenyan city authorities have not been able to quantify amounts of plastic packaging waste in their waste streams. In fact, studies that have been done, including the recently concluded one on integrated solid waste management in Nairobi City (JICA, 2010), only have a generalized classification for plastic waste without categorizing sources. This classification has not been useful in facilitating target-oriented regulations that can capture plastic packaging waste. The recent efforts that city authorities are making in developing integrated solid waste management plans are heavily inclined in favor of plastic waste recycling (see chapter 2). Although neither city authorities nor the Ministry of Local Government participated in the technical working group that developed policy instruments for management of plastic bag waste, the City Council of Nairobi immediately responded by enacting a by-law to ban plastic carry bags (City Council of Nairobi, 2007). The by-law bans selling, importing, manufacturing or storing carry plastic bags of less than 30 micron thickness. But this was also lifted after the change in national policies.

Since the promulgation of EMCA and the subsequent plastic bag policy development, UNEP and foreign embassies have been instrumental in supporting technical capacity building programs and financial needs of CBOs and CBO-SACCOs engaged in plastic waste recycling activities (see chapter 4). These developments confirm that material recovery rather than substitution is the goal that Kenyan waste management systems seek to achieve. Biodegradable plastic bags or any other alternative to plastic bags remains low on the agenda of Kenyan solid waste management socio-technical regime actors.

6.6.3 Socio-technical landscape factors on biodegradable plastic bag development

Landscape variables are considered in this analysis because they help to explain the stability of the existing regime for the biodegradable plastic development and introduction in Kenya. An important landscape variable is the socio-economic condition of the country. The persistently high poverty incidence and low per capita incomes in Kenya do not create much opportunity for people to make a conscious decision in favor of more environmentally friendly, and more costly, packaging options. Conventional plastics have been praised for its numerous functionalities and low costs, making more costly alternatives, with yet uncertain functionalities, less attractive in Kenya.

Another landscape factor influencing the initiation of niche developments towards substitution of conventional plastics is the price of oil as raw material for conventional plastics. However, as indicated in chapter 2, Figure 2-4, imports of polymer material for plastic packaging production in Kenya are still rising, even when world oil prices reach record levels. Other landscape factors, like low availability for biodegradable polymers, the lack of international markets and uncertainty on technology development of these polymers, may play a more important role.

6.7 Conclusion

This chapter analyzed the development of biodegradable plastic bags in Kenya as an emerging prevention strategy in the management of plastic bag waste. SNM has been applied as a tool for the analysis in understanding the failures that characterized this novel development within the Kenyan context. In conclusion, the 1-2 years of experimentation on biodegradable plastic bags lacked adequate engagement amongst key actors in terms of network construction with sufficiently diverse actors, common expectations among these relevant actors and learning moments. This case shows that the failure of biodegradable plastic bags in Kenya has its main causes in insufficient internal niche formation and unfavorable conditions of the plastic production and solid waste management regimes.

7 CONCLUSIONS

7.1 Introduction

With rapid urbanization and the associated growth of industry and services in Kenya, plastic waste levels have increased to about 10% of total waste flows in major urban centers (JICA, 2010). Plastic waste has become a serious contemporary urban problem that Kenyan city managers have to deal with as much of it is littered on public places, dumped at illegal sites and chocks drainage and sewer systems. Plastic waste affects different sectors of the economy, including the provisioning of services such as public health, water and sewerage, and tourism. At the same time, there is increasing recognition that plastic waste also represents a valuable resource, which can be profitably plugged back into the economy. Past and present policies and strategies for solid waste management employed by Kenyan city managers seem to increasingly recognize the problems around solid waste, but are still dismal, fragmented and too generalized to address them effectively. This thesis started with the idea that a transformative and lasting solution to plastic waste problems in urban Kenya rests in the adoption of an integrative strategy, embracing innovative contributions of both formal and informal sectors, and public and private actors within both the plastic waste management and plastic production systems.

The objective of this thesis was to provide insights in the plastic waste management problem and to assess (novel) management strategies for plastic waste in the urban centers of Kenya. The focus was on Kenya's chain of plastic production, consumption and recycling within the context of both industrial development and municipal solid waste management. The research focused on the four major urban centers of Nairobi, Mombasa, Kisumu and Nakuru, as these cities have over the years been most affected by plastic waste problems, but have also started a variety of new activities to cope with plastic waste.

Central in the research has been the analysis of public and private activities and actors in plastic waste management, recycling and prevention, herein referred to as *environmental innovations.* The concept of innovation was defined as any kind of process or practice conducted by individuals or actor groups that adds value to and utilizes plastic waste and with that closes the material cycle or prevents plastic waste from entering the environment. From all possible environmental innovations in handling plastic waste, three have been selected in this thesis for further analysis: (1) plastic waste recovery and associated value addition conducted by informal actors in the solid waste management system; (2) recycling of plastic waste in domestic plastic production and export by private industrial actors; and (3) manufacturing and sale of biodegradable plastic packaging materials. The concepts - derived from Strategic Niche Management - of social network composition, shaping and convergence of actor expectations, and learning processes of actors were applied to analyze the (internal) dynamics of these innovation

activities. In order to understand the conditions under which such innovation activities are conducted and facilitated, the two regimes of plastic production and solid waste management have been analyzed from a multilevel governance perspective (Geels, 2002, 2004, 2005 and 2006).

The research questions of this thesis were:

- How are the solid waste management and plastic production systems organized in Kenya?
- How and to what extent do current and can potential future environmental innovations contribute to the overall management and prevention of plastic waste in Kenya?
- Which current and potential environmental innovations foster integration between SWM and plastic production systems and what insights can be gained from such innovations for building an integrated regime for plastic waste management?

This chapter will answer these three research questions (sections 7.2 to 7.5), and will conclude on what this study has contributed to strategic niche management and the multilevel perspective on transitions (section 7.6). Finally, the chapter presents policy recommendations derived from this research.

7.2 Organization of solid waste management and plastic production systems

In this section, the key findings are presented on the organization of solid waste management and plastic production systems in Kenya, as a background for understanding successes and failures in the proliferation of innovative plastic waste activities.

The solid waste management system

The organization of Kenya's solid waste management system partly determines its performance and the fulfillment of set objectives. This study looked at actors involved in solid waste management activities, relationships between them, and the rules (regulations, policies, procedures) and resources, such as physical infrastructure, human capacity and budgets, for performing solid waste management activities.

The current solid waste management system evolved from initial structures that fulfilled public health goals, which used to be monopolized by city authorities. This changed when private waste collection firms, individuals and Community Based Organizations (CBOs) spontaneously emerged in the early 1990s when city waste collection and disposal services were in constant decline. The emergence of these new

actors came together with city authorities losing power in providing adequate collection services. A household survey conducted during this study – as well as many other investigations –show a general dissatisfaction about the performance of city authorities in waste services. Nairobi, with the highest waste production, only manages to collect and dispose in a controlled way 21% of its waste during the first decade of this Millennium, followed by Mombasa at 12%, Nakuru at 10%, and Kisumu 8% (see also JICA, 2010; KISWMP, 2008). At the moment, private firms are the dominant waste collection agents in both Nairobi and Nakuru, while CBOs lead collection and disposal services in Kisumu and Mombasa.

Open competition amongst these service providers is prevalent, with lack of proper monitoring and co-ordination. Service providers are only accountable to consumers, whose main concern is the immediate removal of waste from their household and neighborhood rather than the ultimate destination for such waste. Hence, at maximum 21% (Nairobi) of the solid waste generated within the studied cities is collected by city authorities and disposed at poor disposal sites, characteristic of Kenya's solid waste management systems. Such dismal performance in waste collection and disposal is also evidenced by plastic waste streams blocking sewers and drainage systems and widespread littering of plastic waste in the environment. Efforts by residential neighborhood associations (under the umbrella organization KARA) to compel city authorities to live up to their legal mandate as well as to monitor the performance of other non-state actors have not borne any fruit. KARA's monitoring role is only focused on waste collection and disposal and not on (plastic) recycling activities. Furthermore such monitoring role lacks effectiveness as KARA works without any legal backing.

Solid waste management in Kenyan cities has attracted a wide range of actors who resource almost all types of waste for recovery and recycling purposes. For decades, the Public Health Act, Local Government Act and city specific by-laws 'labeled' waste only as a nuisance and did not focus on resource recovery activities. The policy and regulatory frameworks of urban solid waste management systems regarded the recovery of waste as informal, even though private actors have always utilized waste materials in production. The enactment of EMCA in 1999, which created NEMA and an enforcement review committee, has changed the landscape for solid waste management. Since then there exists a gradual shift towards embracing recycling of waste as a solid waste management option. EMCA recognizes recycling of waste as a management strategy and recycling is now the key word in a number of government policy documents. The Ministry of Local Government drafted the National Solid Waste Management Strategy in 2008 that embodies recycling targets to be achieved by city authorities for their solid waste management systems. City authorities have responded by enacting solid waste management by-laws, which spell procedural requirements for waste collectors, highlight the need for both technical and infrastructural assistance to individuals and groups

engaged in recycling, and regulate plastic production. But these by-laws often have not adopted recycling targets.

Despite this change, solid waste management systems of Kenyan cities are still not fully embracing material recovery activities and many recycling initiatives grow despite rather than because of local authorities' efforts in solid waste management.

The plastic production system

This study looked at the contribution of the plastic manufacturing sector to Kenya's economy, policies for industrial development and the raw material use within the plastic production system.

The plastic production system in Kenya has over 200 industries, the majority having a capacity of over 1000 tons per year. The sector employs directly 20,000 laborers and a threefold figure is indirectly depending on this sector.

Plastic production in Kenya has been on an upward growth since the 1960s. This growth is largely attributed to a series of ambitious industrial policies that Kenya's government has embraced over the years in order to boost its economic growth as well as to create employment opportunities for its citizens. The plastic production sector has been a major beneficiary of technology importation. Kenya Association of Manufacturers (KAM) has contributed to this development by lobbying the government for favorable policies.

The plastic production processes draw upon two types of resources: virgin polymers and plastic waste material. Plastic producing industries belong to the formal economic sector. The findings presented in this thesis show that these plastic producers are instrumental in converting significant volumes of plastic waste into useful products. Plastic industries using plastic waste as resources can be categorized in conventional recycling industries, home-grown recycling industries and industries exporting semi-processed waste material to international markets. Industrialists are in constant search for market niches. However and as demonstrated by Figure 2-1, the release of plastic products to waste far outweighs the use of plastic waste in the production of plastic products. As a result, plastic waste continues to flow into municipal solid waste streams and to (illegal) dump sites.

Apart from the formal compliance requirements for industries to governmental regulations and policies, no structural collaboration exist between the industry and government departments, for instance to facilitate the development and transfer of local knowledge for plastic industrial development. Most technology used within the sector is imported. Unexploited technological capacity exists within the sector both for virgin plastics and post-consumer plastic waste production.

7.3 Common and comparative analysis of niche developments

In this section, I will analyze and compare the seven niche developments presented in this thesis on plastic waste handling in Kenya. In line with the literature on Strategic Niche Management (i.e. van der Laak *et al*., 2007; Schot and Geels, 2008) the analysis is based on three main characteristics of niche development: building of social networks, voicing and shaping of expectations, and learning processes in the niche innovations.

Building of social networks

In their review of the Strategic Niche Management literature, Schot and Geels (2008: 541) hold that in order to have successful niche developments multiple stakeholders, including relative outsiders, should be involved to express multiple views and voices; and that the networks of such stakeholders are 'deep' enough to mobilize commitment and resources within their own organizations. Actor networks around these niche developments should also be heterogeneous, thus including (a variety of) market actors, policy actors and civil society organizations. Within these heterogeneous networks multiple and intensive interactions are deemed necessary to let niche developments flourish and disseminate, towards influencing regime changes.

In assessing the 7 niches in plastic waste management in Kenya it can be concluded, firstly, that the sizes and the heterogeneity of the networks around each of the seven niche innovations are small, and usually do not involve a large variety of actors from the combined three spheres of markets, policy making and civil society. In case of the CBOs and CBO-SACCOs, for instance, dependency on a single or only small number of non-governmental agencies was evident, while yard-shop plastic handlers were solely working with a few waste suppliers and plastic producing firms. In other niche innovations the lack of heterogeneity is less extreme but still present.

Secondly, the social networks are rather specific for each niche innovation route. There is little mutual strengthening between the different niche innovation networks. Only a few actors function in the center of social networks around multiple niche innovations, NEMA being such an exception.

Lastly, in all niche innovation networks, non-state actors are leading. The leading actors are mostly private economic actors with clear economic motives that push for niche innovations in the network. Environmental motives and considerations, pushed for by environmental advocates (NEMA, municipal environmental authorities, environmental NGOs, etc.), hardly play a dominant role among the network actors around the majority of the niche innovations, and certainly not among the leading economic actors. In a few cases civil society organizations (CBOs, CBO-SACCOs) are leading the niche innovation network. But also in these cases environmental motives do not play a leading role. Rather, social and community development motivates the main actors in the CBO and CBO-SACCO niche innovation routes.

Actor expectations

With respect to the expectations of the main actors conveying the niche innovation routes, the degree of convergence is important regarding the support for and the proliferation of niche developments. A number of conclusions can be drawn from the seven niche developments. Firstly, recycling rather than substitution of plastics for other/alternative materials seem to be the converging expectation in most of the niches, and certainly in the more successful niche innovations and the main actors supporting these successful niches. Among most of the market actors, the main political and policy actors, as well as the CBO and CBO-SACCOs involved in the analysis we see a major convergence towards the benefits and potentials of recycling rather than substitution in solving the problems of plastic waste.

In line with this, there is hardly any convergence of expectations concerning innovations that deal with plastic waste prevention. The governmental ban on bags made of plastic under 20 micron (a measure to limit the use of disposable plastic bags and thus to prevent plastic waste) and the substitution of plastic bags by biodegradable plastic bags, met very little convergence among the major actors involved in plastic waste innovations.

Secondly, a large majority of the actors in the networks around the seven niches do converge in the expectation that economic motives rather than environmental motives or social development motives should drive the niche innovative developments. This coincides with a preference for recycling rather than substitution/prevention, as with recycling initial plastic production economic activities remain intact, while new economic value added activities are supplemented.

Third, there seems to be wide convergence among the dominant actors in the various niche networks on the low priority for separated collection of plastic waste. None of the dominant actors was strongly pushing for separate waste collection systems. Incidentally, there is separate collection of plastic waste (as in the case of PET bottles, or plastic waste at supermarkets or factories), but there is still no systematic separate collection of all different post-consumer plastic waste factions. There is also no major effort from different policy and political institutions at national and local levels to develop initiatives, pilot projects or policies to install such separate collection systems.

From the analysis of the 7 cases on convergence of actor expectations on a consistent plastic waste management approach in the near future we can conclude that some convergence seems present on recycling rather than on substitution; on economic motives dominating over environmental motives and that prevention nor separation at source will be high on the agenda. With prevailing economic motives upholding among the main actors, it can be expected that innovation development in plastic waste management will keep fluctuating with factors like oil prices, national economic growth and unemployment rates.

Learning

Strategic Niche Management theory makes a clear distinction between first and second order learning, and hypothesizes that in order for niche developments to be successful and make it into regime changes, learning processes need to include second order learning: learning not only directed at facts and data but also enabling changes in cognitive frames and assumptions (Grin and Van de Graaf, 1996).

Learning in the 7 cases took place especially as first order learning processes in the different niche developments and practices. In each of the niche developments the main actors have learnt the various technical, economic and regulatory aspects of innovation in plastic waste management. CBOs, yard shop owners, and home grown industries have picked up experiences from each other, especially if they are located close to each other, or have some (informal / family / friendly) relations and are not too much in competition with each other. In the larger companies, learning takes also place in hiring (foreign) experts to work together with their local employees and to learn on the job. Within CBOs and CBO-SACCOs, technical and organizational learning is obtained from various international donor organizations. But most of these learning processes are not institutionalized or formalized and take place on an informal and rather incidental and ad-hoc basis.

In hardly any of the niche developments second order learning takes place, as no institutions are responsible in monitoring practices and gaining knowledge about plastic waste mitigation options and experiences. NEMA, KIRDI, industrial associations of plastic manufacturers and international donors would be the logical institutions for second order learning, but there is limited enduring interest, regularly shifting priorities, and lack of adequate capacity and resources to take plastic waste mitigation knowledge generation and dissemination on board as one of the key tasks.

Conclusions

Based on the analysis of the seven sub-cases of niche development routes in terms of actor networks, convergence of expectations and learning processes, it is now possible to formulate explanations for the relative success and failure of each of the niche developments. Successfulness is then formulated in terms of continuity of dealing with significant amounts of plastic waste and ability to influence changes at the regime level. We can group the seven studied niche innovations into three categories: relatively successful niche formation cases (yard shop owners and conventional plastic industries), not very successful niche developments (CBOs, CBO-SACCOs and home grown industries) and failed niche developments (bio plastics and exports).

Yard shop niche developments can be seen as a relatively successful niche development in handling plastic waste. This route directly links the plastic waste management system with the plastic production systems (see below); it has a high degree of convergence of ideas and expectations among the (limited number of mainly economic/market) actors in its network, and the network is strong and focused towards upgrading plastic waste and recycling. The conventional recycling industries form also a relatively successful niche development. It encompasses a broader and better organized and partly formalized network of actors compared to the yard shop recycling niche. The actors in this network show a high degree of convergence in that plastic waste is seen as a useful resource that can easily feed into normal plastic production as it is clean and homogeneous. It encompasses perhaps the most active learning processes, where even international exchanges and learning take place. Besides it is formally recognized among policy makers, making this niche less vulnerable to harassments or preferences of individual municipal enforcement officers and politicians. Equally to the yard shop route is that it is profitable, making that economic motives do work and ensure a major degree of continuity over time.

The CBO and CBO-SACCO niche routes have to a large extent, similar characteristics and show both ambivalent successes. There is some degree of first order learning taking place among the community based organizations, but such learning processes are poorly institutionalized and strongly dependent from temporary ideas and priorities of international donor agencies. These niche innovations consist of fairly small networks that are quite homogeneous and do not stretch out widely, making the niche innovations quite vulnerable. Continuity of these niche innovations is therefore problematic, also because social and community development are often the main goal, while plastic waste collection and upgrading can easily be exchanged for any other community project, depending on donor, community member or policy-maker preferences.

Home grown industries form a niche development path that also shows ambivalent successes, but for very different reasons. Here the main problem is in the limited network of suppliers of clean and upgraded plastic waste. While the market potential seems promising and the learning of new techniques and new product developments is also reasonably well developed, continuity and expansion of this niche development stagnates due to the limited supply network of plastic waste and the failures to fulfill market expectations.

Finally, two niche developments have largely failed. The bio plastics substitution innovation showed poor convergence of expectations among the (limited number, but potentially wide) political and economic network actors. Few believed in the viability and economic feasibility of this niche innovation in Kenya. Hardly any learning took place from and beyond the only company involved in bio plastics production and from and beyond the only supermarket selling these plastic bags towards other producers and

retailers. In a similar way, the export route can also be seen as a failed niche innovation. There was little learning and dissemination of products conditions, markets, export markets and the like. The network around this niche remains very limited and homogeneous and has not extended to larger numbers of economic and political actors that could support exports of plastic waste. And among the few actors, expectations did not really converge in the idea that this was a major new innovative route for handling plastic waste and solving problems of waste management in Kenya.

Figure 7-1 below indicates where and how niche innovations can be situated within the framework of multiple levels and multiple regimes as introduced in Chapter 3 (see Figure 3-2).

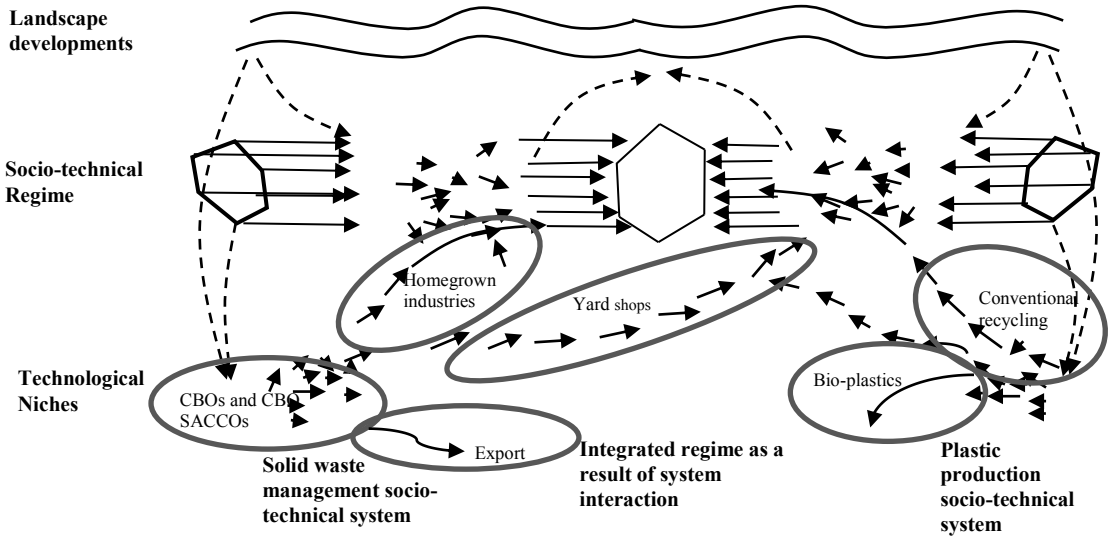

Figure 7-1 Studied niche innovations in a multi-level and multi-regime transition framework

7.4 Regime and landscape analysis

This section starts with comparing the two regimes of plastic waste management and plastic production and analyses the commonalities of the two regimes and the regime factors that contributed or hindered niche innovation developments for plastic waste mitigation. First, the three groups of factors that make up plastic waste and plastic production regimes are elaborated upon (actors and organizations, rules and regulations, material-technical infrastructures), followed by an analysis of landscape factors determining niche innovation developments on plastic waste management.

Actors and organizations of regimes

In terms of actors and organizations at regime level, there is little overlap between the plastic waste management regime and the plastic production regime. The differences between the two regimes in terms of actors and organizations are much more significant than the overlaps. In both regimes actors such as NEMA, KEBS, KIPPRA and UNEP are present and play minor or slightly more important roles in structuring and enabling specific niche innovations, but not in a regime overarching way. There is little coordinating effort of the regime actors and organizations towards the formulation and structuring of both the solid waste management and the plastic production regime, neither politically, nor economically. Moreover, these common actors are mostly of a political/bureaucratic nature and are hardly driven by economic motives and orientations, which are so dominant among the more successful niche innovation networks.

Rules and regulations of regimes

In a similar way, the differences in terms of policies and regulations between the two regimes are much larger than the commonalities or joint efforts. There is no overarching law or major policy document with respect to plastics (and plastic waste) overarching the two regimes. Commonalities between the two regimes in terms of policies and regulations can be found only incidentally, for instance with respect to licensing policies towards the economic actors that are governed through each of the regimes. The negotiations and implementation of regulations on the thickness of plastic bags can be interpreted as one of the few policy making instances that are a product of both regimes (plastic waste management as well as plastic production).

The majority of the policy and regulations, however, are developed within one of the two regimes and serve the actors and niche innovations strongly belonging to that particular system. Economic stimulation, financial subsidies and market incentives differ largely between the two regimes. Niche innovations of plastic producers are strongly stimulated and (to some extent) subsidized by the public sector, while within the solid waste management regime this subsidizing comes mostly from international donors and NGOs. The emphasis of the plastic waste management regime policies and regulations is on the local level, while plastic production policies and regulations mostly originate from and concern the national level.

As a result, from the perspective of policy, regulation and governance, the current integration of the two regimes is indeed rather poor, as was hypothesized at the start of this study.

Material-technical infrastructures of regimes

On the level of the material technical infrastructures that make up the regimes, differences between the two regimes are equally large. The material-technical infrastructure of the plastic production regime consists of intermediate to advanced technologies and operates at a national level, with clear connections in terms of material flows and exchange of knowledge and information. There are even international connections in terms of import of foreign technologies and international exchange of experts, making that upgrading of the material-technical infrastructure more exogenous than endogenous.

With respect to the material-technical infrastructure of the plastic waste management regime, a dominance of endogenous (technological and infrastructural) developments can be witnessed, from within the actors and firms that make up this infrastructure. The technical level is of a low or 'simple' nature, requiring little investment and formalized knowledge; but handling technical infrastructure does require some degree of tacit knowledge. The infrastructure and material flows are mostly locally organized, with only some national connections.

These major differences in material-technical infrastructures make connections, interdependencies and jointness of the two regimes quite limited.

Landscape factors

The identified main landscape factors that structure both regimes and the niche innovation developments, do work differently. Higher oil prices stimulate all niche developments as higher oil prices make plastics produced from virgin material more expensive, which stimulates the recycling of plastic waste (as the dominant niche innovation route) in a similar way through both regimes. But higher levels of economic growth and development within Kenya work out differently for the two regimes and the different niche innovations: higher levels of economic development come together with more plastic production from virgin polymers and thus it limits plastic waste demand and its handling by conventional plastic producers. By the same token, higher levels of economic development result in growing volumes of plastic waste which enable yard shops, CBOs and CBO-SACCOs to collect and process more plastic waste and likewise enable home grown industries and exporters to expand their businesses in plastic waste if demand grows.

Conclusions on regimes and landscape

It can be concluded that regime and landscape factors in both systems of plastic production and plastic waste management are not equally conducive for the respective

niche developments in the two sectors. Within the plastic production system, the regime actors, the organization of the sector, the prevailing economic rules and regulations, and the (advanced) level of technology seem to be more conducive to niche innovation than what we have observed in the waste management sector. The organization of the latter is much more scattered over different governmental and non-governmental actors, with lower levels of technology and local regulations that restrict rather than stimulate small scale innovations. Landscape factors like oil prices and economic growth are influencing both regimes and inherent niche developments, but in a slightly different way. Among those factors, the price of oil and thus of virgin plastic is crucial for innovations to flourish in both sectors.

7.5 Towards an integrated regime for plastic waste management and plastic production

The basic idea behind this thesis was that a closer connection (or even an integration) of solid waste management system and the plastic production system would be a major stimulus and perhaps even a precondition for adequate and efficient plastic waste prevention and management in Kenyan urban centres. Integration can be enhanced by developing an integrated regime that governs both systems, supported by niche developments and innovations within and across each of the two systems. As the analysis in section 7.4 shows, it has to be concluded that Kenya is quite far from developing an integrated regime that structures and enables plastic waste prevention and handling through both the plastic waste management and plastic production systems. To a major extent, currently two separate regimes continue to exist, with a very small common part (of actors, rules and regulations and technical infrastructure). Hence, niche innovations are 'governed' differently from the two regimes or – more often – only from one of the two regimes. Developing niche innovations that are structured and enhanced by the two systems will be very difficult.

Strategic Niche Management theory suggests that regime changes may be initiated by innovations within niches, and it has shown historic cases where that has indeed been the case. In other words, niche innovations are not only governed by regimes but also play a major role in (re)structuring regimes themselves. With respect to plastic waste management in urban Kenya, this study concluded that most of the seven niche innovations on plastic waste that have been studied contribute only marginally to building a more integrated regime for dealing with plastic waste. There are two exceptions to this. The niche innovation route of yard shops seems to be successful in bringing the two separate regimes together (see also Figure 7-1). Yard shop owners have successfully forged economic relations and function as an intermediary between actors on both sides: waste pickers on the one hand and plastic producers on the other. The other exception is the niche innovation route of home grown industries, which contributes to integration of

the two regimes by creating a new economic and material flow for mixed plastic waste and producing new plastic materials for a new market. Not accidentally, these two niche innovation routes are strongly connected, but in practice there are still major barriers for a fluent flow of upgraded plastic waste of yard shop owners to home grown industries.

Having assessed that so far current niches have shown a meager ability to foster integration between the two regimes, the question becomes relevant what kind of innovations still need to take place to further stimulate the building of an integrated regime on governing plastic waste. Starting from what has been observed as impediments to the various niche developments obviously more coordination is needed in terms of governmental, industrial and civil society support for both sectors with a view towards integrated plastic waste management. This would count for all levels: from acknowledging the existence of waste pickers, to the allocation of space for yard shops and waste separation centers, to technological and financial support and education in terms of waste processing, and to plastic product marketing.

A number of new niche innovations may need (further) development so that this integrated regime building actually takes off: for instance, niches supporting the separated collection of plastic waste from other waste streams and the further separation of various plastic materials; supermarkets introducing and testing deposit and return systems; and more in general innovations inducing the prevention of plastic waste that make a step away from linear solid waste management, such as improved transport logistics for plastic products and plastic waste or the widespread introduction and usage of reusable (plastic or non-plastic) bags.

7.6 Theoretical reflection

This study has taken the multi-level perspective (MLP) on transitions and Strategic Niche Management as a starting point, while acknowledging that so far the theory has mostly been applied in the industrialized world. There are only a few cases where the multi-level perspective on transitions and Strategic Niche Management studies have been applied in analyzing cases of socio-technical change in developing countries (see for instance Caniels and Romijn, 2006, 2008). In that respect the application of these frameworks in analyzing plastic waste management niche innovations in urban Kenya is rather unique. What has this empirical study contributed to the multi-level perspective on transitions and Strategic Niche Management? Three main theoretical contributions can be listed.

For one, this study contributed to applying the theories to a developing country, assessing better the usefulness and applicability of a primary western theoretical model in non-western contexts of developing countries. In doing so this study has helped in noting and identifying a developed country bias of the frameworks. A theoretical starting point that has proved to be useful and valid in developed countries or contexts can be rather problematic in situations as the one studied in this thesis. For instance the precondition of

heterogeneous actor networks with intensive interactions for successful niche innovation seems different in our study. In general, networks and interactions among actors in the networks are less extensive in sub-Saharan Africa, but still niche innovation could successfully flourish, making this precondition distinct in developing countries. Also without very intensive actor network interactions niche developments did successfully emerge in this study, like in the case of yard shop owners. Similarly, broad dimension of learning that is highlighted by recent scholars of strategic niche management for any successful niche development did not occur in our cases. Techno-economic lessons are still the spring board of innovation success in developing countries.

Secondly, our study contributed to the multi-level perspective on transitions and to Strategic Niche Management studies by focusing the empirical work on a new area that had not yet been studied from this perspective: plastic waste. In this area of plastic waste management, multiple regimes govern and structure simultaneously niche developments in that one area. Such multi-regimes have rarely been investigated in other cases of MLP transition studies (see for one of the rare examples: Geels, 2007b), making it a rather new element.

Thirdly, the perspective of integration of two regimes as a facilitating and enabling strategy in Strategic Niche Management and transitions is a new element, not present in other MLP transition studies. The idea that integration of regimes can support niche development and transition processes in situations where multiple regimes govern and structure niche innovations around a particular problem brings a new dimension to MLP theory. With respect to this, the current study of plastic waste management in urban Kenya is of course rather meager to firmly extend an existing theory. Hence, further empirical studies in this direction are needed to build regime integration into MLP transition studies. This is especially relevant for transitions towards sustainability (up till now the subject of the majority of transition studies), as most sustainability problems are not related to a single regime but follow from lack of integration of actors, policy and regulations, and infrastructures, which all comprise crucial regime elements.

7.7 Policy recommendations

Having analyzed innovation cases for management, recycling and prevention of plastic waste with a view to providing lessons that can be used to build an integrative framework for plastic waste management involving solid waste management system and plastic production system, this study can formulate the following policy recommendations.

Different informal actors have been able to partly rid the environment of plastic waste as well as supply raw material for production to plastic production system. This type of relationship has been in existence for several decades. While informal actors have been able to sustain their livelihoods based on their plastic waste activities, private industrial actors have always resorted to using plastic waste to leverage them of the

unpredictable economic situations. However, these actors have been faced with a number of challenges denying them the opportunity to reap maximum benefits from their activities and substantially contribute to good environmental management. For instance, informal actors are still faced with deplorable working conditions and lack of clear guidelines on how they should conduct their waste management activities. On the other hand, industrial actors have over the years benefitted from government friendly policies, although these policies have not been sensitive to the different needs of actors involved in different recycling trajectories. In order to maximize recycling of plastic waste, different policy interventions are required focusing on solid waste management and plastic production systems.

First, the solid waste management system has no framework of engagement with informal waste management actors. This condition makes the informal activities remain on the periphery of mainstream solid waste management and actors of such activities are either constantly harassed by enforcement officers or treated unequally. They are therefore not able to substantially contribute to plastic waste management. It is recommended that city authorities develop a framework of engagement with informal waste management actors within their jurisdictions. Such a framework should take into consideration the different challenges facing different actor groups. For instance, yard shop operators who despite working singly, handle much bigger quantities of plastic waste than CBOs and CBO-SACCOs should be facilitated to form associations in order to consolidate their waste material and position. This will enable them to respond adequately to the demand for plastic waste and further allow them to access lending facilities in order to boost their capacity for operations.

Second, within the plastic production system, three categories of recycling have evolved yet industrial policies that have been formulated over time remain insensitive to their varying needs. Conventional recycling industries which emerge dominant in the management of plastic waste bemoan exorbitant electricity and water charges. Homegrown recycling industries whose recycling processes negates the 'recycling rituals' of sorting and washing are still faced with inadequate technological capacity and plastic waste supply. Export of semi-processed PET plastic waste lack standards to enable them access to international markets competitively. All these three recycling trajectories complement each other in the management of plastic waste. It is recommended that in order to enhance plastic recycling, differentiated policies that take cognizance of these needs are formulated.

Third, innovation actors are still dealing with unsorted waste which compels them to incur a lot of expenditures in order for such waste to be used as raw material in plastic production processes. In addition, the solid waste management and the plastic production systems operate at different levels and scales without any collaboration. While solid waste management activities are localized and confined to specific city jurisdictions, plastic production activities extend beyond national boundaries. These varying operating

conditions have made solutions for solid waste problems including plastic waste to be localized and isolated. This situation jeopardizes chances of city authorities to respond to any demand of plastic waste by industries. On the other hand, plastic production industries operate in a liberalized economy where any demand for plastic as raw material can be met from any source competitively. This condition does not oblige plastic industrial actors to obtain their raw materials locally. In order for solid waste management and plastic production systems to coevolve towards maximizing recycling as a strategy for plastic waste management, it is recommended that any city waste management strategy should include waste separation at source to ensure that actors within the recycling chain are guaranteed of less contaminated plastic waste. In addition, development of rules that require industries to take back certain quantities of plastic waste from the solid waste management system would enhance recycling. Such rules should be spearheaded by policy actors such as NEMA, KEBS, KIPPRA, Ministry of Local Government and Ministry of Industrialization, and KAM.

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Appendices

Appendix 1: Solid waste management related policies

Policies	**Stipulate**
Sessional Paper No. 6 of 1999 on Environment and Development	Outlines Kenya Government's fundamental principles to environmental management. Environmental protection is an integral part of sustainable development. Commits to encourage re-use and recycling of residues and to promote use of economic incentives such as taxes to encourage adoption of environmentally friendly technologies.
Interim Poverty Reduction Strategy Paper for the period, 2000-2003.	Emphasizes development of environmental partnerships with stakeholders, including promotion of environmental NGOs and CBOs.
Sessional Paper No. 2 of 2005 on Development of Micro and Small Enterprises for Wealth and Employment Creation for Poverty Reduction	Recognizes that micro and small enterprises (MSEs) across all sectors of the economy provide one of the most prolific sources of employment. Further highlights the need for a review and standardization of local authority's by-laws to align them in support of small scale businesses.
Economic Recovery Strategy for Wealth and Employment Creation 2003-2007	Principally aspire to restore democratic right of Kenyan people and empower them. Recognizes that pollution of environment resulting from poor solid waste management including plastics and polythene needs to be dealt with. It proposes for the development of a policy on recycling.
Policy Instrument for the Management of Plastic Bags in Kenya (KIPPRA, 2006)	Proposes instruments including regulatory, economic and voluntary information base as appropriate for the management of plastic bags in Kenya.
Kenya Vision 2030	It is the first long term policy blue print for the government of Kenya whose overall objective is to realize a higher and sustainable growth of the economy in a more equitable environment, accompanied by increased employment. For the solid waste management sector, it reiterates the development of waste management strategies aiming at involving the youth as well as promotion of public private partnerships in SWM. Proposes establishment of fully functional waste management systems, enforcement of regulations on plastic bags especially the flimsy type, open to application of economic incentives/disincentives.
National Environment Policy 2008	Underscores the value of collaboration in environmental management. Aspires to integrate environmental, economic and social perspectives in policy development for SWM strategies. Recognizes the need for incentives and disincentives in promotion of reuse, recycling and reclamation of reusable packaging materials.
Draft National Solid Waste Management Strategy 2008	Stresses the need for all local authorities to focus on solid waste as an integral element of wealth and employment creation besides protection of environmental resources. Stipulates a statutory requirement of 30% waste recovery within their areas of jurisdiction by 2018, and progressively recover over 50% of the waste by 2030. Underscores the importance of an integrated and collaborative approach to waste management.

Appendix 2: Laws and by-laws related to solid waste management

Laws and by-laws	***Stipulate***
Environmental Management and Coordination Act (EMCA) (Republic of Kenya, 1999)	Establishes the framework for coordination and supervision of environmental activities in Kenya. Places a responsibility of waste on generators to ensure waste minimization through treatment, reclamation and recycling. Provides for establishment of standards and procedures for waste management. The Act has created a number of organs to oversee management of environment. Key among them is the National Environment Management Authority (NEMA) as the principal coordinating organ for all environmental activities. Under EMCA, solid waste management (SWM) regulations of 2006 and environmental impact assessment regulations of 2003 have been formulated. The Act also recognizes recycling as a strategy for waste management and recommends for incentives to industries that invest in recycling technologies.
Local Government Act, Cap 265	The Act establishes local authorities and further grants them the mandate to enact own by-laws including those related to waste management, pronouncement and enforcement of environmental penalties.
Public Health Act, Cap 242	Vests the power to maintain aesthetic conditions for a healthier living environment for all within a local authority's jurisdiction. Places a responsibility for maintaining cleanliness and prevention of danger to health by local authorities.
Physical Planning Act, Cap 286	Is the principle Act for management of land as a resource for economic development. Provides for the designation of solid waste disposal sites within a local authority's jurisdiction.
City authorities by-laws	Regards solid waste as both public health and environmental nuisance and creates penalties for any act of illegal disposal of waste

Appendix 3: Organizations with solid waste management responsibility

Organizations	**Mandate over SWM**
City authorities	Have created departments of environment in the recent past charged with the responsibility of solid waste management including policy guidelines.
National Environment Management Authority (NEMA)	The principal coordinating body for all environmental management activities in the country. NEMA has prioritized enforcement of environmental standards, regulations and enhancement of public education and awareness creation around sustainable environmental management. Part of NEMA's responsibility is to strengthen linkages with stakeholders, and implementation of multilateral environmental agreements. The organization's officials singly or in collaboration with officials of other lead organizations including local authorities monitor and regulate activities with negative impacts on the environment.
Kenya Bureau of Standards (KEBS)	Established to promote and make manufactured goods competitive in both local and external markets by raising quality. KEBS is therefore a regulatory body with mandate to strengthen manufactured goods and services through application of standards and technical advice on quality management in Kenya. For the solid waste management, KEBS has developed a 30 micron thickness for manufacture of plastic materials and bags in order to encourage re-use of plastic materials especially the carrier bags thus reducing environmental pollution arising from waste.
Kenya Institute for Public Policy Research and Analysis (KIPPRA)	Conduct policy research and analysis necessary to advise government and private sector on various aspects of operation and development, Including those in the area of environment and waste management. Has been instrumental in the study that led to the development of the 30 micron thickness standard for plastic production.

Appendix 4: Semi-structured questionnaire sent by post to plastic industries producing from post-consumer plastic waste

Plastic waste management present greatest challenge to the local authorities and it would take a well-coordinated effort of various actors to provide a sustainable solution to its problem. Kindly provide answers to the following questions which will strictly be used for research purpose only.

1. What year was your industry established? _____
2. Give the number of employees in your industry
   - Male _____
   - Female _____
3. Where do you source for your raw materials?(Tick as appropriate)
   - ☐ Local
   - ☐ Abroad
4. Kindly name your suppliers of raw materials
   - _____
   - _____
   - _____
5. What kind of raw materials does the firm use?
   - _____
   - _____
   - _____
   - _____
6. Is your production based on non-virgin raw materials or a mixture of virgin and post-consumer plastic waste? _____
7. What kind /type of plastic products do you produce?
   - _____
   - _____
   - _____
   - _____
   - _____
8. Give an inventory of the manufacturing and reprocessing technologies in your industry?
   - Type of machinery used
     1. _____
     2. _____

3. _____

9. What quantities of products do you produce per month?(**Tick as appropriate**)

   - 0-150
   - 151-300
   - 301-500
   - 501 +

10. What are the main categories of plastics produced on the basis of physical structure?(**Tick as appropriate**)

- Polyethylene Terephthalate (PETE)
- High-Density Polyethylene (HDPE)
- Poly Vinyl Chloride (PVC)
- Low-Density Polyethylene (LDPE)
- Polypropylene (PP)
- Polystyrene (PP)

11. Name your distribution network for plastic products

- _____
- _____
- _____
- _____
- _____

Appendix 5: Follow up interview with consumers of biodegradable plastic packaging bags

1) Gender of the respondent

- Male
- Female

2) Age group

- <25
- between 25-35
- Between 36-45
- Over 45

3) Level of education:

- Primary
- Secondary
- University

4) Place of residence

- High income residential
- Middle income residential
- Low income residential

5) Did you buy this bag from the supermarket?

- Yes
- No

6) If **Yes** in 5, name the supermarket _____and price bought at Ksh. _____

7) What prompted you into using this bag?

- Smart/good
- Strong/durable
- Capacity
- Environmental friendly

8) How often do you use this bag once bought?

- Always
- Not frequently

9a) Do you carry the bag with you always while going shopping?

- Yes
- No

9b) Briefly explain the reason for your response in 9(a)

_____

10) Do you know of any of your friends that also use this bag?

- Yes
- No

11) Do you use this bag **only** or **with** polythene bags when you go shopping?

- Uses biodegradable bag only
- Also uses polythene

12) How did you come to learn of the availability of this bag?

- From the supermarket
- Others (specify)

Appendix 6: Comprehensive semi-structured questionnaires for innovation actors and waste pickers

IN DEPTH INTERVIEW –Plastic Recycling Industries, SME Recycler, CBOs, Co-ops, traders or pickers							
Research Team Member					Date and time		
Name of Respondent					Gender	Male	Female
Name of Plastic Recycling Industries, Yard shop, CBO, Coop, or picker					Years in role		
Actor					Mobile/Telephone #		
Location	Nairobi	Mombasa	Nakuru	Kisumu	Age (years)	Below 18 18 - 25 26 - 30 31 - 35 36+	
Physical location and general comment							

Question	Information by Respondent

What type of waste do you handle? Quantities per day/week? Where and who do you buy the waste from? What types of plastics? Quantity of each type of plastic material? Do you buy on a cash or credit basis?	Type of Waste	Qty per wk (kg)	Source of Waste		Buying Price Ksh	Credit or cash
			Location	Actor		
	Metal					
	Organic					
	Paper/cardboard					
	Bones					
	Clothes					
	Plastic *specify below types					
If they purchase on credit, on what terms (i.e. interest rate, repayment)						

What is the state of the waste when you receive it?	State quality	Yes (1) No (2)	If yes, do you specify to your supplier? Why? If no, why not?
	Clean		
	Sorted & Separated		

	Other		
Other than those raised, what specification do you make to your supplier in regard to the waste plastic?			
Do you give any advice to your suppliers? *explain			
Do you give any type of information on market condition? (prices, or contacts for selling)			
Do you offer your suppliers any support?			

Please can you explain to me what you do to the waste plastic once received?	Type of Plastic	Value addition (activities) i.e. clean, sort and separate, shred, store, grind)	Final product	Time taken in (Hrs)	# staff M- F	Selling Price/ kg

What types of equipment/machinery/technology is used? Is the technology adequate to handle plastic waste if an industry, SME or a cooperative?	Type of equipment/machine/technology	Where sourced?	Usage (daily, week, monthly)	Cost	Maintenance cost p/ month

What inputs do you need for your business? i.e. water, electricity, petrol, rent	Input	Cost each time	How often	(1) Cash payment (2)Credit payment	If credit, on what terms (repayment, interest)

Any problems with getting/paying the inputs you need for the enterprise? Why?	
Which type of innovations are you involved with, social/technical? *Explain*	
What would be the ideal type of equipment/machinery used in your activities?	

<table>
<tr><td rowspan="2">Who do you sell your final products to and which types?

If on credit, what terms? (i.e. repayment, interest rate)</td><td>Plastic product/ material</td><td colspan="2">Buyer
*name of individual/company and type of actor (large manufacturer/ recycler/ MSE/ retailer)</td><td>How often Daily/weekly/monthly etc.</td><td>Qty (kg)</td><td>Credit (1) or Cash (2)</td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td>What specifications or quality demands do they make in terms of each type of plastic product sold?</td><td colspan="6"></td></tr>
<tr><td>Do your buyers offer you any advice? Type</td><td colspan="6"></td></tr>
<tr><td>Do you share with your buyers any market condition information?

Do your buyers offer you any other support besides information and advice?</td><td colspan="6"></td></tr>
<tr><td rowspan="3">How do you determine the market demand for your products?

Which plastic materials or products are in greatest demand?
Who demands it?
Are you able to meet this demand?</td><td colspan="6"></td></tr>
<tr><td>Plastic product/materials in demand</td><td>Who demands it?</td><td>Type of actor?</td><td colspan="2">Are you able to meet demand?</td></tr>
<tr><td></td><td></td><td></td><td>Yes</td><td>No</td></tr>
<tr><td>If no, why not? i.e., problem in supply, problem with technology, storage, transport</td><td colspan="6"></td></tr>
<tr><td>Does this establishment face any constraints in getting a supply of waste plastic? If so elaborate.
Does this establishment face any constraints in selling plastic waste products?</td><td colspan="6"></td></tr>
<tr><td>Does the enterprise face any constraints in regard to its growth?</td><td colspan="6"></td></tr>
</table>

How do you source your employees? Do you have any arrangement for development of the skills and knowledge of your employees? What type of skills and knowledge do employees need?									
Are you able to get the right employees who have the right skills and knowledge just discussed?									
When you need advice, support, technical assistance, and cash or simply help for the enterprise, who do you go to? What do they provide?	Type- advice, tech assistance,		Source		Provide with what? Explain, i.e. terms				
How many people are employed at this establishment, including yourself? If co-op or CBO, how many members? What is their level of education? Do the employees receive training and if CBO, your members? In what? How long for? How often? What benefits do members receive from being a member in the co-op, CBO?		Casual	perm	# below 18	# 18-35	# 35+	O Level	College	University
	Male								
	Female								
	Male								
	Female								
		Type of training						How long for (days)	How often
	Employee								
	Member								
		Type of benefit							
	Employee	i.e. health coverage, holidays,							
	Member	i.e. Credit, dividends							

What licenses do you need to operate and do you have them? How easy are they to get and renew? What policies and regulations affect this establishment? How do the licenses, policies and regulations constrain or benefit your business? Are there infrastructural problems that your business faces and which ones? Did the post-election violence disrupt your supply of waste? How long for? Has supply returned to pre-conflict times? Did the post-election violence disrupt your sales? How long for? Has it returned to pre-conflict times? How were your businesses, relationships disrupted or affected? Are you able to buy and sell to the same people as before? Do the effects of the post-election violence still affect the business? How?	License required	Cost	Time taken to get	Comments
What are the strengths of the plastic recycling and waste management sector? What are its weaknesses?				

What are its greatest challenges? What are the major risks and constraints in investing in your business?	
Additional Information In your own perspective, how do you see the problem of plastic waste in this area (Kisumu, Nakuru, Mombasa and Nairobi) being solved and what would be your role therein?	*observations, additional questions, new ideas or insights, follow up ideas.

Appendix 7: Household survey questionnaire

The aim of this questionnaire is to assess issues around solid waste management system, particularly plastic wastes in Kenya. As a resident of this city, you have been selected as as a respondent to the issues raised hereunder. ***Individual responses to this questionnaire will be accorded utmost confidentiality***. Your honest and elaborate responses to the issues will be an immeasurable asset to the success of this research. Thanks in advance for your kind cooperation.

[A] Background Information

1) Location of household in Nairobi/Mombasa/Kisumu/Nakuru

Division	
Estate	
Nearest street	

2) Gender of respondent [1] Male [2] Female

3) In which of the age categories (years) provided below do you belong, TICK appropriately in the corresponding box underneath?

15-20	21-25	26-30	31-35	36 and above

4) Indicate your current marital status

Married	Single	Divorced	Widow/Widower

5) Please indicate the highest level of education you have attained

Primary incomplete	Primary complete	Secondary	Tertiary	University

6a) For how long have you lived in this estate?
[1] Less than 12 months [2] 1-5 years [3] Over 5 years

6b) For how long have you lived in this city?
[1] Less than 12 months [2] 1-5 years [3] Over 5 years

7) Can your house be easily reached from the main road in this area?
[1] Yes [2] No

8) Which of the following correctly describes the house you live in?

[1]Flat [2] Bungalow [3] Single unit [4] Massionette [5] Other (please specify)…….

9) State the number of people who live in this house regularly, by age and gender

Females	
Males	
Youth (1-24 year olds)	
Adults (25 and above year olds)	

[B] Situation on solid Waste Management

1) In order of expenditure priority, rate the following:-

	1st priority	2nd priority	3rd priority
Solid waste management			
Water provision			
Electricity supply			

2a) Based on your own observation over time, how would you rate the performance of the City authority in solid waste management on the basis of the scale provided below:

Very poor	Poor	Fairly Good	Good	Very Good

2b) Briefly explain the reason for the rating you have given in 1(a) above

……..……
……

3a) Who collects your household solid waste for disposal

[1] City authority
[2] Community based organization
[3] Private firm
[4] A household member
[5] Landlord/Landlady
[6] Other (***please specify***)……..

3b) If, waste is not collected by city authority, how much do you pay for collection services?

Amount paid per week (Ksh.)	
Amount paid per month (Ksh.)	

3c) Do you think the fee you pay is commensurate to the services rendered?

[1] No [2] Yes [3] Not sure

3d) If **NO** in 3c, explain why you are not satisfied?

……
……

4) Are you aware of where the solid waste collected from your house is taken to?

[1] No [2] Yes and if **YES**, where is it taken to?

[C] Plastic Waste Management

1a) Do you separate plastic from other waste material before it is taken away from your house for disposal? **[**If **No,** go to **1c]**

[1] Yes [2] No

1b) If yes in **1a** above, give reasons

……
……

1c) Do you regard plastic wastes as a major problem in the management of municipal solid waste in Kenya?

[1] Yes [2] No

1d) If Yes in 1c above, what suggestion would you give for its better management?

……
……

1e) Would you be willing to separate your plastic waste from other wastes?

[1] Yes [2] No (Give reasons for this response**)**

……
……

2a) Do you think that plastic wastes can be recycled?

[1] Yes [2] No

2b) Are you willing to participate in a recycling programme for improved plastic waste management?

[1] Yes [2] No

3) In Your own opinion, list all individuals, leaders, organizations, groups, government agencies and business firms that you think should be involved in plastic waste management practices in this city?
……
……

(D) SOURCES of PACKAGING PLASTIC WASTE

1a) On average, how often do you buy items from a supermarket?
[1] At least once a month
[2] At least once a week
[3] Daily
[4] Never at all

[5] Other (state as applicable)…….

1b) Which supermarket do you mostly buy from? [Indicate by name]

……

1c) How are the goods packed for you from the supermarket?

[1]Polythene bags [2] paper/carton
[3] Other (specify)……..

2a) Are you aware of the existence of biodegradable packaging bags provided in the supermarkets as alternatives to polythene bags?
[1] No [2] Yes

2b) If **YES** in 2a, have you ever bought it?
[1] No [2] Yes

2c) If you have ever bought it, what is your opinion on the price?
[1] Too high [2] High [3] Fair [4] Low [5] Too low

2d) Suppose the biodegradable bags were to replace the polythene packaging bags, would you be willing to pay for its price?
[1] No [2] Yes

3) In general, what do you think can be done to enable residents in various parts of this country be effectively involved in plastic waste management?
…….
……

Appendix 8: List of Actors interviewed and their Organizations

	Name / Title	Organization	Date of Interview	Actor Category	Location
1	Peter Mukama		5-Jul-09	Picker	Nairobi
2	Wambua John		5-Jul-09	Picker	Nairobi
3	Joseph Rimui		5-Jul-09	Picker	Nairobi
4	Simon Ndungu		6-Jul-09	Picker	Nairobi
5	Joseph Ndinya		6-Jul-09	Picker	Nairobi
6	Timothy George		6-Jul-09	Picker	Nairobi
7	Victor Kivisa		6-Jul-09	Picker	Nairobi
8	Moses Awiti - Technical Officer	Nairobi Plastic Recyclers	2-Jun-09	CBO-SACCO	Nairobi
9	Valentine Odhiambo-Secretary	Bamato Environmental and Sanitation Initiative	12-Feb-10	CBO-SACCO	Kisumu
10	Leonard Were-Vice Chairman	Kisumu Waste Management (KIWAMA)	12-Feb-10	CBO-SACCO	Kisumu
11	Saidi Hamisi-Chairman	Bokole Cleaners	11-Dec-08	CBO	Mombasa
12	Muhamed Kasiwa-Chairman	Mijikenda Professionals	10-Dec-08	CBO	Mombasa
13	Andrew Mativo-Chairman	Kidogobasi Friends Environmental Self Help Group	11-Dec-08	CBO	Mombasa
14	Shem Ogendo-Chairman	Nyalenda Community Development Group	12-Feb-10	CBO	Kisumu
15	Aggrey Kere-Chairman	Riruta Environmental Group	5-Dec-08	CBO	Nairobi
16	Andrew Macharia	City Garbage Recyclers	9-Nov-08	CBO	Nairobi
17	Simon Munywe-Chairman	Kayole Environmental Management Association	15-Jul-10	CBO	Nairobi
18	Medina Abubakar-Chairperson	Carolina For Kibera	19-Dec-09	CBO	Nairobi
19	Githae Nyaga-Chairman	Mwiki Action Group	16-Jan-09	CBO	Nairobi
20	Sammy Okeno-Chairman	Kayole Environmental Stakeholders Development Group	5-Dec-08	CBO	Nairobi
21	Douglas Kiriama-Chairman	Umoja Ward Garbage Collectors Association	5-Dec-08	CBO	Nairobi
22	Michael Mkubwa-Chairman	KAMALIZA Environmental Group	5-Dec-08	CBO	Nairobi
23	Thomas Akendo-Program coordinator	Citizen Awareness Network	4-Feb-09	CBO	Nairobi
24	Charles Muriuki	Africa Community Development Resource Centre	7-Feb-09	CBO	Nairobi
25	Abel Twabe-Chairman	Kibera Youth Self Help Group	8-Feb-09	CBO	Nairobi
26	Alex Munala-Chairman	Muthurwa Eco Club	8-Mar-09	CBO	Nairobi
27	John Irungu-Chairman	Mukuru Brotherhood Self Help Group	20-Mar-09	CBO	Nairobi
28	David Orondo-Chairman	Mlolongo Recycling Project	20-Mar-09	CBO	Nairobi
29	Esther Nyaoro-Chairperson	Basket Weavers	4-Feb-09	CBO	Nairobi
30	Rajab Ndungu-Chairman	Kibera Zulu Youth Group	5-Dec-08	CBO	Nairobi
31	Sudu John	Mombasa Plastics	16-Apr-09	Yard shop Operator	Mombasa
32	Peter Muthoka	Yard shop Operator	16-Apr-09	Yard shop Operator	Mombasa
33	Ahmed Abdulaid	Mombasa Plastic Recycling Enterprise	17-Apr-09	Yard shop Operator	Mombasa
34	Kennedy Onyango-Owner	Junken Recycling	30-Dec-08	Yard shop Operator	Kisumu
35	Dickens Ochieng-Owner	Manyatta Solid Waste Management	22-Dec-08	Yard shop Operator	Kisumu
36	Benter Anyango-Owner	Upendo Katwaro Women Group	9-Apr-09	Yard shop Operator	Kisumu

	Name / Title	Organization	Date of Interview	Actor Category	Location
37	Josephat Kibwodi-Owner	Josephat Scrap Metal	23-Dec-08	Yard shop Operator	Kisumu
38	Regina Owuor-Owner	Regina Waste Dealers	9-Apr-09	Yard shop Operator	Kisumu
39	Mary Maluda-Owner	Mary Scrap Metal Dealers	24-Dec-08	Yard shop Operator	Kisumu
40	Patrick Katen-Owner	Japolo Scrap Metal	17-Feb-09	Yard shop Operator	Kisumu
41	Evelyne Kavere-Owner	Kaloleni Sustainable Environmental Development	17-Feb-09	Yard shop Operator	Kisumu
42	Ben Makalara-Owner	Jalawi Centre	30-Dec-08	Yard shop Operator	Kisumu
43	Joyce Adhiambo-Owner	Kajames Scrap Papers	30-Dec-08	Yard shop Operator	Kisumu
44	Mary Wairimu-Owner	Mama Kiki Scrap Metal	6-Dec-08	Yard shop Operator	Nakuru
45	Simon Maina-Owner	Aberdare Scrap Metal	5-Dec-08	Yard shop Operator	Nakuru
46	Maina Macharia-Owner	Just Plastic Collection	6-Dec-08	Yard shop Operator	Nakuru
47	Ruth Nyambura-Owner	Ebenezer Scrap Metal	6-Dec-08	Yard shop Operator	Nakuru
48	Zachariah Ng'anga-Owner	Merizak Scrap	5-Dec-08	Yard shop Operator	Nakuru
49	Richard Otieno-Owner	Yard shop Operator	27-May-09	Yard shop Operator	Nakuru
50	Victor Komo-Owner	Machine Youth Group	27-May-09	Yard shop Operator	Nakuru
51	Jane Wanjiru-Owner	Gioto Services	28-May-09	Yard shop Operator	Nakuru
52	Catherine Kariuki-Owner	Mama George Plastics	6-Dec-08	Yard shop Operator	Nairobi
53	Eunice Wangeci-Owner	Yard shop Operator	5-Dec-08	Yard shop Operator	Nairobi
54	Stephen Odera-Owner	Beautiful Cleaning Company	27-Oct-08	Yard shop Operator	Nairobi
55	Paul Ndiva-Owner	Yard shop Operator	5-Dec-08	Yard shop Operator	Nairobi
56	Bruce Juma-Owner	Nairobi Recycler	5-Dec-08	Yard shop Operator	Nairobi
57	Wilson Amin-Owner	Kibera Waste Recyclers	5-Dec-08	Yard shop Operator	Nairobi
58	Daniel Nzuki-Owner	Yard shop Operator	6-Dec-08	Yard shop Operator	Nairobi
59	Njoki Mumbi-Owner	Yard shop Operator	14-Feb-09	Yard shop Operator	Nairobi
60	Paul Mutua-Owner	Bruce Yellow Bins	14-Feb-09	Yard shop Operator	Nairobi
61	Millicent Aire-Owner	Yard shop Operator	8-Jan-09	Yard shop Operator	Nairobi
62	Nichodemus Otieno-Owner	December Waste Paper	17-Nov-10	Yard shop Operator	Nairobi
63	Simon Kariuki-Owner	Wilzaks Steel	13-Mar-09	Yard shop Operator	Nairobi
64	Benson Kinyanjui-Owner	Wato Plastics	14-Mar-09	Yard shop Operator	Nairobi
65	Jane Njoki-Owner	Yard shop Operator	12-Sep-09	Yard shop Operator	Nairobi
66	Erick Karume-Owner	Pride Street Services	3-Dec-08	Yard shop Operator	Nairobi
67	Evans Kinuthia-Owner	Yard shop Operator	3-Dec-08	Yard shop Operator	Nairobi
68	Martin Ouma-Owner	Yard shop Operator	5-Dec-08	Yard shop Operator	Nairobi
69	Jacinta Wambui-Owner	Jua Kali Self Help Group	5-Dec-08	Yard shop Operator	Nairobi
70	Isabella Otieno-Owner	Yard shop Operator	15-Dec-08	Yard shop Operator	Nairobi
71	Edward Mbukwa-Owner	Yard shop Operator	8-Dec-08	Yard shop Operator	Nairobi
72	Warbi Maina-Owner	Yard shop Operator	10-Dec-08	Yard shop Operator	Nairobi
73	Franco Esengi-Owner	Yard shop Operator	17-Nov-10	Yard shop Operator	Nairobi
74	Divine Maurice-Owner	Mercy Scrap Yard Centre	15-Dec-08	Yard shop Operator	Nairobi
75	Absalome Keya-Owner	Wangkal Company	16-Dec-08	Yard shop Operator	Nairobi
76	Josephat Ndungu-Owner	Josephat Waste Paper	6-Dec-08	Yard shop Operator	Nairobi

	Name / Title	Organization	Date of Interview	Actor Category	Location
77	John Makumi-Owner	Yard shop Operator	5-Dec-08	Yard shop Operator	Nairobi
78	Anne Anindo-Owner	Yard shop Operator	16-Jul-08	Yard shop Operator	Nairobi
79	Francis Ndungu-Owner	Mukuru Recycling Centre	29-Nov-08	Yard shop Operator	Nairobi
80	Hussein Badi-Owner	Bunker Youth Enterprise	29-Nov-08	Yard shop Operator	Nairobi
81	Charles Mongare-Owner	Jose Scrap	6-Dec-08	Yard shop Operator	Nairobi
82	John Karanja-Owner	Dandora One Tushauriane Self Help	28-Nov-08	Yard shop Operator	Nairobi
83	Evans Kinuthia-Owner	Yard shop Operator	7-Dec-08	Yard shop Operator	Nairobi
84	Stephen Mwangi-Owner	Umoja Self Group	23-Apr-09	Yard shop Operator	Nairobi
85	Lawrence Macharia-Owner	Jua Kali Eastleigh Enterprise	5-Jul-09	Yard shop Operator	Nairobi
86	David Mburu-Owner	Mburu Scrap Metal	5-Jul-09	Yard shop Operator	Nairobi
87	Geoffrey Kinyanjui-Owner	Sakayema Recyclers	10-May-09	Yard shop Operator	Nairobi
88	Bernard Nyamete-Owner	Kijabe Youth Enterprise	12-Sep-09	Yard shop Operator	Nairobi
89	Salim Muhamed-Operation Manager	Devani Ramji Haribhai Ltd.	24-Apr-09	Home-grown Recycling Industry	Nairobi
90	Evanson Githinji-General Manager	Green Africa Limited	16-Apr-09	Home-grown Recycling Industry	Nairobi
91	Lawrence Namayi-Operations and Logistics Manager	Green Africa Limited	24-Nov-08	Home-grown Recycling Industry	Nairobi
92	Jai Shah-Managing Director	Green Loop International	24-Nov-08	Export To China	Nairobi
93	Chiraq Soni-Operational and Personnel Manager	Afro-Plastics Limited	17-Nov-11	Conventional Manufacturing Industries	Nairobi
94	Wilson Ndolo-Operational Manager	Star Plast Limited	19-Nov-11	Conventional Manufacturing Industries	Nairobi
95	Patrick Njoroge-Factory Manager	Elson Plastics Limited	19-Nov-11	Conventional Manufacturing Industries	Nairobi
96	Nitin Shah-Managing Director	Rainbow Plastics	5-Mar-09	Semi Processors	Nairobi
97	Simon Mwangi-Managing Director	FEMO Works	29-Oct-08	Semi Processors	Nairobi
98	Moses Mukangali-Managing Director	Waste Ward Enterprise	23-Jun-09	Semi Processors	Nairobi
99	Ashok Panahal-Managing Director	Meenakshi Limited	5-Mar-09	Semi Processors	Nairobi
100	Jobi Krishnan-Operations Manager	Kings Plastic Industries	18-Mar-09	Semi Processors	Nairobi
101	James Kuria-Operations Manager	Times Plastics	17-Mar-09	Semi Processors	Nairobi
102	Benson Mahogo-Director	Benmah Engineering Services	29-Oct-08	Semi Processors	Nairobi
103	Mahesh Dodhia-CEO	Hi-Plast Limited	12-Feb-09	Conventional Recycling Industries	Nairobi
104	Benson Mbarua-Technical Advisor	Hi-Plast Limited	23-Jun-09	Conventional Recycling Industries	Nairobi
105	Dhiraj Dhodia-Managing Director	Premier Industries Limited	12-Jul-10	Conventional Recycling Industries	Nairobi
106	Benju Shah-Operations Manager	Packaging Industries Limited	15-Dec-09	Conventional Recycling Industries	Nairobi
107	Bimal Kantaria-Managing Director	Elgon Plastics	17-Nov-10	Conventional Recycling Industries	Nairobi
108	Amit Shah-Operations Engineer	Kenpoly Limited	11-Jul-10	Conventional Recycling Industries	Nairobi
109	Sunil Shah-Director	Hala Industries	15-Aug-09	Conventional Recycling Industries	Nairobi
110	Vimal Shah-Manager	Sun-Plast Limited	17-Nov-10	Conventional Recycling Industries	Nairobi

	Name / Title	Organization	Date of Interview	Actor Category	Location
111	Simon Kiarie-Director Environment	Nakuru Municipal Council	17-Feb-10	City Official	Nakuru
112	Mohamed Bilhafif-Director Environment	Mombasa Municipal Council	9-Apr-10	City Official	Mombasa
113	Belinda Nyakinya-Acting Director	Kisumu Municipal Council	15-Apr-10	City Official	Kisumu
114	Benjamin Njenga-Acting Director	Nairobi City Council	2-Feb-10	City Official	Nairobi
115	Luke Gatimu-Chief Accountant	Nairobi City Council	17-Dec-09	City Official	Nairobi
116	Andrew Adendo	Nairobi City Council	15-Feb-10	City Official	Nairobi
117	Patrick Kuloba-Assistant Director	Kenya Industrial Research Development Institute	17-Nov-10	Government Official	Nairobi
118	Charles Moturi-Deputy Director	Kenya Industrial Research Development Institute	6-May-09	Government Official	Nairobi
119	Benjamin Malwa-Director Compliance and Enforcement	National Environment Management Authority	18-Feb-10	Government Official	Nairobi
120	Samson Ombok-Manager Chemical Standards	Kenya Bureau of Standards	16-Nov-10	Government Official	Nairobi
121	Stephen Murigi	Zoa Taka	23-Jul-09	Waste Collection Companies	Nairobi
122	Isaac Irungu	Bio-Bins	23-Jul-09	Waste Collection Companies	Nairobi
123	Joshua Kyalo	Bins Nairobi Limited	23-Jul-09	Waste Collection Companies	Nairobi
124	John Muchemi	Environ Clean Limited	23-Jul-09	Waste Collection Companies	Nairobi
125	David Simiyu	Masters Garbage Collection Limited	23-Jul-09	Waste Collection Companies	Nairobi
126	Mwakima -Branch Manager	Uchumi Supermarkets Limited	9-May-09	Supermarkets	Nairobi
127	Atul Shah-Chief Executive Officer	Nakumatt Holding Limited	14-Jul-10	Supermarkets	Nairobi
128	Ibrahim Karanja-Operations Manager	Nakumatt Holding Limited	17-Dec-09	Supermarkets	Nairobi
129	Anne Njeri-Customer Service Coordinator	Tuskys Supermarket Limited	20-Jan-09	Supermarkets	Nairobi
130	Stephen Mutoro	KARA	15-Apr-09	Citizen Lobby Group	Nairobi
131	Damaris Kimilu-Corporate Affairs Officer	KAM	14-Dec-08	Industrial Lobby Association	Nairobi
132	Suresh Patel-Chairman(Environment Committee)	KAM	6-Feb-09	Industrial Lobby Association	Nairobi
133	Paul Chege	Practical Action	23-May-09	NGO	Nairobi

Summary

The problems with plastic waste in Kenyan cities are increasing to alarming levels. Especially disposable packaging made of very light plastic materials continues to burden the environment as well as compromise management capacities for waste. Apart from filling the disposal sites of cities in Africa, plastic waste pollutes the environment by littering the streets, clogging of waterways and blocking drainage and sewer systems. In Kenya's major cities, the proportion of plastic waste is rising and stands at 10 percent of the total municipal waste generated currently.

City authorities as the responsible agencies for solid waste management are performing poorly and have failed to graduate from their conventional practices in which plastic waste is considered as valueless. This has attracted participation of formal and informal private actors with strategies to either provide satisfactory solid waste management services to city residents or to curtail the flow of plastic waste to the environment. The activities of these actors depart from the classical practices of city authorities and present 'new' pathways (labelled as 'innovations'). These innovations can be categorized as innovations in plastic waste collection, in plastic waste recycling and in prevention. However, not much is known about how these innovations are conducted or the extent to which they improve and transform the plastic waste management of Kenya's urban centres.

The aim of this research was therefore to analyze the innovation activities on collection, recycling and prevention of plastic waste in the urban centres of Kenya. To achieve this central objective, this research addressed the following research questions:

1) How are the solid waste management system and the plastic production system organized in Kenya?

2) How and to what extent do current and can potential future environmental innovations contribute to the overall management and prevention of plastic waste in Kenya?

3) Which current and potential environmental innovations foster the interaction between SWM and plastic production systems and what insights can be gained from such innovations for building an integrated regime for plastic waste management?

The analysis in Chapter 2, on the development and current organization of solid waste management and plastic production systems, confirms a general lack of urgency for support of innovative activities that can eradicate plastic waste from the environment. As concerns the organization of solid waste management system, responses by city authorities to solid waste since 1990 have been dismal and lack internal coordination necessary to achieve both public health and environmental goals. Financial and human

resources allocated to waste management are inadequate, resulting in service dissatisfaction by the public. Furthermore, the rules that structures the use of these resources regard waste, including plastics, as a nuisance that requires immediate removal from the environment as opposed to it being a resource which can bolster economic activities and still guarantee environmental quality.

National actors responsible for waste management, such as NEMA and MOLG, have responded to the plastic waste menace by developing regulations and providing directives but these have not been adequately embraced by city authorities. Governmental actors charged with the principle mandate of waste management lack internal co-ordination. Many other actors, including firms, NGOs, small-scale informal businesses and waste pickers have since long been active in urban waste management and particularly in recycling of waste.

Over the years, plastic production firms have increasingly been using plastic waste in their production processes. These firms have benefited from the policies that are crucial in spearheading Kenya's manufacturing sector as the engine for economic development. Due to Kenya's inconsistent economic performance and the ever increasing local, regional and international demand for plastic products, different recycling trajectories have emerged, varying from recycling of commingled plastic waste to the separated collection and treatment of specific wastes (like packaging plastics at supermarkets or the collection of PET materials and subsequent export to China).

Chapter 3 explores the theories of strategic niche management (SNM) and the multiple level perspective (MLP) on socio-technical transitions. Both theories focus on processes of 'innovation' but from a different perspective. SNM provides a framework to study niche innovations from within, focussing on actor networks, convergence of expectations and learning processes, while MLP focusses on the development and uptake of niche innovations by regimes and hence is used to analyse system change from niche up to landscape level. SNM theory postulates that the social network composition should be broad and diverse to bring in different resources to the development of innovation. In the same way, expectations of participating and potential actors in innovation activities are expected to converge if a particular innovation activity emerges. Strategic Niche Management theory makes a clear distinction between first and second order learning, and hypothesizes that in order for niche developments to make it into regime changes, learning processes need to include second order learning: learning not only directed at facts and data but also enabling changes in cognitive frames and assumptions.

The regime concept as derived from the multilevel perspective on socio-technical transitions was used to assess developments within solid waste management as well as plastic production systems. A concept of system interaction was used to assess innovations that cross system boundaries and are likely to foster integration between the systems.

In a methodological intermezzo it is explained that this study used a multiple case study design to analyse innovative activities that might foster integration between two different systems. Plastic waste collection, recycling and plastic prevention activities are considered categories of innovation which contribute to the management of plastic waste. Within the first category the three cases under study were plastic waste collection, buying and value addition activities by Community Based Organizations (CBOs), Savings and Credit Cooperative Organizations (SACCOs) and yard shop operators. In plastic waste recycling, the three studied cases were plastic waste recycling activities by conventional industries, home-grown industries and a company exporting semi-processed plastic waste to China. Plastic waste prevention involved manufacturing and sale of biodegradable plastic bags by a conventional recycling firm and a supermarket retailer, respectively.

Multiple sources of data were used. A review of secondary data on the solid waste management system and the plastic production system was done to provide background information relating to the development of the two systems. Interviews with representatives of innovation categories provided data on actors' operations and their historical development. Further interviews with governmental agencies, international NGOs and experts and scientists, widened insights and gave information on external validity of our selected sub-cases in each of the seven case study innovations. Household questionnaires provided complementary data on household perspectives on innovation activities. Statistical data, sales records and observations provided additional data regarding development and operations of different innovation activities.

In the subsequent Chapters (4-6), strategic niche management theory was used to analyse seven innovation cases (activities by CBOs, CBO-SACCOs, yard shop operators, conventional recycling industries, home-grown industries, industry exporting and manufacture and sale of bio plastic bags respectively) for their internal niche processes: building of social network, convergence of actor expectations and actor learning. In addition, the multi-level perspective on socio-technical transitions was used to analyse the cases for regime and landscape factors that facilitated or hindered their development for plastic waste mitigation. Based on this combined analysis, explanations for the relative success and failure of each of the innovation cases were given. Successfulness was formulated in terms of continuity of dealing with significant amounts of plastic waste and ability to influence changes at the regime level.

Chapter 4 deals with the innovations by CBOs, CBO-SACCOs and yard shop owners. The CBO and CBO-SACCO niche routes have to a large extent, similar characteristics and show both ambivalent successes. Some degree of first order learning is taking place among the community based organizations, but such learning processes are poorly institutionalized and strongly dependent from temporary ideas and priorities of international donor agencies. These niche innovations consist of fairly small networks that are quite homogeneous and do not stretch out widely, making the niche innovations vulnerable. Continuity of these niche innovations is therefore problematic, also because

social and community development are often the main goal, while plastic waste collection and upgrading can easily be exchanged for any other community project, depending on donor, community member or policy-maker preferences.

The yard shop route to plastic waste recycling can be seen as a relatively successful niche development in handling plastic waste. This route directly links the plastic waste management system with the plastic production system. It has a high degree of convergence of ideas and expectations among the (limited number of mainly economic/market) actors in its network and the network is strong and focused towards upgrading plastic waste and recycling. The innovations by conventional recycling industries form also a relatively successful niche development. They encompass a broader and better organized and partly formalized network of actors compared to the yard shop niche activities. The actors in this network show a high degree of convergence in that plastic waste is seen as a useful resource that can easily feed into normal plastic production as it is clean and homogeneous. It encompasses perhaps the most active learning processes, where even international exchanges and learning take place. Besides it is formally recognized among policy makers, making this niche less vulnerable to harassments or preferences of individual municipal enforcement officers and politicians. Equally to the yard shop route is that it is profitable, making that economic motives do work and ensure a major degree of continuity over time.

Chapter 5 analyzes plastic waste recycling activities of industrial actors within the plastic production socio-technical system. After assessing that the semi-processors play a significant intermediary role in the flow of plastic waste from SWM to plastic production socio-technical systems, the chapter continues with comparing plastic recycling activities of three different categories of industrial actors: exporters, conventional plastic industries and home-grown industries. Home grown industries form a niche development path that shows ambivalent successes, but for very different reasons than what was found in the CBO cases. Here the main problem is in the limited network of suppliers of clean and upgraded plastic waste. While the market potential seems promising and the learning of new techniques and new product developments is also reasonably well developed, continuity and expansion of this niche development stagnates. This is due to their limited supply network of plastic waste and the failures to fulfil market expectations.

Conventional recycling industry as a socio-technical route is a successful niche development. The route has evolved from a small niche of mainstream plastic manufacturers to a large constituency of manufacturers within the wider plastic manufacturing sub-sector. This route has proven to handle huge quantities of plastic waste yet their capacity is still underutilized. The route presents an elaborate and well-organized network of suppliers for waste materials, which extends to capture waste materials even from emerging urban centres in Kenya.

The export route should be considered as a failed niche innovation. There was little learning and dissemination of products conditions, domestic markets or export

markets. The network around this niche remains very limited and homogeneous and has not extended to larger numbers of economic and political actors that could support exports of plastic waste. And among the few actors, expectations did not really converge in the idea that this was a major new innovative route for handling plastic waste and solving problems of waste management in Kenya.

Chapter 6 analyzes the policy debates about, and the production, retail and consumption of, biodegradable plastic bags in Kenya. It explores the case of developments and retail of bio-plastics as prevention innovation route. It shows poor convergence of expectations among the (limited number, but potentially wide) political and economic network actors. Few believed in the viability and economic feasibility of this niche innovation in Kenya. Hardly any learning took place from and beyond the only company involved in bio-plastics production and from and beyond the only supermarket selling these plastic bags towards other producers and retailers.

With respect to regime and landscape factors explored in Chapters 4 to 6, the study concludes that varying conditions facilitate niche development from both systems of plastic production and solid waste management. Within the plastic production system, the regime actors, the organization of the sector, the prevailing economic rules and regulations, and the (advanced) level of technology seem to be more conducive to niche innovation than what we observed in the waste management sector. The organization of the latter is much more scattered over different governmental and non-governmental actors, with lower levels of technology and local regulations that restrict rather than stimulate small scale innovations. Landscape factors like oil prices and economic growth are influencing both regimes and inherent niche developments, but in a slightly different way. Among those factors, the price of oil and thus of virgin plastic is crucial for innovations to flourish in both sectors.

Having assessed the seven niche innovations, the study concludes in Chapter 7 that they show a meager ability to foster integration between the waste management and the plastic production system and that a number of innovations still needs to take place in order to stimulate the building of an integrated regime for plastic waste management. In light of this, the study makes the following policy recommendations towards building an integrative framework for plastic waste management: city authorities to develop a framework of engagement with informal waste management actors within their jurisdictions; government to develop policies that take cognizance of the differentiated plastic recycling trajectories. Lastly, city waste management strategy should include waste separation at source to ensure that actors within the recycling chain are guaranteed of less contaminated plastic waste.

Samenvatting

Problemen met plastic afval in Keniaanse steden bereiken alarmerende niveaus. Vooral wegwerpverpakkingen gemaakt van zeer lichte kunststof materialen dragen bij aan de stedelijke milieuvervuiling en zetten het stedelijk afvalbeheer onder druk. Plastic afval vult stortplaatsen van steden in Afrika, en het vervuilt straten, verstopt waterwegen en blokkeert drainage- en rioolstelsels. De plastic afval productie in de grote steden van Kenia is groeiende en bedraagt momenteel 10 procent van het totale huishoudelijk afval.

De stedelijke instanties die verantwoordelijk zijn voor afvalbeheer in Kenya presteren slecht en zijn er niet in geslaagd om los te komen van de conventionele praktijk waarin plastic afval als waardeloos wordt beschouwd. Dit heeft er toe geleid dat formele en informele private actoren strategieën zijn gaan ontwikkelen, ofwel om betere afvalinzameling- en -verwerkingsdiensten aan inwoners van de stad te leveren, ofwel om de stroom van plastic afval in het milieu te beperken. De activiteiten van deze actoren wijken af van de klassieke praktijk van stedelijke overheden en representeren 'nieuwe' manieren van afvalbeheer (aangeduid als 'innovaties'). Deze innovaties kunnen worden gecategoriseerd als innovaties in plastic afvalinzameling, in plastic recycling en in afvalpreventie. Er is echter niet veel bekend over hoe deze innovaties worden uitgevoerd de mate waarin innovaties het plastic afval beheer van de stedelijke centra van Kenia verbeteren en transformeren.

Het doel van dit onderzoek is s dan ook om de innovatieve activiteiten op het gebied van inzameling, recycling en preventie van plastic afval in de stedelijke centra van Kenia te analyseren. Om deze centrale doelstelling te bereiken, richt dit onderzoek zich op de volgende onderzoeksvragen:

1) Hoe zijn in Kenia het afvalbeheer systeem en het plastic productiesysteem georganiseerd?
2) Hoe en in welke mate dragen huidige milieu-innovaties bij aan het beheer en de preventie van plastic afval in Kenia, en wat kunnen potentiële innovaties in de toekomst bijdragen?
3) Welke huidige en potentiële milieu-innovaties bevorderen de interactie tussen de managementsystemen rondom vast afval (*solid waste management*: SWM) enerzijds en het plastic productiesystemen anderzijds en welke inzichten zijn te ontlenen aan dergelijke innovaties voor de bouw van een geïntegreerd managementsysteem voor plastic afval?

De analyse in hoofdstuk 2 gaat in op de ontwikkelingen en huidige organisatie van systemen voor afvalbeheer en plastic productie, en bevestigt een algemeen gebrek aan urgentie voor een ondersteuning van innovatieve activiteiten om plastic afval in de omgeving te verminderen. Wat betreft de organisatie van het managementsysteem voor vast afval zijn de ontwikkelingen van stedelijke autoriteiten sinds de jaren negentig van

de vorige eeuw teleurstellend te noemen: er is een gebrek aan interne coördinatie die noodzakelijk is om doelstellingen op het gebied van volksgezondheid en milieu te bereiken. De financiële en personele middelen beschikbaar voor afvalbeheer zijn ontoereikend, wat resulteert in ontevredenheid van het publiek over de dienstverlening. Bovendien is wet- en regelgeving rond (plastic) afval gericht op het onmiddellijk uit de leefomgeving verwijderen van afval, terwijl afvalbeheer en recycling ook kan worden gezien als een bron voor economische activiteiten waarbij de kwaliteit van het milieu gewaarborgd blijft.

Nationale actoren die verantwoordelijk zijn voor afvalmanagement, zoals NEMA en MOLG, hebben gereageerd op de problemen rondom plastic afval door het ontwikkelen van regelgeving en richtlijnen, maar deze werden onvoldoende omarmd door stedelijke autoriteiten. Interne coördinatie tussen overheidsinstanties belast met het mandaat voor afvalbeheer ontbreekt. Vele andere actoren, waaronder bedrijven, niet gouvernementele organisaties (NGO's), kleinschalige, informele werkplaatsen en afvalverzamelaars zijn sinds lange tijd actief in het stedelijke afvalmanagement, in het bijzonder in afvalrecycling.

In de loop der jaren zijn plastic productiebedrijven in toenemende mate plastic afval in hun productieprocessen gaan gebruiken. Deze bedrijven hebben geprofiteerd van het beleid gericht op het versterken van de Keniaanse industrie als motor voor economische ontwikkeling. Als gevolg van economische prestaties van Kenia en de steeds toenemende lokale, regionale en internationale vraag naar plastic producten zijn er verschillende recycling trajecten ontstaan, variërend van recycling van vermengd plastic afval tot de gescheiden inzameling en verwerking van specifieke afvalstoffen (zoals verpakkingsplastic bij supermarkten of de inzameling van PET materialen en de daarbij horende export naar China).

Hoofdstuk 3 verkent de theorieën van *strategic niche management* (SNM) en *multiple level perspective* (MLP) ten aanzien van socio-technische transities. Beide theorieën richten zich op processen van ‘innovatie’, maar vanuit een verschillend perspectief. SNM biedt een kader om innovaties in een niche te bestuderen door te kijken naar netwerken van actoren, en het samenbrengen van verwachtingen en leerprocessen. MLP richt zich juist op de ontwikkeling en verbreiding van niche innovaties door regimes en wordt zodoende gebruikt om systeemveranderingen te analyseren. SNM theorie stelt dat de samenstelling van sociale netwerken breed en divers moet zijn om de ontwikkeling van innovatie te ondersteunen. Op dezelfde manier wordt aangenomen dat verwachtingen van (potentieel) deelnemende actoren in innoverende activiteiten zullen convergeren naar mate een bepaalde innovatieactiviteit zich ontwikkelt. De *strategic niche management* theorie maakt een duidelijk onderscheid tussen eerste-orde leren en tweede-orde leren. De veronderstelling is dat ontwikkelingen in een niche zullen leiden tot veranderingen in regimes als leerprocessen tweede-orde leren omvatten: het leren

moet niet alleen gericht zijn op feiten en data, maar ook op veranderingen in cognitieve kaders en veronderstellingen.

Het concept 'regime' is ontleend aan het *multiple level perspective* op socio-technische transities en gebruikt om de ontwikkelingen binnen management van vast afval en plastic productiesystemen te beoordelen. Het concept 'systeeminteractie' wordt gebruikt om innovaties te bestuderen die systeemgrenzen overschrijden en waarschijnlijk de integratie tussen de systemen kunnen bevorderen.

In een Methodologisch Intermezzo wordt uitgelegd dat deze studie gebruik maakt van meervoudige case studies om innovatieve activiteiten, die de integratie kunnen bevorderen tussen twee verschillende systemen, te analyseren. Plastic afvalinzameling, recycling en preventie-activiteiten worden beschouwd als innovatiecategorieën die bijdragen aan het management van plastic afval. In de eerste categorie vallen drie case studies, gericht op het verzamelen, kopen en waardevermeerdering van plastic afval, door respectievelijk *Community Based Organizations* (CBO's), spaar-en kredietcoöperaties (SACCOs) en kleine bedrijfjes die vanuit hun eigen erf werken. Ten aanzien van de recycling van plastic afval drie onderzochte case studies betreffen de recyclingactiviteiten van de conventionele industrie, lokale *home-grown* industrie en bedrijven die half-verwerkt plastic afval exporteren. Preventie van plastic afval is bestudeerd door te kijken naar de productie en verkoop van biologisch afbreekbare plastic zakken door een conventioneel recyclingbedrijf en een supermarkt.

Voor het onderzoek werden meerdere bronnen gebruikt. Er is een overzicht gemaakt van secundaire gegevens over afvalmanagementsystemen en plastic productiesystemen om achtergrondinformatie over de ontwikkeling van de twee systemen te geven. Interviews met actoren betrokken bij innovaties in de verschillende categorieën gaven inzicht in het functioneren van de. Interviews met overheidsinstanties, internationale NGO's, deskundigen en wetenschappers plaatsten inzichten in een breder perspectief en gaven informatie over de externe validiteit van de geselecteerde sub-cases in elk van de zeven bestudeerde innovaties. Vragenlijsten afgenomen bij huishoudens waren complementair omdat deze inzicht gaven in de perspectieven van huishoudens op innovatieve activiteiten. Statistische gegevens, verkoopcijfers en observaties boden aanvullend informatie met betrekking tot de ontwikkeling en de werking van de verschillende innovatie-activiteiten.

In de hoofdstukken 4, 5 en 6 werd *strategic niche management* theorie gebruikt om de zeven case studies (innovatieve activiteiten door: CBO's; CBO-SACCOs; kleine bedrijfjes op eigen erf; conventionele recyclingindustrie; *home-grown* industrie; export industrie; en productie en verkoop van biologisch afbreekbare plastic zakken) te analyseren. Hierbij zijn hun interne niche processen bestudeerd: het ontwikkelen van sociaal netwerk, het samenbrengen van verwachtingen van actoren en het leren. Daarnaast werd de *multiple level* benadering van socio-technische transities gebruikt om regime- en landschapsfactoren te analyseren, welke de vermindering van plastic afval

kunnen faciliteren of kunnen bemoeilijken. Gebaseerd op deze gecombineerde analyse werd het relatieve succes of falen van elk van de innovaties verklaard. Succes werd geformuleerd in termen van continuïteit in het verwerken van grote hoeveelheden plastic afval en het vermogen om veranderingen te beïnvloeden op regimeniveau.

Hoofdstuk 4 gaat over de innovaties van CBO's, CBO-SACCOs en erfbedrijfjes. De wijzen van aanpak van zowel de CBO als de CBO-SACCO hebben voor een groot deel dezelfde kenmerken en tonen wisselende successen. Er vindt in de lokale organisaties een zekere mate van eerste orde leren plaats, maar zulke leerprocessen zijn slecht geïnstitutionaliseerd en sterk afhankelijk van tijdelijke ideeën en prioriteiten van internationale donoren. Deze niche-innovaties bestaan uit vrij kleine netwerken, die redelijk homogeen zijn en zich niet op grote schaal uitstrekken, waardoor de niche-innovaties kwetsbaar zijn. Continuïteit van deze niche-innovaties is zodoende problematisch, ook omdat vaak sociale en maatschappelijke ontwikkeling het voornaamste doel is, waarbij inzameling en waardevermeerdering van plastic afval makkelijk kan worden ingewisseld voor een ander project, afhankelijk van de voorkeuren van donoren, gemeenschapsleden of beleidsmakers.

De aanpak van recycling door erfbedrijfjes kan worden gezien als een relatief succesvolle niche ontwikkeling in het omgaan met plastic afval. Deze aanpak verbindt het plastic afvalmanagementsysteem direct met het plastic productiesysteem. Het heeft een hoge mate van convergentie in ideeën en verwachtingen van de actoren (beperkt in aantal en voornamelijk economische/markt spelers) in het netwerk en het netwerk is sterk gericht op waardevermeerdering van plastic afval en op recycling. De innovaties van de conventionele recyclingindustrie vormen ook een relatief succesvolle niche ontwikkeling. Zij omvatten een breder, beter georganiseerd en deels geformaliseerd netwerk van actoren ten opzichte van de niche-activiteiten van erfbedrijfjes. Voor de actoren in dit netwerk geldt een hoge mate van convergentie, in de zin dat plastic afval wordt gezien als een nuttige grondstof die gemakkelijk kan worden meegenomen in de normale plastic productie, aangezien het schoon en homogeen van samenstelling is. Deze aanpak omvat misschien wel de meest actieve leerprocessen, waarin zelfs internationale uitwisselingen en vormen van leren plaatsvinden. Daarnaast is er formele erkenning van beleidsmakers, wat ertoe bijdraagt dat deze niche minder kwetsbaar is voor pesterijen of voorkeuren van individuele gemeentelijke handhavers en politici. Net als bij de aanpak van erfexploitanten geldt dat deze aanpak rendabel is, wat ervoor zorgt dat economische motieven effectief zijn en dat er een grote mate van continuïteit is.

In hoofdstuk 5 worden de plastic afval recyclingactiviteiten van industriële actoren binnen het socio-technisch systeem van de plastic productie geanalyseerd. Nadat vastgesteld is dat *semi-processors* een belangrijke rol als intermediair spelen in de stroom van plastic afval van het afvalbeheer systeem naar the plastic productiesysteem, gaat het hoofdstuk verder met een vergelijking van plastic recyclingactiviteiten van drie verschillende categorieën van industriële actoren: exporteurs, conventionele plastic

industrieën en *home-grown* industrieën . In *home grown*-industrieën laat de niche aanpak een ontwikkeling zien waarin ambivalente successen worden geboekt, maar om andere redenen dan wat werd gevonden in de CBO case. Het grootste probleem is hier het beperkte netwerk van leveranciers van schoon en opgewaardeerd plastic afval. Terwijl het marktpotentieel veelbelovend lijkt te zijn en het leren van nieuwe technieken en nieuwe productontwikkelingen ook redelijk goed ontwikkeld is, stagneert de ontwikkeling van deze niche op het gebied van continuïteit en uitbreiding. Er is te weinig geïnvesteerd in het bouwen van een netwerk van aanbod van plastic afval en daarom kan niet aan de verwachtingen van de markt worden voldaan.

De conventionele recyclingindustrie laat een succesvolle niche ontwikkeling zien. Een kleine niche van plastic producenten is uit gegroeid tot een grote groep van fabrikanten binnen de bredere plastic productiesector. Deze aanpak bewijst dat grote hoeveelheden plastic afval kunnen worden verwerkt, hoewel de capaciteit van producenten nog steeds onderbenut is. De analyse laat zien dat een uitgebreid en goed georganiseerd netwerk van afvalleveranciers in staat is om afval te verwerken, zelfs in de stedelijke centra in Kenia.

De exportaanpak moet worden beschouwd als een mislukte niche innovatie. Er is weinig sprake van leren, alsook beperkte verspreiding van productvereisten binnen de binnenlandse markt of de exportmarkt. Het netwerk rond deze niche blijft zeer beperkt en homogeen en wordt niet uitgebreid met een groter aantal economische en politieke actoren die de export van plastic afval kunnen ondersteunen. Daarnaast is er onder de weinige actoren die betrokken zijn, niet echt convergentie van de verwachting dat dit een belangrijke nieuwe innovatie is voor de behandeling van plastic afval en het oplossen van problemen rond afvalbeheer in Kenia.

Hoofdstuk 6 analyseert de beleidsdiscussies over, en de productie, verkoop en het gebruik van biologisch afbreekbare plastic tassen in Kenia. Het onderzoekt de ontwikkelingen en verkoop van bio-plastics als een innovatieve methode van afval preventie. Het toont slechte convergentie van verwachtingen bij het (beperkte aantal, maar in potentie brede) netwerk van politieke en economische actoren. Weinigen geloofden in de levensvatbaarheid en de economische haalbaarheid van deze niche innovatie in Kenia. Noch in het enige bedrijf dat betrokken is bij de productie van bio-plastics, noch binnen de enige supermarkt die deze biologisch afbreekbare plastic tassen verkoopt aan andere producenten en retailers was er sprake van een leerproces over de mogelijkheden van deze innovatie voor bio-plastic productie en verkoop, en afvalpreventie.

Met betrekking tot regime- en landschapsfactoren welke zijn onderzocht in de hoofdstukken 4 tot en met 6 komt deze studie tot de conclusie dat verschillende condities de niche ontwikkeling van beide systemen van plastic productie en het beheer van vast afval faciliteren. Binnen het plastic productiesysteem lijken de regime-actoren, de organisatie van de sector, de heersende economische regels en voorschriften, en het

(geavanceerde) technologisch niveau gunstiger voor niche-innovatie dan wat is waargenomen in de afvalmanagement sector. De organisatie van de laatste is veel meer verspreid over verschillende overheidsactoren en niet-gouvernementele actoren, met lagere technologieniveaus en plaatselijke voorschriften die kleinschalige innovaties limiteren in plaats van stimuleren. Landschapsfactoren zoals olieprijzen en economische groei beïnvloeden zowel regimes als structurele niche-ontwikkelingen, maar op een andere manier. Van deze factoren is de prijs van olie, dus ook van nieuw plastic, van cruciaal belang om innovaties in beide sectoren tot wasdom te laten komen.

Na een evaluatie van de zeven niche innovaties concludeert de studie in hoofdstuk 7 dat er beperkte mogelijkheden zijn om de integratie tussen het afvalbeheer en het productiesysteem rond plastic te faciliteren, en dat een aantal innovaties nog moet plaatsvinden om de ontwikkeling van een geïntegreerd stelsel voor plastic afval management te bevorderen. In het licht van deze conclusie komt de studie tot de volgende beleidsaanbevelingen voor de ontwikkeling van geïntegreerd stelsel: stedelijke autoriteiten moeten komen tot een kader waarin met informele actoren wordt samengewerkt binnen de wettelijke grenzen; de overheid moet een beleid ontwikkelen dat verschillende recycling trajecten onderkent; de strategie van stedelijk afvalbeheer zou erop gericht moeten zijn om afvalscheiding aan de bron aan te pakken.

About the author

Leah Oyake-Ombis was born on 25th December 1966 in Kericho- Kenya. After completing high school, she joined the University of Nairobi to study Physical and Biological Sciences, obtaining a Bachelor of Science Degree in Chemistry in 1990. Between 1991 and 1992, she worked for Optimum Lubricants as a Chief Chemist. In 1993, she joined the City Council of Nairobi as a Laboratory Chemist and in the same year, obtained a World Bank Scholarship to pursue a Master of Science Degree. In 1999, she graduated from the University of Nairobi with a Master Degree in Environmental Chemistry. Her thesis focused on the nature and sources of pollution in major rivers traversing the City of Nairobi.

In 1996, she had the opportunity to be appointed as one of technical officers to spearhead the creation of a Department of Environment within the City Council of Nairobi. She rose from an Assistant Director of Environment through the ranks to become the Director of Environment in 2005. She has implemented several environmental programmes within the department. In 2005, she spearheaded the zoning of solid waste collection and transportation and the installation of a weighbridge at Dandora disposal site (the only disposal site in Nairobi) introducing a total shift in the way waste management was conducted. Still in the same year, she initiated the greening of Nairobi project where over 100,000 indigenous trees were planted along major highways to counter highway pollution and increase tree cover in Nairobi.

In 2008, Leah Oyake-Ombis was awarded a Ford Foundation International Fellowships Programme to pursue a PhD study. She started her studies at Wageningen University, Environmental Policy Group. From 2009 to 2010, Leah steered a team of local and international professions to develop a solid waste management master plan and an integrated solid waste management plan for Nairobi. In 2010 as a consultant, Leah made an important contribution in the UN-Habitat prize-winning publication, *Solid Waste Management in the World's Cities*. In 2012 as a consultant for UN-Habitat, she developed capacity building and solid waste management plans for six small towns bordering Lake Victoria on Kenya and Uganda sides.

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Oral Presentations

- Closing the Loop between Production and Consumption of Plastics: Major Urban Centres of Kenya, 15th International Sustainable Development Research Conference, 5 – 8 July, Utrecht, The Netherlands
- Innovative urban plastic waste management practices in Kenya: Emerging policy issues for sustainable development, 15th International Sustainable Development Research Conference, 5 – 8 July, Utrecht, The Netherlands

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