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Managing plastic waste in East Africa: Niche innovations in plastic production and solid waste

Leah Oyake-Ombis [a, b], Bas J.M. van Vliet [b, *], Arthur P.J. Mol [b]

[a] Nairobi City County, P.O Box 30075, Nairobi, Kenya
[b] Environmental Policy Group, Wageningen University, The Netherlands

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ABSTRACT

This paper assesses the uptake of environmental innovation practices to cope with plastic waste in Kenyan urban centres at the interface of solid waste management and plastic production systems. The Multi Level Perspective on Technological Transitions is used to evaluate 7 innovation pathways of plastic waste prevention, reuse or recycling. An assessment is made as to whether the innovations lead to changes in the regimes of waste management and plastic production and eventually an integrated regime for plastic production and reuse. The study comprises of a review of policy documents and statistics, site visits and in-depth interviews with main actors involved in plastic waste related innovation. The comparative analysis of social network building, actor expectations and learning processes in the 7 innovation routes reveals that Kenya is still far from having a well-aligned plastic production-cum-waste regime that enables plastic waste prevention, recycling and handling practices. Innovations by yard shop owners and home grown industries contribute to an aligned plastic waste recycling regime, where PET exporters, bio-degradable plastic sellers and CBO collectors fail to do so. All innovation actors face a lack of governmental recognition and guidelines to close the loop of plastic production and waste handling.

1. Introduction

The percentage of plastic waste in domestic solid waste is closely related to levels of economic development. Generally, in terms of weight, plastic waste is the third major component of municipal waste in East African cities after organic waste and paper waste (UNEP, 2009). With rapid urbanization and economic development, and the associated growth of industry and services, plastic waste levels in East Africa are approaching 10% wet weight of the total solid waste flows in major urban centres (JICA, 2010; Oberlin, 2011; Oyoo, Leemans, & Mol, 2011). Much of the plastic waste in East Africa is littered on public places, dumped at illegal sites and blocks drainage and sewer systems. As such plastic waste affects public health, water and sewerage services and tourism, among others. But plastic waste also represents a valuable resource, which can be profitably ploughed back into the economy.

While many cities in developed countries have instituted effective approaches to waste management through separation, re-use/recycling, and prevention, the general situation for cities in East Africa is different (Oyoo et al., 2011; Scheinberg, Spies, Simpson, & Mol, 2011; UNCHS, 2010). The delivery of public services has for a long time been failing in East Africa, where access to adequate waste collection and sanitation is still very low (see also Crook & Ayee, 2006; Katusiimeh, Mol, & Burger, 2012; Oosterveer, 2009; Oyoo et al., 2011; Van Dijk, 2006). For close to two decades, the solid waste management systems of East African major urban centres have been suffering from a lack of adequate human, financial and technological resources, a poor organization of operational processes, and a typical relation between central and local government (Karanja, 2005). Local authorities have little autonomy in financial and administrative decision-making, including those responding to waste challenges (UNCHS, 1998). The poor waste management situation manifests in the very low waste collection levels (JICA, 2010; Rotich, Zhao, & Dong, 2006) and geographical restrictions of waste collection to central business districts and high income neighbourhoods. The urban poor, usually residing in informal settlements are abstained from access to solid waste collection and disposal and face the health and environmental consequences of that (Katusiimeh et al., 2012; Tukahirwa, Mol, & Oosterveer, 2013).

* Corresponding author.
E-mail address: bas.vanvliet@wur.nl (B.J.M. van Vliet).

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In studying plastic waste problems in East Africa – and in particular in Kenya, our research area – most authors have focused on post-consumer aspects of solid waste collection and disposal, putting municipal authorities central as the core institution that can provide viable sustainable waste management systems (e.g. Bahri, 2005; Karanja, 2005; Kassim & Ali, 2005; Mugambi, 2001; Oyoo et al., 2011; Rotich et al., 2006). But collecting and adding value to plastic waste has been practiced in Kenya by private actors since the 1980s, when individual waste pickers, yard shop owners and small-scale traders started to sell unprocessed plastic waste directly to plastic producers who used these materials to manufacture new plastic products. Since the 1990s and partly driven by a general lack of employment and high poverty levels (Republic of Kenya, 2010), 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 for loans, as well as other social benefits. Several authors, from different perspectives, have stressed the important contribution of these (in)formal CBOs, CBO-SACCOs, yard shop owners and small-scale traders in effective waste management (e.g. Allison, Harris, Hofny-Collins, & Stevens, 1998; Katusiimeh et al., 2013; Liyala, 2011; Scheinberg & Mol, 2010; Tukahirwa, Mol, & Oosterveer, 2011; Tukahirwa et al., 2013; UNDP, 2006; WASTE, 2004).

Parallel to plastic waste management activities of (in)formal private actors, plastic producers and other chain actors have explored the use of plastic waste as a raw material in Kenyan plastic production (KNCPC, 2006; Mugambi, 2001; Njeru, 2006). An extensive body of literature underscores the benefits of promoting plastic waste recovery and recycling as a viable strategy to sustainable plastic waste management (e.g. Furedy, 1997; Karanja, Ikiara, & Davies, 2004; Scheinberg et al., 2011). Plastic production started to take off in Kenya from the early 1990s, although Kenya still imports all the polymers (polyethylene PE and polypropylene PP especially, and smaller quantities of polystyrene PS, polyethylene-terephthalate PET, polyurethane PU and polyvinyl-chloride PVC) as it has no petro-chemical polymer production units. Around 2010 the use of post-consumer waste as raw material for plastic production has increased to 11% of total raw material (Oyake-Ombis, 2012). Easy access to plastic production technology and liberalization of trade at regional and global levels enabled the use of plastic waste as a raw material in production processes. In Kenya, private industrial actors largely rely on informal actors to provide them with plastic waste as raw material. Hence, better collaboration between the solid waste management system and plastic production system might further increase the amount of plastic waste removed from the environment and turned into profitable raw material.

This paper assesses the uptake/institutionalization of novel practices to cope with plastic waste (labelled environmental innovations) at the interface of the solid waste management and the plastic production system. An environmental innovation is here defined as a practice in which actors add value to plastic waste and close the material cycle. Such plastic waste innovations can relate to better management/recovery of plastic waste to reduce littering, recycling/re-use of plastic waste, and prevention of plastic waste. The Multi Level Perspective on Transitions (MLP)(Geels, 2002) is used to put the envisioned regime change into its multi-layered context. Strategic Niche Management (Schot & Geels, 2008) is utilised as an analytical frame to assess whether and to what extent the innovations lead to changes in waste management and plastic production regimes and – eventually – into an integrated regime for plastic production and reuse. The geographical focus is on the four major urban centres of Nairobi, Mombasa, Kisumu and Nakuru where a variety of new practices have been experimented to cope with plastic waste. The next section outlines the applied theoretical frame, transition theory, followed by the research methodology. Subsequently, the success or failure of seven different niche innovations is analysed, also in terms of aligning the solid waste management and the plastic production systems. Finally conclusions are drawn.

2. Transition theory

Better management of plastic waste can be interpreted as a change or transition of conventional solid waste management and plastic production systems. Transition theory and especially the Multi Level Perspective on Transitions will be applied to study such changes in urban Kenya.

2.1. Multi-level perspective on transitions

The Multi Level Perspective on Transitions has been applied especially in developed societies to analyse long term developments and major changes in socio-technical systems, such as transport systems, energy systems, water systems and food systems. This perspective builds on insights from complex systems theory, innovation studies, theories on large technical systems, history of technology and long-wave theory in economics. It adopts the idea that different analytical levels need to be distinguished for analysing and explaining change in socio-technical systems. Three levels are discerned: niche innovations, socio-technical regimes, and socio-technical landscape (Geels, 2002; Rip & Kemp, 1998; see Fig. 1). System innovation and transformation come about as a result of the interplay between processes at the three levels: major changes materialize because processes at multiple levels link up, align and influence each other (Geels, 2005a, 2005b; Rip & Kemp, 1998). Radical innovations emerge in niches (the lowest level), which are often outside or at the fringe of an existing regime (the second level). At the niche level, there are no stable rules to support innovations and therefore it is up to the involved actors to come up with a configuration that can either compete with or replace the dominant regime. If and when actors succeed to innovate, small niche markets stabilize, which support and partly institutionalize the innovation and may even grow to change the dominant regime. Innovations may also remain stuck in these niches for a long time or completely fail to take-off altogether, when they face a mismatch with the existing regime and landscape (highest level) and have not enough strength to change the latter two. The last phase of a successful innovation journey is when there is a breakthrough within the existing (dominant) regime and an innovation is able to embed itself in society and create market linkages necessary to be able to compete with the existing regime (Geels & Schot, 2007). Fig. 1 provides an illustration of the process of niche development, regime breakthrough and system change.

The multi-level perspective holds that both internal niche dynamics and external regime and landscape developments are important in ensuring a breakthrough in the regime and diffusion of innovations. Hence, the MLP provides us a general framework to understand and explain (the absence of) radical changes within either the conventional solid waste management system or the plastic production system. The next sub-section provides the tools to analyse niche innovations and the actors who 'carry' these innovations.

2.2. Strategic niche management

Strategic Niche Management (SNM) is used within a multi-level perspective to study the development of niche innovations, crucial

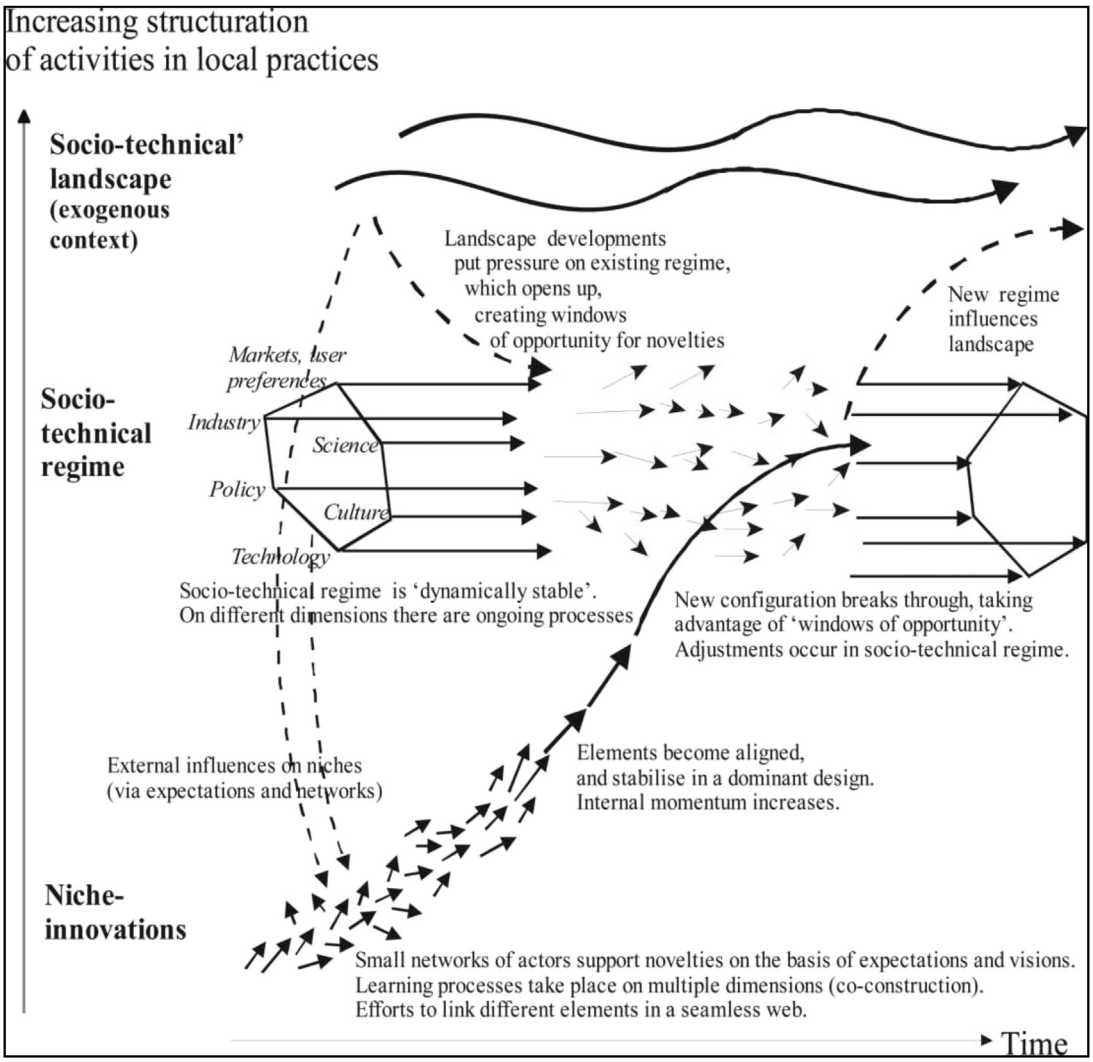

Fig. 1. Multi Level Perspective on Transitions (Geels, 2002: 1263).

for regime change. Strategic Niche Management brings together knowledge and expertise of actors into socio-technical innovation processes to generate new technologies and practices, enhance interactive learning processes and facilitate institutional adaptation. Three processes for successfully constructing and taking-off of a niche innovation are distinguished (Kemp, Schot, & Hoogma, 1998; Van der Laak, Raven, & Verbong, 2007): 1) building of social networks, 2) voicing and shaping shared expectations and 3) social learning. These three processes will be elaborated below.

The building of broad social networks around niche innovations is important to facilitate interactions between relevant stakeholders and to provide necessary resources (money, people, authority, and expertise). According to Coenen, Raven, and Verbong (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 functional when they are facilitated by regular meetings between actors (Van Eijck & 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 (see below), while a variety of stakeholder organizations bring in resources as well as mobilize commitment of their organizations and members to the innovation process. Coenen et al. (2010) assert that geographical proximity stimulates social network building and thus successful niche experimentation, because short geographical distance favours social interactions, trust-building and the development of joint expectations.

Strategic Niche Management 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, Brown, Konrad, and Van Lente (2006), articulation and convergence of expectations are regarded as an important resource in niche-based experimentation as it helps to reduce uncertainties which may slow down the process of innovation. When niche actors are able to articulate their joint and shared expectations arising from their participation in the innovation process, it means that they have pictured what real and tangible outcomes the future holds for each of the actors (Coenen et al., 2010). Shared expectations are important to attract attention and resources and gain legitimacy from other actors (Geels and Raven (2006). Furthermore, convergence of expectations provides direction to the learning process and

technical development activities, which may further enhance niche experiments.

Learning is crucial in innovation processes and contributes to niche development if it is not only directed at facts and data but also at cognitive frames and assumptions, commonly referred to as second order learning (Grin & Van de Graaf, 1996). Development and implementation of innovations is largely a social process and the subject of learning must not reduce it to techno-economic connotations if success is to be achieved. Learning would therefore enhance the capacity of actors to develop a broad and flexible vision of sustainability and further discover how to overcome system barriers that may hinder the development of innovation leading to a new socio-technical trajectory (Van der Laak et al., 2007).

2.3. Analysing change in multiple regimes

While Strategic Niche Management has proved to be a useful analytical tool in analysing innovation activities, so far it has been applied mainly in explaining innovations within single systems. However, in the case of plastic waste, innovation activities may cross system boundaries and involve changes in both the waste management and the plastic production systems. Niche innovations, actor networks, learning processes and expectations and visions from one system need to be aligned with counterparts in the other system in order to bring about transformations useful for solving plastic waste problems. With Konrad, Truffer, and Voß (2008) we posit that multi-regime dynamics become relevant to consider if radical innovations create linkages between different regimes. Some studies have adopted this approach before, i.e. Raven (2006) and Raven and Verbong (2007) on waste and electricity regimes in the case of heat and power technologies, or Geels' (2007b) analysis of the breakthrough of rock 'n' roll (1930–1970).

Drawing on the concept of regime interaction, we study innovations at the crossroad of the solid waste management socio-technical system and the plastic production socio-technical system, and evaluate the prospects for a more integrated regime change to manage plastic waste.

3. Methodology

Seven different innovative practices were selected from a wider group of innovative experiments within the solid waste management and plastic production system, which all aimed at solving the plastic waste problem. Together, the selected cases provide a fair representation of distinct (managing, recycling, prevention; see Oyake-Ombis, 2012) innovations in plastic waste and plastic production.

Three innovations in *plastic waste managing/recovery* involve the following actor groups: CBOs, CBO-SACCOs and yard shop operators (see Fig. 2). These actors collect or buy, sort, clean and sell plastic waste. Apart from occasional semi-processing by CBO-SACCOs, the activities and technological processes of these three actor groups are to a major extent similar. But the time of their emergence, their motivation and drive for these innovations, the degree of integration with the plastic production system, and their scale of operation differ considerably. Three innovative *plastic recycling practices* involve industrial actors: home-grown recycling industries, conventional recycling industries and industrial semi-processing for export. These innovative practices all fall under the plastic production system (be it with inputs from the solid waste management system), and represent diverse recycling trajectories of post-consumer plastic waste in Kenya. Finally, one innovative practice (biodegradable plastic bag) concerning *prevention of plastic waste* relates to plastic producers, supermarkets and consumers.

Data collection methods included review of policy documents and (public and private) statistics, site visits and (participatory) observation, and in-depth interviews with the main actors involved in the innovation activities (Table 1).

Quantitative data on waste types, quantities of waste handled, waste flows, and selling prices and years in operation provides information of success and size of niche innovations. Qualitative data obtained from interviews, observations and document analysis were coded and categorized into themes to allow for a meaningful analysis. This analysis was done by utilizing and assessing innovations on the key concepts of Strategic Niche Management: the building of actor networks, convergence of actor's expectations, and learning by actors in innovations. Comparison of case studies involved in plastic waste innovation gave additional value to understanding innovation processes. The key characteristics of the 7 cases are summarized in Table 2, and more extensively described in Oyake-Ombis, 2012. Next an analysis is made of regime alignment between the plastic waste management and plastic production regimes (Section 5)

4. Comparative analysis of niche developments

In this section, the seven niche developments on plastic waste in Kenya are compared. The analysis is based on three main requirements for successful niche development: building of social networks, voicing and shaping of expectations, and learning processes in the niche innovations.

4.1. Building of social networks

The sizes of the networks around each of the 7 niches in plastic waste in Kenya (as presented in Table 2) are small and usually do not involve a large variety of market, policy making and civil society actors. In case of plastic waste collection/recovery by CBOs and CBO-SACCOs, for instance, dependency on a single or only small number of non-governmental actors was evident, while yard-shop plastic waste handlers were solely working with a few waste suppliers and plastic producing firms in their value chain. In other niche innovations the lack of actor heterogeneity is less extreme but still present. Moreover, the social networks are rather specific for each niche innovation. There is little mutual strengthening between the different niche innovation networks. Only a few actors such as Kenya's National Environmental Management Authority (NEMA) function in different social networks around multiple niche innovations. Lastly, the leading actors in innovation networks are mostly private actors with mainly economic motives that push for niche innovations. Environmental motives and considerations, articulated and pushed for by environmental advocates (e.g. NEMA, municipal environmental authorities, environmental NGOs) hardly play a role among network actors around the majority of the niche innovations, arguably with the exception of the biodegradable bag. 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 innovations.

4.2. Actor expectations

Convergence of expectations of the main actors that convey the niche innovation cases co-determines the support for and the proliferation of niche developments. A number of observations can be made from the seven niche developments with reference to Table 2. Firstly, the converging expectation in most of the niches, and certainly in the more successful niche innovations and among

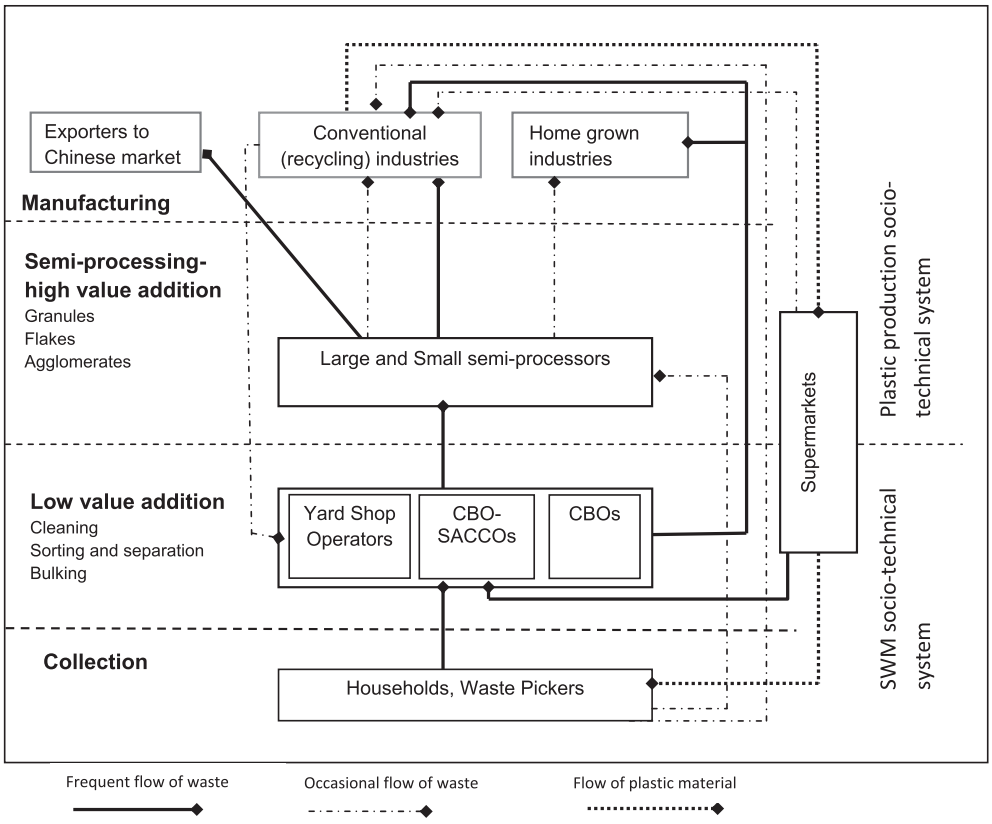

Fig. 2. Actors and plastic (waste) flows in the plastic production and solid waste management systems in Kenya.

the main actors supporting these, seems to be the value of plastic waste recycling. Among most market actors, the main political and policy actors, as well as the CBOs and CBO-SACCOs we see a major convergence towards the economic benefits and potentials of recycling for solving the problems of plastic waste. Secondly, a large majority of actors in the networks around the seven niches agree that economic motives rather than environmental intentions or social development gains drive niche innovative developments. This economic inclination coincides with a preference for recycling rather than substitution/prevention innovations (e.g. paper instead of plastic bags, glass instead of plastic bottles, wooden instead of plastic furniture), as with recycling initial plastic production economic activities remain intact, while new economic value added activities are supplemented.

Thirdly, there seems to be wide consensus among the dominant niche actors on the low priority for systems of separate collection of plastic waste. None of the dominant actors was strongly pushing for separate waste collection systems. Incidentally, there are niche experiments entailing separate collection of plastic waste (as in the case of PET bottles, or plastic waste at supermarkets or factories), but no systematic separate collection of post-consumer plastic waste factions has emerged. There is also no major effort from different policy and political institutions at national and local levels to develop initiatives, larger pilot projects or policies to advance such separate collection systems.

Fourthly, prevention of plastic waste prevails in some of the policy documents but hardly in niche innovation practices or among the actor expectations in the various networks. Neither are taxes on plastic bags, alternative packaging material for supermarkets, and biodegradable plastic bags – to name a few – widely supported among actors in the various networks.

Hence, it can be concluded that convergence moves towards recycling, triggered rather by economic outlooks than by environmental motives. And neither prevention nor separation at source is high on the agenda in Kenyan plastic waste policies and practices. It can thus be expected that innovation development in plastic waste will keep fluctuating with economic factors like oil prices, national economic growth and unemployment rates.

Table 1
Actors interviewed in plastic waste innovation in Kenya.

Actors	Number interviewed
Yard shop operators	58
CBO	20
CBO-SACCO	3
Conventional plastic recycling industry	7
Home-grown recycling industry	2
Supermarkets officials	4
Manufacturer of biodegradable plastic bags	1
Retailer of biodegradable plastic bag	1
Export Industry	1
Semi-processors	7
Pickers	7
Private waste collection companies	5
Government organizations	4
City authorities officials	6
Lobby organizations	3
NGOs	1
Total	**130**

4.3. Learning

For niche developments to be successful and to make it into regime change, learning processes need to include second order learning: learning not only directed at facts and data but also in

Table 2
Key findings on operations, nature of engagement and conditions faced by different actors under plastic waste management and recycling (Oyake-Ombis, 2012).

Actors characteristics	CBOs	CBO SACCOs	YARD SHOPS	Conventional recycling industries	Home grown recycling industries	Industries exporting to China	Bio-plastic bag
Nature of activities	Collect plastic waste; Sort by colour and type; Wash, dry and bulk; Sell	Collect plastic waste; Sort by colour and type; Wash, dry, semi-process and pack; Sell	Sort by colour and type; Wash, dry and bulk; Sell	Produce a variety of household products using modern machinery	Produce hard plastic poles from commingled waste materials by means of locally re-modelled machinery	Semi-process PET waste materials into flakes for export	Produce biodegradable plastic bags and sell
Suppliers of waste/ material	Households to whom they provide waste collection services	Households; Member CBOs	Waste pickers; Supermarkets; Manufacturing industries	Waste pickers; CBOs; CBO SACCOs; Yard shop operators; Semi-processors	Waste pickers; Industries; Yard shop operators; Semi-processors	Yard shop operators	Imported from South Africa
Amount of plastic waste handled	Less than 250 kg per week	Over 1000 kg per week	0ver 1000 kg per week	300–600 tons per month	90–110 tons per month	160 tons per month	Nil
Area of Operation	Within informal settlements and low income residential areas	Anywhere suitable for location of their premises identified by City Authorities	Open lands adjacent to industrial areas, often at a fee	Areas designated as industrial areas by City Authorities	Any area suitable for location of industry	Any area suitable for location of industry	As conventional industries
Source of startup funds	(Inter)national NGOs; Faith based organizations	International funds and NGOs	Individual or family resources	Private investment	Private investment	Private investment	Private investment
Market for plastic waste products	Recycling industries; CBO SACCOs; Local markets	Mainly conventional recycling industries	Semi-processors; conventional recycling industries; Home-grown recycling industries; Industries exporting to China	Local and regional markets	Local and regional markets	Export to China	Local supermarket chain
Relationship with other actors	With city authorities: cordial; With industries: nothing beyond supplier–buyer relationship	With city authorities: cordial where at times benefitting from land allocation for operations; With industries: business like	With city authorities: frosty; With industries: Cordial (given cash advances and transport for their waste) as well as sharing information especially on market situation and health hazards	With city authorities: only when seeking compliance requirements; Informal arrangements with semi-processors and yard shop operators for waste materials in return of technical support	Frequent consultations with technical and institutions of higher learning; Limited to compliance requirements with city authorities	Limited interactions with government related institutions on license compliance	Hardly any with city authorities except for the normal compliance requirements; Supplier-buyer relationship
Motivation for engagement in plastic waste	Social welfare issues including environmental improvement	Economic empowerment to members by providing loans at reasonable rates	Employment creation and economic empowerment to individuals involved, ultimately displaying stronger business orientation	Higher profits, environmental hygiene; Government friendly polies like zero ratings on technology imports with fluctuating prices of virgin raw materials	View recycling as a business with the potential to avoid plastic waste in the environment while creating a new market niche	Highly competitive market environment of recycling for packaging bags and a new market opportunity with likely higher profits	Pressure from government on plastic bag production (Announced legal ban on plastic bags)
Training, capacity building and other networks	With NEMA and City Authorities for knowledge on policies, legal requirements and infrastructural support; Occasional oversees networks for knowledge on technologies and benchmarking; With faith based	With local and international NGOs for knowledge on technologies, entrepreneurial skills and financial support; With policy community for knowledge on policy and legal requirements,	With policy community (NEMA) for legal and operational knowledge; With micro-financing institutions for knowledge on entrepreneurial skills; With civil and private actors for supply of materials and products; With training institutions for	With foreign expatriates for knowledge on technology; With civil actors and other private actors for supply of materials and products; With KAM to highlight and lobby government for their interest and access to market and technology information	With technical and university organizations for standardization of their products; With NEMA for certification of products and lobbying for energy concession; With civil and private actors for supply of raw	With foreign expatriates for knowledge on technology; With civil and other private actors for supply of raw materials and products respectively	None with any policy community; Supply of raw material and delivery of products to private actors

(*continued on next page*)

Table 2 (*continued*)

Actors characteristics	CBOs	CBO SACCOs	YARD SHOPS	Conventional recycling industries	Home grown recycling industries	Industries exporting to China	Bio-plastic bag
	organizations, other civil actors for knowledge on technologies, financial support, material and product supply	waste operational standards; With civil and private actors for supply of materials and products	knowledge in machine operations; With policy community for knowledge on compliance requirements; Minimal networks with City Authorities for issuance of operational licenses		materials and delivery of products respectively		
Constraints faced	Limited financial resources; Stringent local authorities' policies; High fees paid to local authorities; Usually run by two officials only; Difficulties sustaining operations beyond donor funding	Limited income to roll out loaning scheme for members; Difficulty meeting demand with low sale's frequencies; Difficulty sustaining demand beyond donor funding; Occasional lack of trust by industries about supplies	Limited financial resources; Open premises which are exposed to hazards including fire and rain; Prohibitive cost of licenses	Limitation on how many times post-consumer plastic waste can be reprocessed; High impurities in waste plastic materials; High costs of electricity	Limitation on supply networks as there is no level field amongst competing actors for waste material resulting in batch production; Inadequate and inefficient machines resulting in high maintenance costs; High electricity costs; Inadequate capacity to meet demand of the emerging market; Multiple licensing requirements	Idling capacity due to low consumption of PET plastic products; Not able to meet demand; Not able to meet quality demand for export as Kenya has not standardized flakes materials; High electricity costs	Lack of policy, marketing and advocacy support of this development; Inadequate technological knowledge

Sources: Site visits and interviews with 27 entrepreneurs, 58 yard shop owners, 20 CBOs, 3 CBO-SACCOs, 1 supermarket between 2008 and 2011

terms of changes in cognitive frames and assumptions (Grin & Van de Graaf, 1996).

Learning in the 7 cases took place especially as first order learning processes. In each of the niche developments the main actors have learnt various technical, economic and regulatory aspects of innovation in plastic production and waste management. CBOs, yard shop owners, and home grown industries have picked up experiences from each other, especially when in close geographical or social proximity and without fierce competition among each other. In larger companies, learning took place through hiring (foreign) experts that work together with local employees who learned on the job. Within CBOs and CBO-SACCOs, technical and organizational learning is obtained through various bilateral and international donor organizations. But most of these learning processes are not institutionalized or formalized and take place on an informal and rather incidental/*ad-hoc* basis.

In hardly any of the niche developments second order learning materialized, as no institutions have responsibility for monitoring practices and knowledge articulation about plastic waste mitigation options and experiences. NEMA, industrial associations of plastic manufacturers and international donors would be the logical institutions for second order learning, but with regularly shifting priorities there is limited enduring interest in plastic waste, and lack of capacity and resources for knowledge generation and dissemination on plastic waste mitigation.

4.4. *Explaining success and failure of niche innovations*

Based on the analysis of the seven cases of innovative niche development in terms of actor networks, convergence of expectations and learning processes, the relative success and failure of each of the niche innovations can be explained. Successfulness is defined in terms of continuity in handling significant amounts of plastic waste and the ability to influence changes at the regime level.

Yard shop niche developments can be interpreted as a relatively successful niche innovation in handling plastic waste. This innovation 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. Conventional recycling industries also form a relatively successful niche development. They encompass a broad, better organized and more formalized actor network, compared to the yard shop recyclers, making it less vulnerable to harassments or preferences of individual municipal enforcement officers and politicians. Ideas and expectations of actors in this network converge in interpreting plastic waste as a useful, clean and homogeneous resource to be fed into normal plastic production. The network encompasses active learning processes with international exchanges. Equally to the yard shop innovation this case is profitable, ensuring economic self-interest and thus a major degree of continuity over time.

CBO and CBO-SACCO niche innovations have similar characteristics (see Table 2) and show both ambivalent successes. They share some first order learning among community based organizations, be it poorly institutionalized and strongly dependent on ideas and priorities of international donor agencies. The niche innovations consist of fairly small homogeneous networks that do not stretch widely and thus make niche innovations vulnerable. Continuity of innovations is therefore problematic, also because social and community development is often the main motive and goal, making plastic waste collection and upgrading exchangeable for any other community project, depending on donor, community or policy-maker preferences.

Home grown industries form a niche innovation with some success as their market potential is promising and social learning (new techniques, new product development) has been developed. However continuity and expansion of this niche innovation stagnates due to a limited supply network of plastic waste and consequently the failure to fulfil market expectations for supply of a stable quality and quantity of recycled plastic products.

The processing and export of PET bottles and the production and introduction of biodegradable plastic bags are two niche innovations that have both failed. Very small networks, lack of convergence of expectations among wider constituencies (policy makers, customers, consumers), and unsuccessful learning prevented these innovations from establishing a sizable market and become somewhat institutionalized. Only very few stakeholders believed in the viability and economic feasibility of these niche innovations in Kenya. Both innovations have been discontinued after some time of experimentation and have not managed to make an impact on the conventional regimes.

5. Aligning regimes for plastic waste management and plastic production

The problem of plastic waste is governed by both the plastic production and the solid waste management regimes. Better alignment or even partial integration of the two regimes might facilitate solving the plastic waste crisis in East African urban centres. As the analysis in the former section shows, Kenya is quite far from having a well-aligned, let alone integrated, plastic *production-cum-waste* regime that structures and enables plastic waste prevention, recycling and handling practices. To a major extent, 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.

But Strategic Niche Management theory also suggests that regime change may be initiated by niche innovations. 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 managing plastic waste in urban Kenya, this study illustrates that the seven niche innovations on plastic waste currently contribute only marginally to building more aligned regimes, or an integrated regime, for coping with plastic waste (Fig. 3). There are two exceptions to this. The niche innovation of yard shops seems to successfully bring the two regimes together. Yard shop owners have successfully forged economic relations and function as intermediary between plastic waste pickers and plastic producers. The other exception forms the niche innovation of home grown industries, which contributes to aligning the two regimes by creating a new economic and material flow for mixed plastic waste and producing new plastic products for a new market. Not accidentally, these two niche innovations are strongly connected. Still, in practice major barriers prevent a fluent flow of upgraded plastic waste of yard shops to home grown industries. This is even stronger the case in the flow of plastic waste towards conventional plastic industries given the fact that their uptake of plastic waste is more dependent on the international prices for virgin polymer materials (Oyake-Ombis, 2012).

As current niche innovations have shown a meagre ability to foster integration between the two regimes, the question emerges what future innovations can further stimulate the building of an integrated regime for governing plastic waste. Niche innovations that support separate collection of plastic waste and niche innovations inducing prevention of plastic waste are likely candidates. But we have seen that the key condition for such successful innovations are not yet present in contemporary Kenya, making the prospects for regime change quite limited. Besides new innovations, more coordination to facilitate integrated plastic waste management among governmental authorities, industrial actors and civil society can also better align the two regimes via existing innovation niches. One could think of acknowledging the existence of informal waste pickers, the better allocation of space for yard shops and waste separation centres, technological and financial support and education for waste processing, and marketing support of products made from plastic waste or even biodegradable plastic.

6. Conclusion

With continuing economic growth over the last decades in most East African urban centres the problem of plastic waste has become severe. The default situation in most urban centres is that plastic producers and importers ensure the continuing production of plastic products from virgin resources and their flow into African urban economies. And that significant parts of these products end up in the environment due to failing waste collection and recovery

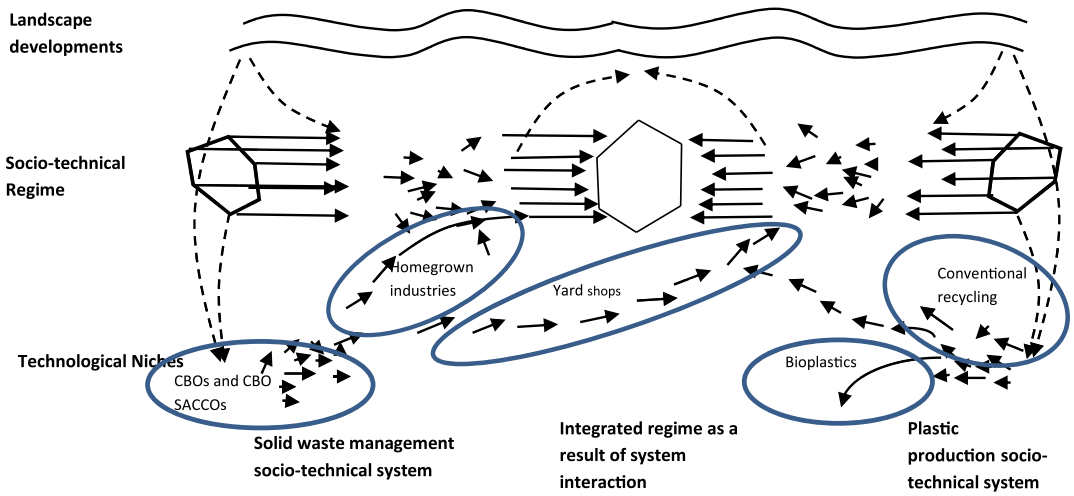

Fig. 3. Plastic waste niche innovations in a multi-level and multi-regime transition framework.

systems. Municipal and sometimes private solid waste collectors collect some of the plastic waste and dispose it off via landfills or illegal waste dumps, while another part ends as litter. This study analysed (existing) innovative niche practices to assess whether and how they are developing towards alignment or even integration of the plastic production and solid waste systems. This is done under the premises that sustainable management of plastic waste should move from a linear towards a circular mode of plastic production and consumption.

Seven of these niche innovations have been analysed for Kenyan urban centres. Some innovations (by yard shop owners, home grown industries) proved more promising in contributing to a change of the two regimes of plastic production and solid waste management into one plastic waste recycling regime, than others (PET export; bio-degradable plastic; CBO and CBO-SACCO collection). But in all cases of innovation actors faced impediments preventing them to reap maximum benefits from their activities and substantially contribute to a new plastic waste regime. Informal actors are often faced with deplorable working conditions, lack of clear guidelines and lack of governmental recognition. Formal industrial actors face governmental policies that have not been sensitive to recycling trajectories. And all actors lack incentives and converging expectations of preventive solutions. National and city authorities, informal waste collection and management actors, industrial plastic producers and plastic customers, could develop a common plastic recycling framework with specified supportive and mandatory policies to enable an integrative plastic waste regime. Mandatory targets for plastic waste reuse in conventional and home-grown plastic industries, quality guidelines for plastic materials and plastic waste categories, and official recognition, training and support of yard shop owners can be useful elements in such a framework. For this, local and national authorities could take the lead, as they are part of the networks of various innovation practices.

This study can also draw conclusions with respect to the theoretical frame applied. The theoretical model (Multi Level Perspective on Transitions), has been developed primarily in the context of Western developed societies, in a non-Western context. This enables us to draw some conclusions on the usefulness and applicability of Western innovation and transition models for developing country contexts. Several theoretical starting points of MLP transition theory have shown to be rather problematic in the Kenyan situation. For instance, the precondition of having heterogeneous actor networks with intensive interactions for successful niche innovation is not supported by our findings. With less extensive networks and actor interactions niche innovation could still successfully flourish. Similarly, broad – second order – modes of social learning did not occur in our cases, which however did not always prevent innovation. Innovation success in plastic waste in Kenya is explained by technological and economic lessons taken, rather than broader learning processes highlighted by scholars of Strategic Niche Management. Finally, and not surprisingly, shared economic motives and views proved in urban Kenya more important than shared views on sustainability, while the latter seems to prevail in Western (sustainability) transitions.

A final conclusion can be drawn with respect to regime alignment/integration in MLP theory. Most MLP transition studies focus on socio–technological transitions of one system and governed by a single regime, but it might very well be that in our increasingly complex and interwoven world the default case for future transitions will be regime interaction, alignment and integration. Further empirical studies are needed to better build regime integration into MLP transition studies and theory. This is especially relevant for transitions towards sustainability (up till now subject of the majority of empirical transition studies), as sustainability problems are hardly related to single regimes, and often follow from the lack of alignment and integration of actors, policy and regulations, and infrastructures, in multiple regimes.

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