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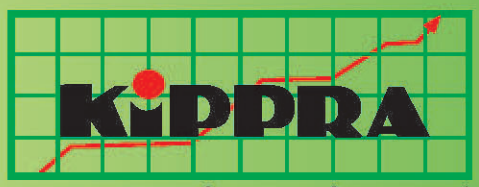

The KENYA INSTITUTE for PUBLIC POLICY RESEARCH and ANALYSIS

Accelerating the Circular Economy in Plastic Waste Management for Kenya

Jecinta Anomat and Hassan Ali Ibrahim

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

YOUNG PROFESSIONALS (YPs) TRAINING PROGRAMME

Accelerating the Circular Economy in Plastic Waste Management for Kenya

Jecinta Anomat and Hassan Ali Ibrahim

Kenya Institute for Public Policy
Research and Analysis

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Abstract

Circular economy has gained momentum and traction across the globe as countries are moving from the take-make-dispose business model to a closed loop waste management. Kenya's transition to circular economy is just picking up, spearheaded by the private sector, and by government in developing policy frameworks. Plastics are ubiquitous and are causing serious nuisance to the environment, yet only 8 per cent of what is collected is recycled in Kenya. In examining the transition to circular economy, this study critically reviews, the policy and legislative frameworks and the existing and potential technologies along the plastic value chain in bringing out existing gaps. The plastic value chain is defined by design, production, product use, disposal, segregation/sorting, collection, reuse, and recycling. The findings of this study show that despite having a number of policy and legislative frameworks in waste management, plastics waste management in Kenya is highly fragmented, with none of the frameworks having addressed fully the entire plastic value chain. Most of them are prescriptive and not clear on the roadmap in addressing plastic circularity. Regulations such as Environmental Management Coordination Act (EMCA) (plastic bag control and management) are focused only on plastic flat bags (polythene), leaving out other categories of plastics and products. In addition, counties are lagging in developing relevant laws and policies despite being the implementing entities for waste management, including plastics. Technologies in plastic circularity are limited in Kenya, with existing ones being mechanical by nature and addressing fewer plastic value chain nodes such as sorting and recycling. Specific technologies available in Kenya are pelletizers, grinders, and digital solutions (mobile apps) for collection. This study therefore recommends harmonization of existing policies on waste management with a view to addressing plastics circularity, and fast-tracking development of plastic circular economy policy and bill as espoused in the Medium-Term Plan III (MTPIII). Counties need to develop their own legislations and policies around waste management as required by the National Sustainable Waste Management Act 2022, and re-introduce incentives for plastic recycling such as zero tax on imported technologies, including machinery and equipment for recycling and material recovery infrastructure.

Abbreviations and Acronyms

C2C	Cradle to Cradle
CE	Circular Economy
EPR	Extended Producer Responsibility
EMCA	Environmental Management Coordination Act
EMF	Ellen MacArthur Foundation
GHG	Green House Gases
GESIP	Green Economy Strategy and Implementation Plan
HDPE	High-Density Polyethylene
KAM	Kenya Association of Manufacturers
KEPSA	Kenya Private Sector Alliance
LCD	Liquid Crystal Display
LDPE	Low-Density Polyethylene
MTP III	Medium-Term Plan III
NEMA	National Environment Management Authority
NCCAP	National Climate Change Action Plan
NSWM	National Sustainable Waste Management Act
PET	Polyethylene Terephthalate
PP	Polypropylene
PVC	Polyvinyl Chloride

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1. Introduction

Waste management is one of the core policy issues in addressing environmental integrity and control of resource depletion for sustainable development. The approaches to management of waste have been largely linear as opposed to circular. The linear economy is a take-make-dispose economy, which entails extraction of materials from the natural environment to make a product that is disposed after use and ends up as waste. On the contrary, circular economy represents approaches whose intention is regenerative and restorative by design (MacArthur, 2013). Restoration ensures that resources are utilized fully by converting the waste into similar form, while regenerative transforms the waste into other useful products. Pearce and Turner (1990) described circular economy as an aspect of minimizing wastes by reusing, repairing, refurbishing, and recycling existing materials.

The approach of circular economy is applicable to other sectors, including construction, manufacturing, and agriculture and plastic waste circularity is one of the major components in it. Kenya mainly gets its plastics by importing from abroad since it does not produce virgin plastics. The plastics come in form of resins, finished products and packaging. Resin plastics are processed into products and packaging materials. The Kenya National Bureau of Statistics categorizes plastic import as primary, non-primary and articles of plastics. The net imported plastics for the categories were 491,305 tons in 2019, an increase from 474,713 tons in 2018 (KNBS, 2019).

Kenya has made some strides towards a transition to circular economy in plastic waste management through some deliberate legislations, including a ban on single use of plastic bags in 2017, and development of Extended Producer Responsibility Regulations 2021, and Sustainable Waste Management Act 2022. Waste management is a devolved function bestowed on the county governments in accordance with the Constitution of Kenya (2010). The government commitment in moving the country towards a circular economy has been witnessed through collaboration with other partners such as the private sector. The private sector players involved in advancing the narrative on waste management are the Kenya Association of Manufacturers (KAM), Kenya Private Sector Alliance (KEPSA), Sustainable Inclusive Business Kenya, and Kenya association of waste recyclers, among others.

Limited uptake of circular economy approach undermines the progress the country makes towards achievement of environmental conservation, control of environmental health hazards and promotion of efficient utilization of resources for sustainable development agenda. In Kenya, only about 27 per cent of plastics are collected countrywide; that is, 125,000 of 506,000 tonnes of plastic wastes

that are either recycled or disposed off safely (IUCN, 2020). In the capital city of Nairobi alone, about 2,400 tons of solid wastes are produced every day, of which 20 per cent is in plastic forms (World Bank, 2021). Most of the wastes generated end up in open landfills or is littering in most urban towns without proper disposal, which has harmful impact on the environment and health. The rate at which plastics are recycled in Kenya has also been very low at 8 per cent, meaning that most of it is not properly managed. However, very few studies have focused on plastic waste management (Ambuchi, 2006 and Nyambura, 2012). Other existing literature are basically ad hoc reports that do not address plastic circularity along the value chain.

There is a lot of potential in public circularity in Kenya both in creation of jobs and economic growth while ensuring environmental sustainability and public health. Evidence from literature has established that increasing plastic circularity improves revenue generation and employment creation. For example, it was estimated that the global recycling market value chain equaled to US$ 31 billion in 2015 and is expected to reach US$ 57 billion worldwide by 2024 (TMR, 2017). This study, therefore, sought to identify and analyze existing regulatory frameworks (policies and legislations) in plastic waste management along the value chain in Kenya with a view to identifying gaps that impede transition to circular economy. In addition, the study evaluated how existing and potential technologies can enable Kenya to fully transition to circular economy.

The other sections in this study are organized as: Section 2 reviews the theoretical and empirical literature, section 3 the approach for undertaking the study, the theoretical and analytical frameworks underpinning the delivery of the study and the desk-review approach, section 4 gives the analysis and the findings, and section 5 draws the conclusion and recommendations based on the study findings.

2. Literature Review

2.1 Theoretical

Circular economy (CE) as a new concept continues to receive attention from various sectors, including business practitioners, people in the policy making space and academics across the globe (Merli et al., 2018). There is no agreed definition when it comes to the concept of the CE, and various authors have coined different definitions, but one of the key proponents in this area who have continued to propagate and call for action to the countries in moving from the business as usual (BAU) of the take-make-dispose model to more "restorative and regenerative" by design ana intention is Ellen MacArthur, who in 2010 established Ellen MacArthur Foundation.

Theories around the concept of CE continue to evolve in the recent past. Notable among them are the Kenneth Boulding theory of the Spaceship Earth and Environmental Economics, the Cradle to Cradle (C2C) theory by William McDonough and Dr Michael Braungart, and more recently through the works of Ellen MacArthur, such as the performance economy, which have continued to shape CE.

2.1.1 Spaceship Earth and Environmental Economics Theory

American economist, Kenneth Boulding (1966), postulated the concept of CE in his works such as 'The economics of the coming Spaceship Earth', in which he argued that CE is an alternative for the human life sustainability on Earth (Boulding 1966). He viewed the current systems as an open system, where natural resources that are required as raw materials for production of other products are seen as limitless in their supply. This is despite this current model causing environmental impacts and health hazards. He, therefore, introduced the concept of "spaceman economy", which considers the natural ecosystem as a closed system and that there is no waste ideally as everything that is produced, used can be used again and again as input to another (recycling).

2.1.2 Cradle to Cradle theory

As a concept, the Cradle to Cradle (C2C) was proposed and developed by architect William McDonough and the chemist Dr Michael Braungart. They called for a shift in the way we design our material goods and going beyond the concept of eco-efficiency, which has traditionally focused on the impacts of human activity on environment. They observed that eco-efficient strategies are good in minimizing

ecological harm in the short-run but are not sufficient to meet the desired goal in the long-run.

McDonough and Braungart (2002) coined the concept of eco-effectiveness with focus on reduction of waste to increase quality for positive impact rather than reduction for negative impact. In other words, "working on the right things - the right products, services and systems instead of making the wrong thing less bad". Eco-effective approach has been known to address the source of the problem while aiming at re-establishing a positive relationship between the human and environment. Therefore, the goal of eco-effectiveness minimizes the "cradle-to grave" flow of materials to the cyclical "cradle-to-cradle" where materials are used repeatedly without losing its property and quality (Braungart et al., 2006).

This theory considers materials involved in the industrial and commercial processes to be nutrients, which are categorized into biological and technical nutrients. While the biological nutrients are returned to the soil after their use, the technical products can be used repeatedly.

2.1.3 Theories of Value Chain

The value chain consists of a full range of activities from the conceptualization or design of the product through the production of the product to its final consumption and disposal of residual waste (Kaplinsky, 2000). It recognizes the need for the seamless flow from production to consumer and linking the supply with the demand of the consumers (Porter, 1985).

Various theories have advanced the concept of the value chain, and these include Michael Porter's framework for value chain with a view to helping organizations to understand their competitive advantage over other firms. According to Porter, firms' competitive advantage can be created according to the value it generates. The value chain model explains how value is added in each of the product development stages from ideation, design, production, marketing, delivery, and ultimate consumption by the consumers (Ensign, 2001).

The second is the value configuration theory that builds on the Porters value chain framework for the analysis and development of organizations. It rests on the same premise that motivated value chain framework, where performance stems from the many discrete activities that a firm performs in generating and developing value to its customers. However, Porter's framework assumed that value chain is applicable in all industries and firms the value configuration represents manufacturing of physical goods with a view to transforming and assembly of inputs into finished goods.

2.1.4 Analysis of the common grounds for these theories on circular economy

While there are some divergent views on the concept of the circular economy, the different theorists started from similar views that the current industrial system of the 'take-make-use-dispose' model does not work and is not sustainable in the long-run. They called for measures that are inspired by the nature of efficient use of resources while at the time been cognizant of the impact of the environment. The review of these concepts showed that while the Spaceship Earth, the Industrial Ecology and the Cradle to Cradle looked more into the environmental/ecological impact of the systems and products, the performance economy theory is more of business model looking into how to decouple the economic growth and shift from the resource efficiency perspective to resource sufficiency with the aim to create more wealth and jobs. The concept of the circular economy relates to all theories, and thus it has to be considered as a wholistic approach.

2.2 Empirical

The literature review under this section is on plastic waste management along the value chain and underpins the aspect of regulatory frameworks and technology that enhances transition to circular economy. The concept on circular economy has gained attention over the recent years from global business leaders and policy makers and is now gaining attention from scholars as noted by Lehmann et al., (2022). The circular economy model is one of promising models that global citizens require to achieve sustainable development goals. When innovation and modern technology are is applied, waste is regarded as a desired resource that can be used to run industries (Ahmed et al., 2022).

The shift towards circular practices for countries that are developing is required in all sectors, and more important on waste management as argued by Khan and Ali (2021), and when it comes to technology discussions, sophisticated and cost-effective technologies are required to aid in accelerating the transition (Khan and Ali, 2021; Serrano et al., 2021; Ding et al., 2019) in their study noted that governments in developing countries are facing challenges in implementation of the policies that are supposed to aid circular model in waste management.

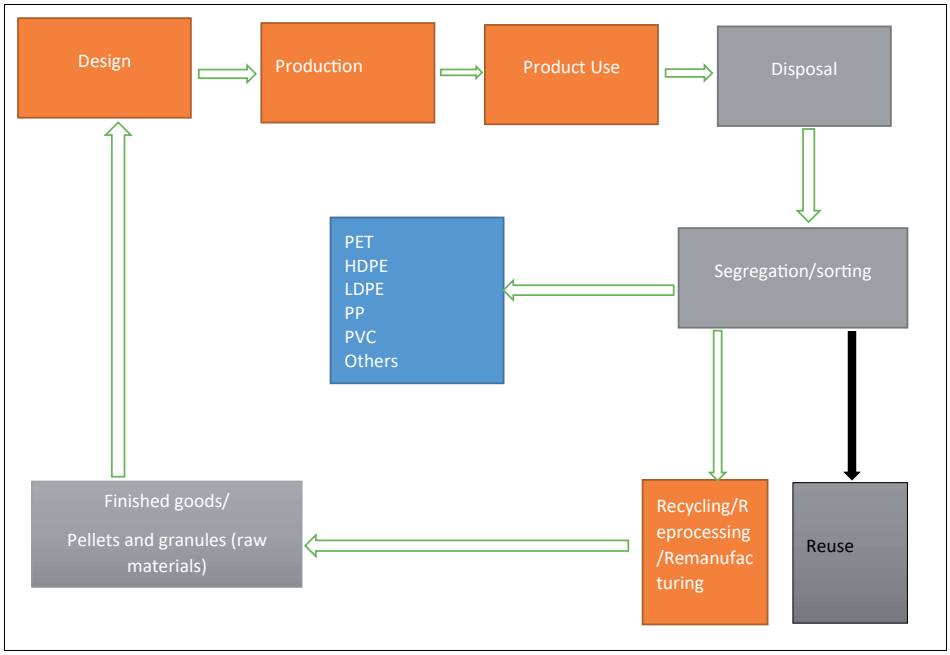
In a report by Eunomia (2018), plastic waste materials account for the largest share of municipal solid waste after organic waste and paper. Such wastes originate predominantly from plastic packaging of goods. Circular economy models and approaches are currently used innovatively to make carpets, and bioplastic products from plastic products (Vasmara and Marchetti, 2016).

Feroz and Yousaf (2021) in their study argued that waste management can be better tackled through adoption of new smart waste technologies. In addition, policies that support the transition must be put into place. This will help in improving the efficiency of plastic waste management. Findings from different literature on plastic circularity along the value chain shows how the authors analyze it depending on their objectives. Gall et.al (2020) in their study while assessing plastic bottles recycling after end use and advised that the design stage should take into consideration use of fewer polymers to prevent contamination during the recycling process. They concluded that to have higher recycling rates of plastics, a comprehensive approach on material composition and quality is important. When a plastic product is manufactured in its initial stage, the design must be put in such way that it is easily defined and recyclable. This will eventually improve plastic product circularity and reduce pollution caused by single use of such products. Foschi et al (2020) emphasize on the aspect of designing plastics that can be recycled. Getting it right in terms of design at the initial stage is beneficial because it ensures sustainable and a safe value chain, high recyclability rates and reduced energy consumption.

Literature on production stage for plastics along the value chain highlights the composition of different polymers and contamination in recycled plastics as major challenges during recycling as it reduces the quality and value of recycled plastics. Therefore, fewer polymer types should be used when producing plastics to ensure they remain within the loop and support a circular system (Gall et al., 2020).

Boesen et al. (2019) investigated consumers perception on the effects of product consumption on the environment and found that consumers lack knowledge on environmental sustainability and the need of consuming eco-labelled products and in closing the gap, producers, retailers, and policy makers need to act (Figure 1).

Figure 1: Plastic circularity value chain



Source: Johansen et al. (2021)

3. Methodology

3.1 Theoretical Framework

In accelerating circular economy in plastic value chain, we worked within the framework of Porter's value chain, which looks at how values are added in each of the activities and stages of product development from ideation, designing, production, marketing, delivery, and final consumption.

3.2 Analytical Framework for Plastic Circular Economy

In this study, we reviewed national regulatory frameworks (legislations, policies, and strategies) relevant to the circular economy in plastics with a view to characterizing the type of policy and legal framework in use and evaluate the gaps that exist. In the analysis, we adopted Porter's framework on value chain. We mapped out the entire plastic value chain from the designing of the product, production, use, disposal, collection, segregation/sorting, reuse and recycle in understanding which regulatory frameworks (legislations and policies) address each of the value chain (Appendix 3.1).

In addition, we mapped and reviewed the technologies used along the value chain of plastic waste management and identified best practices in plastic circularity globally and how Kenya could adopt and learn from such technologies (Appendix 3.2)

3.3 Desk Research Review

This study adopted qualitative desk research review. The study reviewed published journals, reports, policies, plans, Acts and strategies about plastic circular economy in Kenya. In addition, we reviewed the existing literature on technology and best practices along the plastic value chain.

The key regulatory frameworks that were reviewed included but not limited to: the Constitution of Kenya, 2010; Environmental Management and Coordination Act, 1999; Gazette Notice No. 4858, 2019 on plastic ban; Solid Waste Management Strategy, 2014; National Environmental Policy, 2013; National Sustainable Waste Management Policy, 2021; Vision 2030 (social pillar); Third Medium-Term Plan (MTP III, 2018-2022); Green Economy Strategy and Implementation Plan (2016-2030); National Climate Change Action Plan (2018-2022), Extended Producer Responsibility Regulations, among other official government documents.

4. Analysis and Findings

This section presents the analysis and findings of the desk research review of various legal and policy frameworks that guide the implementation of the plastic circular economy and identification of gaps. In addition, literature on the existing and potential technologies that promote transition to plastic circular economy were reviewed.

4.1 Review of the Policy, Strategies, and Legal Framework along Plastic Value Chain

Waste management is the collective responsibility of individuals, communities, industries, and government. As a devolved function, planning and delivery for waste management is the responsibility of County governments. The National government develops legal and policy frameworks that guide the County governments to either adopt or come up with new policies and legislations within the framework provided by the National government, and in so doing they should not contradict the provisions provided. In this study, we reviewed both the County and the National government regulatory frameworks on waste management with a view to identifying and evaluating the provisions and gaps on plastic waste management along the value chain.

4.1.1 Design

The design of the product is the initial phase in the plastic value chain. During this phase, qualities such as the color, the recyclability property and the polymer mix of the product is often decided (Iacovidou et al., 2019). In our review of the policy and legal frameworks, only two regulations and one policy address the aspect of the design of the product. The EMCA (Plastic Ban Control and Management Regulations, 2018) call manufacturers of plastic flat bags to ensure that they include at least 30 per cent of the total recyclable content in their products, In addition, the EMCA (Extended Producer Responsibility, 2021 Regulations) require every producer to design product and packaging materials for possible reuse, recycling and are environmentally friendly. The National Sustainable Waste Management Policy (2021) calls for better design of the products to enhance durability, reusability, and recyclability. However, most of these are prescriptive and do not give how to design plastic products in a way that allows for 100 per cent recyclability due to the different polymers and resins of the plastics currently in production. Studies by Gall et al. (2020) and Iacovidou et al. (2019) found that contamination and mixed polymers are the two main problems

in designing especially when incorporating recycled plastics into new products. They suggested that fewer polymer types should be considered to close the loop. Literature has shown that there are number of ways in designing products to ensure its recyclability, such as designing for sustainable sourcing; designing for optimal resource use; designing for the environmental soundness and safety of the product use and designing for prolonged product use (Bocken et al., 2016, Le Blevennec et al., 2018).

4.1.2 Production stage

After the design of the product, the next phase in the plastic value chain is production, which encompasses multiple steps including moulding and melting of the primary plastic raw materials to get finished products. A common problem with recycled plastic is that most often they are composed of different polymer types and are often contaminated with non-plastic materials including additives, causing the product to form lumps, which reduces the value of the final product (Getor et al., 2020).

This stage is important, just like the design stage, because it helps in determining what type and how much plastic ends in the environment as waste. Some of the legislations and policies reviewed that touched on production include the National Sustainable Waste Management Policy (2021), which calls for the measures and economic instruments to reduce the need for the virgin materials in favour of the local recyclable materials in the production of new secondary products. In addition, the policy requires all producers to use eco-friendly raw materials that generate less waste, use cleaner production technologies, and manufacture ecofriendly products that promote circularity. The draft EMCA bill, 2021 calls for the establishment of standards for the use, manufacture, and distribution of all plastics. The ban on the single use plastics (SUPs) was through Gazette Notice No. 4858, also known as wildlife conservation and management Act on single use plastics, straw and other related products in all protected areas including parks, beaches, forest among others. Johansen et al. (2021) found that to ensure circular production, other phases of value chain must be explored, especially where the plastic products are designed with mixed polymers or contaminated in the waste.

4.1.3 Product Use

The third phase of the plastic value chain is the demand and use of the finished plastic products and post-consumption handling. The National Sustainable Waste Management (NSWM) Policy, 2021 calls for quality standards and markets for recycled materials. In addition, the policy calls for widespread public awareness,

participation and actions on the sustainable waste management. The draft EMCA bill, 2021 under sec 133(1) calls for establishment of standards for the use, manufacture, distribution and import of all plastics and setting guidelines and regulations for best management of plastics. The Kenya Environmental Sanitation and Hygiene Policy (2016-2030) calls for regulations on the use of plastic bags.

Since waste is a devolved function, the policy calls for the County governments to take a central role in sustainable waste management, including regulatory environment that promotes functional market for waste and recyclable materials.

4.1.4 Disposal

After products in plastics have been consumed, they are disposed off or recycled back into the loop to create secondary products. In Kenya, such products may end up in landfills, oceans and others litter the environment. The Kenyan Constitution of 2010, Article 42, provides that every person has the right to a clean and healthy environment. Part 2 of the 4th Schedule of the Constitution explicitly provides for the County government to manage refuse removal, refuse dumps and solid waste disposal. A number of other regulatory frameworks have addressed the disposal value chain; these include: National Sustainable Waste Management Policy that calls for the removal of key recyclable materials before final disposal; National Sustainable Waste Management (NSWM) Strategy 2015 recommends minimal disposal of waste and properly engineered sanitary landfills and EMCA (1999) under section 86(3), which prescribes standards for waste classification, analysis and advise on standards of disposal methods. Both Nairobi County Plastic Control Act (2016) and the Kericho County Environmental Management Act (2021) calls for disposal of waste including plastics in a manner that may not be deleterious to the public health and the environment where such products are not reusable, recyclable, or recoverable.

4.1.5 Collection

Waste collection entails the transfer of recyclable materials and wastes from the point of generation to either disposal sites or material recovery infrastructure. Traditionally, for containers such as drinking bottles, plastics, glass, a deposit-return system as a measure to enhance collection of materials and packages and take-back system to loop the economy is needed. Most of the policies and legislations reviewed addressed collection of waste from the point of generation. Notable among these are the NSWM Policy 2021, which calls for the counties to provide a well-managed central collection for materials that can be recovered for purposes of reuse or recycling. The Kericho County Environment Management Act,

2021 requires that waste producers comply with the requirements for collection of wastes by type, origin, and properties by placing in wastes receptacles approved, designated, or provided by service providers. In addition, the Nairobi County Plastic Control Act, 2016 mandates the owner or occupier of land or building to collect from their respective premises non-biodegradable garbage and deposit in public receptacles.

4.1.6 Segregation and sorting

Waste segregation refers to the process of identifying, classifying, dividing, and sorting of garbage and waste products. It entails measures to ensure quality of materials extracted from waste are reprocessed and maintained for the realization of maximum value of resource. The National Sustainable Waste Management Policy 2021 calls for more sustainable zero waste principle where waste generation is minimized or prevented, waste at the source is segregated, reused, and recycled. In addition, the policy requires the waste service providers to provide separate waste segregation receptacles to enable sorting at the source according to the waste types, including organic and recyclable materials. The same was also highlighted in the Nairobi County Plastic Control Act 2016 and the Kericho County Environment Management Act, 2021.

The Sustainable Waste Management Act of 2022 mandates the County governments to take responsibility for waste management. They are supposed to develop county specific waste management laws, plan and budget for sustainable waste management including establishment of infrastructure for material recovery where waste is subjected to segregation, sorting, recycling, and safe disposal for non-recoverable residual waste and ensure segregation of wastes at household level, public and private entities with penalties of omissions.

4.1.6 Re-use

Reuse entails using again a component or the whole product for the same purpose and it may include repairing or cleaning of the item so that it can be reused. Legislation that encourages the reuse, including the NSWM Act, 2022 that encourages counties to establish infrastructure that will allow for the reuse of materials recovered, is also echoed in the NSWM policy 2021, which requires counties to provide well-managed central collection for materials that can be recovered for the purpose of reuse, the same was also captured in the Kericho County Environment Management Act, 2021 and Nairobi County plastic control Act 2016, National Environmental Management Policy, 2013 and National Waste Management Strategy, 2015.

4.1.7 Recycling/reprocessing

Recycling of plastics involves making the discarded materials more useful by bringing it back into the loop through mechanical and chemical recycling methods. It involves transformation of a polymer from a long into a short chain. Several legislations and policies reviewed addressed recycling. For instance, Extended Producer Responsibility calls for setting up of material recovery infrastructure for sustainable waste management. To encourage recyclability of the plastics flat bags any manufacturer who would like to import them is required to submit plans for recycling. The National Solid Waste Management Strategy provides for solid waste management hierarchy-waste, including recycling of the recyclable materials to reduce the amount of waste being disposed at the land fill. The EMCA 2018 Regulation 13 requires manufacturers selling plastic flat bags for use or distribution in Kenya to label each of the bags to identify the recycled content in the bag. The manufacturers of plastic flat bags are also required to include at least 30 per cent total recycled content in their products. NCCAP 2018-2022 promotes circularity by encouraging diversion of at least 90 per cent of the solid waste from disposal sites towards various recycling plants.

4.2 Gaps in Regulatory Frameworks

Our review of the policy and legal frameworks around plastic waste management in Kenya found that most of them are too general and do not directly address the problem of plastic waste. While subsequent legislation and policies over the years have tried to solve the problem of plastic along the value chain, none of them addresses the entire value chain. For instance, out of the eight plastic value chains mapped (design, production, use, disposal, collection, segregation, reuse, and recycling), it is only the recent National Sustainable waste Management Act, 2022 and the EMCA (EPR, 2021) regulations that address at most six out of the eight-value chains. Even so, most of them seem prescriptive and vague as they do not provide a road map on how they will be implemented. In addition, the question of plastic waste management seems to be fragmented in these documents and there is no specific policy on plastic circular economy in Kenya. The Third Medium-Term Plan 2018-2022 under the Kenya Vision 2030 as part of policy and legal reforms calls for the development of the Plastic Policy and a bill on plastics, which are yet to be realized.

Among the policies and legislations, there seems to be contradictions in their provisions. For instance, while the National Environment Policy 2013 encourages waste management through reuse, recycling and recovery of recyclable materials, the ban on single use plastics through Gazette Notice No. 4858 of 2019 and related

products poses a risk to plastic circular economy and investment in recycling infrastructure in the country as inputs materials may not be available in the long-run. Other legislations such as the EMCA (Plastic bag control and management regulations) focused only on plastic flat bags (polythene), leaving other plastic categories and products completely out in the regulation.

While the EMCA (EPR, 2021) regulations introduce extended producer responsibility (EPR) scheme for packaging materials and products to reduce pollution and environmental impacts, existing laws do not specifically give requirements for the set-up of such schemes. EPR calls the post-consumer collection and take back scheme system, including the deposit refund system which does not give adequate details on how such schemes will be implemented. In addition, public awareness on this regulation remains largely insufficient.

Despite waste management being the responsibility of the counties, most of the counties still lag in developing legislations and policies on waste management, including laws on plastics. Based on our review, only a handful of counties have developed these regulatory frameworks on solid waste; these include Nairobi County Plastic Control Act 2016, and Kericho County Environment Management Act, 2021. Mombasa County has developed both a policy and a law on Solid Waste Management (Mombasa County Solid Waste Management Policy, 2019 and Mombasa County Solid Waste Management Bill, 2021).

Most legislations that entities to establish and operationalize material recovery facilities such as segregation and recycling plants are largely prescriptive and do not provide details on how such facilities will be set up, and regulations on the same are also scanty.

4.3 Enhancing Plastic Circularity using Technology

A transition towards a circular economy in plastic waste management requires innovation and application of new technologies. Technology application should provide a fundamental basis to rethink plastics manufacturing and packaging, envisioning a more effective system to achieve better economic and environmental outcomes.

In Kenya, plastic waste management has taken shape as local innovators are embracing technology to convert plastic waste into useful products, leading to generation of revenue.

Plastic waste management recovery in Kenya is done mechanically. When analyzing activities along the plastic value chain, most technological applications happen after the wastes are collected and sorted according to their chemical

characteristics and color. The study was able to identify technologies used along the value chain and how they are used to support plastic waste management in Kenya along the plastic value chain. The technologies identified were pelletizer, grinder, digital solutions (mobile apps) and GPS.

4.3.1 Use

This stage is where the consumers get to decide how to utilize and use the product. Technologies that are applicable here are the digital-enabled solutions such as mobile Apps that help drive and influence consumer behaviour. The messages in the apps educate people on the importance of product circularity, buying eco-friendly products and buying recycled products. The study was not able to identify any technology that is being used at the moment under this stage.

4.3.2 Disposal

This stage is the most crucial one in a circular economy because it is where the problem starts. After the end-life of a product and its value is deemed to have ended, it is then discarded. Most solid waste in Kenya from residential, offices and hospitals end up in open dumpsites, ocean, or litter around in the environment. The wastes are collected by trucks and other informal pickers and are then disposed. The study could not identify a technology that is applicable at this stage of the value chain.

4.3.3 Collection

To achieve a higher recycling rate needs improvement of technologies used in collection schemes and sorting. Digital solution technologies such as mobile Apps help in driving positive behavioural change and increase organizations access to plastic wastes (GSMA Climatic Tech report, 2021). In Kenya, plastic waste management firms such as Mr Green Africa, which is one of recycling companies in Africa, has leveraged on mobile-app technology in its collection process by integrating informal waste collectors, consumers, and entrepreneurs into the value chain. They create profiles of their informal collectors and update the amount of recyclable plastic they deliver and make payment online. This increases the amount of plastic waste that Mr Green Africa collects and at the same time all stakeholders get a fair share of income and benefits. Mr Green Africa converts the collected plastic wastes into post-consumer recyclates to replace virgin plastics that are imported. They also export the pellets outside Kenya, which is used in manufacturing processes. Other actors have lorries installed with GPS so help

them determine their location, such as the Takataka Solution, as this enhances the speed of monitoring waste collection.

4.3.4 Recycling

The major technological methods employed at recycling stage are mechanical in nature using a pelletizer and a grinder to break the plastic wastes into small pellets that are then washed to remove contamination. Such plastic materials that are recovered this way are high-density polyethylene (HDPE) and polyethylene terephthalate (PET). Most industries in Kenya involved in the recycling of plastics use this method. Chemical recycling incorporates technologies such as gasification, hydro-cracking, depolymerization and pyrolysis. Here, the chemical structure of the plastic is changed by breaking the long hydrocarbon chains in the plastics into fractions of hydrocarbons that are shorter using catalytic or thermal processes. The short polymers produced are used to manufacture recycled plastic materials.

Some of the actors who have invested in recycling technology is Gjenge Makers Limited, a company in Kenya that converts plastic wastes into alternative and affordable building materials that are used to make pavements. The flooring exterior material combines plastics and concrete and they source their materials from post-consumer plastics and industry. Other products produced by the company include construction posts and building blocks developed from recycled plastic waste.

Takataka Solutions is another waste management company that deals with waste collection, sorting, recycling, and composting. It collects wastes from residential houses, offices, restaurants, and hospitals then takes waste to their various sorting plants where they are sorted further. The sorted plastic wastes are then washed and grinded into pellets using a specialized machine. The high value pellets are sold to local manufacturing industries, who use it to make other plastic products.

The findings on technology indicate that most of the technology is applied at the collection and recycling stage along the value chain. The other stages along the value chain that include design, and production did not register use of technology. Most waste sorting is done manually by pickers who then sell it to collectors to sort the plastics further, wash it then sell to the firms who do the grinding.

4.4 Best Global Practices in Plastic Technology

Plastic is becoming a global problem as human population increases and so is the production of plastics. Most countries that are doing well in plastic waste management are employing good technologies to help tackle the challenge

of plastic waste management. GSMA, in their report, noted that embracing technologies such as mobile payments, artificial intelligence and mobile Apps plays a critical role increasing transparency and improving the engagement of citizens in recycling. It helps in increasing efficiencies in operations along the plastic value chain (GSMA Climatic Tech report 2021). Along the plastic value chain, this technology is applicable for disposal, segregation, reuse, and recycling stages. Frontier technologies such as AI and Internet of Things can be used in bin monitoring, weighing, and automating plastic segregation. The third technology in play is online portals and mobile-based tools that can be used to connect all actors along the supply chain.

Nordsense, a tech company in Denmark, develops smart sensors for waste bins to help improve the way waste is being collected. The small sensor fixed on the waste containers helps measure fill levels and allows real time surveillance of the bins. Drivers can login and navigate to where the bins are. In San Francisco, the use of this technology led to 80 per cent decrease in overflowing of bins, 66 per cent decrease in street cleaning service request, and 64 per cent decrease in illegal dumping (Plastic Smart Cities, 2022).

In addition, Recykal has adopted technology to connect all stakeholders along the value chain, including waste generators, collectors and recyclers seeking to increase collection and recycling rates by merging the informal and formal waste sectors into the value chain. It is currently operational in India.

A UK-based developer has introduced a Catalytic Hydrothermal Reactor using steam subjected to high temperatures and pressure that is able to convert plastics back into their initial chemical form. The steam is used to break down the long hydrocarbon chains in plastics into short hydrocarbons. The steam produced is used to cut the long hydrocarbons into short hydrocarbon chains of plastic products. The end products are used to make new virgin plastics and other materials. The important thing about this technology in plastic waste circularity is that its sustainable and can recycle plastics that have been considered unrecyclable, and that are currently incinerated. Examples are trays, pots, tubs, and other packaging's currently used. Application of this technology will help in supporting the circular economy of plastics and in the long-run lead to a closed loop in plastics.

5. Conclusion and Policy Recommendations

5.1 Conclusion

Kenya has made significant progress in waste management through enactment of legislations and policies, the most recent being the National Sustainable Waste Management Act 2022, the National Sustainable Waste Management Policy, 2021 and the Extended Producer Responsibility (2021) Regulations, which are calling for more sustainable waste management by transitioning the country from the business-as-usual take-make-dispose to the circular economy. Plastic circularity along the value chain seems to be fully addressed in most of these policies but reference to plastics waste management seems fragmented. In addition, while counties are supposed to enact laws and policies around waste management, most of them still lag in realization of these regulatory frameworks.

The dominant technology in Kenya that is used is mechanical, which incorporates processes such as sorting, grinding, washing, drying and granulation. The specific technologies identified along the value chain are pelletizer, grinder, digital solutions (mobile Apps) and GPS applications. Application of these technologies is mostly on collection and recycling, and this leaves the other stages such as design, production and disposal operated manually by informal pickers in the country. This means that to achieve a closed loop to support the circular economy, the technology has to address all stages in the value chain.

Kenya has the potential to transforms its economy through plastic circularity by aligning its policies and legislations around plastics, both at the National government and County government levels.

5.2 Recommendations

(i) Fast-tracking development of Plastic Circular Economy Policy and bill as espoused in MTP III (2018-2022) to contribute to economic transformation of the country.

(ii) Harmonization of waste management legislations and polices that address plastic circularity along the value chain to have a comprehensive and wholistic approach to plastic waste management.

(iii) County Governments, being a lead entity in implementation of waste management in the country, need to develop legislations and policies in waste management, including in plastic circular economy along the value chain.

(iv) Regulatory agencies in collaboration with counties could create public

awareness on plastic waste management and the use of the secondary products and its contribution to the economy through media and campaigns.

(v) Fast-track implementation of Extended Producer Responsibility (EPR) regulations by the relevant stakeholders such as ministries within the National government, counties, non-governmental organizations, manufacturers and private sector.

(vi) Both the National and the County governments to re-introduce incentives for plastic recycling, such as zero tax on imported technologies, including machinery and equipment for recycling, material recovery infrastructure for companies and businesses involved in plastic circularity along the value chain. This would encourage new investment in plastic circular economy in the country, create more jobs and reduce on the impacts of wastes on the environmental health in line with the Sustainable Development Goal No. 12.

(vii) Waste collectors to leverage on technologies that use sensor detectors in waste bins to help in segregation and collection of wastes. The bins have sensors installed, such as they can monitor the level fills and can be monitored in real time.

(viii) To transition to a circular economy needs application of technologies that support the whole plastic value chain. Therefore, all actors in plastic waste management could invest in technologies that start from design to the recycling level.

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Appendix

Appendix Table 3.1: Mapping of regulatory frameworks along plastic value chain

Legal and policy frameworks/Value chain	Design	Production	Product Use	Disposal	Collection	Segregation and sorting	Reuse	Recycling
Sustainable Waste Management Act, 2022				√	√	√	√	√
Draft EMCA Bill, 2021		√	√		√			
EMCA (1999)				√		√	√	√
EMCA (Extended Producer Responsibility)	√		√	√	√			√
EMCA (Plastic ban control & management regulations, 2018)					√			√
Kenya Vision 2030 (MTPIII) 2018-2022						√	√	√
Kericho County Environmental Management Act, 2021				√	√	√	√	√
Nairobi County Plastic Control Act, 2016				√	√	√	√	√
National Sustainable Waste Management Policy, 2021	√	√		√	√	√	√	√
National Environmental Policy, 2013			√				√	√
National Solid Waste Management Strategy, 2015				√	√	√	√	√
Kenya Environment Sanitation and Hygiene Policy			√			√		
National Climate Change Action Plan (2018-2022)				√	√			√
Green Economy Strategy and Implementation Plan (GESIP 2016-2030)				√	√	√		√

NB: The tick represents where the policy, legislations and regulations apply in the plastic value chain

Appendix Table 3.2: Technologies used in plastic waste management

Technology in Kenya	Design	Production	Use	Disposal	Collection	Segregation	Recycling
Pelletizer							√
Grinder							√
Digital solutions (Mobile APP)-ZiwaSafi App in Kisumu√√			√		√		
GPS (Taka taka solutions)					√		
Technologies in other countries							
Remote sensing					√		
Smart sensor waste bin (Nodsense)				√		√	
Digital Solution (Recykal)					√	√	

NB: The tick represents where the technologies apply in plastic value chain

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Single use plastic banned

- Cotton buds
- Cutlery, plates, straws and stirrers
- Sticks for balloons and balloons
- Food containers (some fractions of plastic polymer)
- Cups for beverages (some fractions of plastic polymer)
- Beverage containers (PET bottles)
- Cigarette butts
- Bags
- Crips packets, sweet wrappers, bread bags and confectionery wrappers
- Wet wipes and sanitary items.

Appendix Table 3.4: Plastic polymers characterization

Type of plastic	Example of plastic waste materials	Recycling and reuse potential
1. PET	Food packaging, plastic soft drink and water bottles, detergent bottles	Recycled and reused
2. HDPE	Milk bottles, shampoo bottles, detergent bottles, oil jerry cans, and toys	Reusable and recyclable
3. PVC	Electric and plumbing pipes and floor carpets	Recyclable, not reusable
4. LDPE	Bread bags, frozen food bags, squeezable bottles, fibre, bottles, clothing, furniture, carpet shrink wraps and garment bags	Reusable but rarely recyclable
5. Polypropylene	Margarine and yogurt containers, caps for containers	Reusable but rarely recyclable

6. Polystyrene	Egg cartons, fast food trays, and disposable plastic silverware	Reusable but rarely recyclable
7. Others	These include items made with a resin other than the six listed above or a combination of different resins	Not recyclable or reusable

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