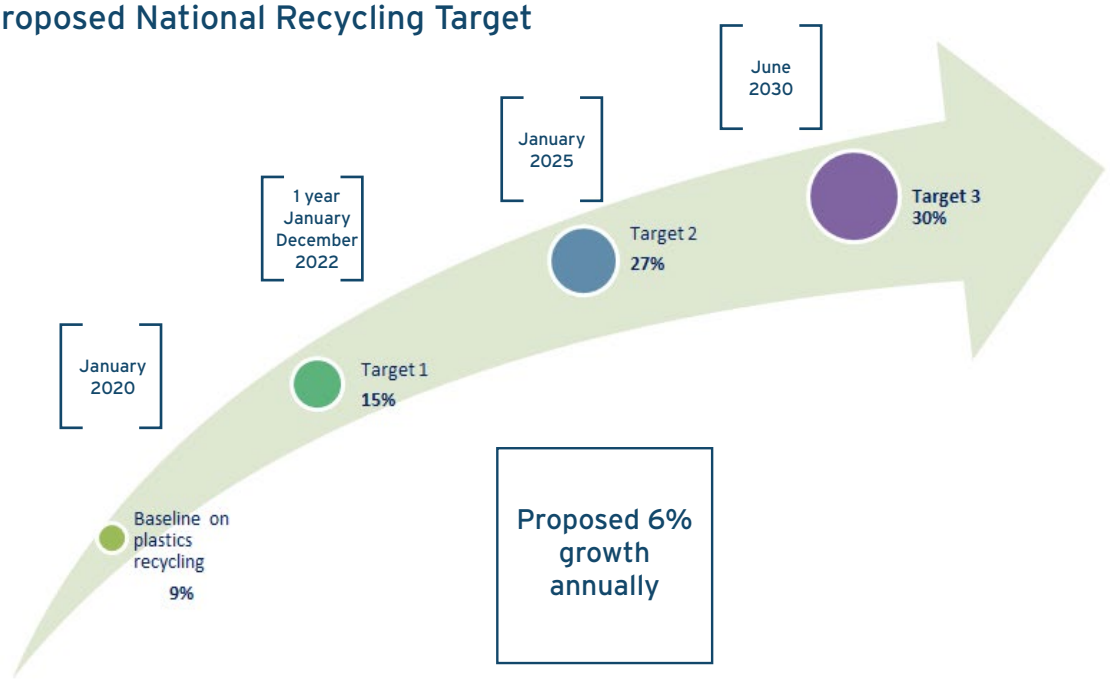
KENYA ASSOCIATION OF MANUFACTURERS
Driving Global Competitiveness
60 YEARS
OF ADDING VALUE

Kenya Plastic Action Plan

Accelerating a Circular Economy in Kenya

November 2019

a) Proposed National Recycling Target



b) Three Year Plan to operationalize producer responsibility organizations for all plastics stream

Operationalize a pilot project jointly between industry and Government in order to develop a sound Plastic Producer Responsibility Organisation

- Setting plastic mass flow data and recycling targets
- raising awareness
- integrating informal sector
- reporting to measure goal progress.

Policy, legal frameworks and measures established to support;

EPR scheme/ Producer Responsibility Organization (PRO)

Incentives to create an enabling environment for waste recycling

National and County coordination on waste management

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Definition of terms

Bio- based plastics	Plastics which are manufactured from renewable sources; for instance sugar cane (as opposed to fossil-based plastics, which are derived from fossil fuels). The term bio-based doesn't necessarily imply bio-degradability.
Biodegradable plastics	Plastics which can be degraded or composted by microorganisms under specific, environmental conditions. Biodegradable plastics can be made both of bio-based as well as fossil-based plastics.
Circular economy	The circular economy is defined as an economic model in which resources like plastics are used more efficiently through the three guiding principles of "reduce, reuse and recycle" to close the loop. Shifting to such a system has economical as well as social and environmental benefits through reduced import dependency, employment creation, reduced littering, less resource extraction as well as improved human health conditions.
Deposit-refund system (DRS)	A surcharge which is placed on certain products and containers by manufacturers. When consumers return quantities of these containers or products, the surcharge is refunded.
Disposal	Refers to any operation which is not defined as recovery; this also applies if the operation later results in a secondary consequence for the reclamation of substances or energy.
Energy recovery	A process in which energy (heat, electricity, fuel) is generated from the primary treatment of waste. The most common implementation is incineration. It is not material recycling.
Extended producer responsibility (EPR)	An environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle, i.e. when a product turns into waste. Already during the production and sale (and export), producers are responsible for disposal of their packaging. Producers/importers pay a fee for later disposal of the packaging (before) when their packed goods are placed on the market. The contribution/ fee is used for collecting, recycling and disposing of the packaging waste and other costs arising from maintaining the system. It is not used as a contribution to the general public budget of a state.
Feedstock recycling	The process of breaking down collected plastics into monomers and other basic chemical elements. These monomers can be used as virgin material alternatives in manufacturing new polymers. Particularly interesting for plastics which are difficult to recycle – due to their low quality, composite nature or low economic value.
Free riders	Producers/manufacturers and importers that enjoy the benefits of the EPR system without paying the corresponding fees, including those that under-declare their volumes.
Material recycling	Describes a recycling process in which waste materials are mechanically reprocessed into products, materials or substances with equivalent properties – also referred to as closed-loop recycling – or a product which requires lower properties.
Manufacturer / converter	Companies which produce plastic packaging or plastic items by converting raw material.
Landfill	A location where most generated municipal solid waste is disposed. In the Kenyan context, there are no sanitary landfills that include proper ecological precautionary measures like wastewater treatment or landfill sealing. In many cases, it cannot be distinguished whether the disposal site is a landfill or dumpsite.

Life cycle analysis	Life cycle analysis (also called Life-cycle assessment or LCA) is a technique to assess environmental impacts associated with all the stages of a product's lifespan (from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, to disposal or recycling).
Obliged companies	Companies which are obliged to pay a fee within a running EPR system.
Oxo-fragmentable plastics	Plastics which quickly fragment into micro-particles in the presence of warmth, light and oxygen but do not degrade in the environment, thereby becoming a source of environmental pollution in the form of microplastic.
Packaging	The materials in which a product is wrapped or covered in to protect it before being sold or transported.
(Packaging) user	Companies that use packaging for their products when placed on the market. In literature, often referred to as "producer" instead of "user".
(Packaging) filler	Companies that fill empty packaging with their products before placed on the market.
Polluter pays principle	The waste producer or owner is the potential polluter and carries responsibility (including financially). The "polluter pays" principle creates the necessary incentives for environmentally-friendly conduct and the required investment.
Producer	See "(Packaging) user".
Waste prevention	Measures taken before a substance, material or product has become waste, which reduces quantities of waste and also includes re-use of products and the extension of the lifespan of products. Also reduces amounts of hazardous substances being used and the adverse impacts of the generated waste on the environment and human health.
Producer responsibility organisation (PRO)	The central element for the organisation of all tasks associated with the EPR system. Allows producers/users to assume responsibility by combining their efforts and jointly managing the arising waste through collective responsibility. The PRO is the most important stakeholder (organisation) and is responsible for setting up, developing and maintaining the system as well as the take-back obligations of the obliged companies.
Recovery	Describes any operation in which waste serves a useful purpose by replacing other materials or using its material properties (includes preparation for reuse, recycling as material or feedstock recycling and energyrecovery).
Recyclables	Materials that still have useful physical or chemical properties after serving their original purpose and therefore can be re-manufactured. Some are of positive economic value as well (e.g. rigid PE, PET bottles).
Recyclates	A product which has passed through a life cycle and subsequently a recycling process, which means it is made from used materials (e.g. plastic regranules).
Recycler	Companies that recycle pre-processed waste streams (e.g. sorted rigid PE plastics) by washing, flaking, agglomerating and regranulating. With these actions, an economically marketable output product is reached.
Reducing	The practice of using less material and energy to minimize quantities of generated waste and preserve natural resources. Includes ways to prevent materials from becoming waste before they reach the recycling state. Also includes re-using products.

Definition of terms

Re-use	The repeated use of a product in the same form for the same or a different purpose. In this case, the product does not become waste.
Rigid plastics items	Plastic items that are stable in form, e.g. PET-bottles, PP cups, plastic pipes (in contrast to flexible plastic items such as film).
Single-use plastics products	Are used only once and then thrown away, includes items like plastic cutlery, straws or coffee stirrers.
Solid waste management (SWM)	The storage, collection, transportation and disposal of solid wastes. Also describes a practice by which several waste management techniques are used to manage and dispose of specific components of solid waste. Waste management techniques include avoidance, reduction, reuse, recycling, recovery and disposal.
Source separation	The segregation of specific materials at the source for separate collection.
Waste hierarchy	Describes a ranking of waste management options according to what is best for the environment. It gives top priority to waste prevention; if waste is generated, the priorities lie within preparing for re-use, then recycling, then recovery and lastly for final disposal.
Waste management	The term waste management discribes characteristic activities include (a) collection, transport, treatment and disposal of waste, (b) control, monitoring and regulation of the production, collection, transport, treatment and disposal of waste and (c) prevention of waste production through in-process modifications, reuse and recycling.

Abbreviations & Acronyms

BMO	Business Membership Organization
CGK	Clean Green Kenya
DRS	Deposit Refund System
EMF	Ellen MacArthur Foundation
EOL	End-of-Life
EPR	Extended Producer Responsibility
EPS	Expanded Polystyrene
GWP	Global Warming Potential
HDPE	High Density Polyethylene
JICA	Japan International Cooperation Agency
KAM	Kenya Association of Manufacturers
KEBS	Kenya Bureau of Standards
KEPSA	Kenya Private Sector Alliance
KPAP	Kenya Plastic Action Plan
LCA	Life Cycle Analysis
LDPE	Low density Polyethylene
MSW	Municipal Solid Waste
NGO	Non-Governmental Organisation
NRED	Non-Renewable Energy Demand
OECD	Organization for Economic Co-operation and Development
PE	Polyethylene
PET	Polyethylene Terephthalate
PP	Polypropylene
PRO	Producer Responsibility Organisation
PS	Polystyrene
PVC	Polyvinyl Chloride
SDGs	Sustainable Development Goals
SUP	Single Use Plastic
TOC	Total Organic Carbon
WEEE	Waste Electrical and Electronic Equipment

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Foreword

Waste is a fact of human life. How we handle it, either depletes us of our most critical natural resources; or, restores, regenerates and enhances our humanity.

As the world's dynamism continues, time is of the essence. Nothing in the world will stop long enough to allow us to come up with the greatest, most perfect solution, to any problem, let alone one as complex as that of waste. It is upon us to act fast, turn this ship with innovative agile thinking, collaborative efforts and, a zeal to create a better world.

The Kenya Plastics Action Plan is a giant step by the country to arrest the problem of plastic waste management, turning it into an environmental and economic solution. This private-sector led initiative aims to be a catalyst for the establishment of more long-term, progressive and revolutionary measures to tackle waste management holistically.

As we begin this journey, we need to enhance the collaborative frameworks that have brought us to this point, by bringing onboard actors that will ensure that the spirit of this initiative is centered in the national development discourse for the short-term and long-term. For instance, how do we make the environment a critical part of our national consciousness, so that the ethos of every home, school, institution and business in the country is anchored on leaving the planet, better than we found it? How can we ensure that everyone sees environmental restoration as a personal, institutional and organizational responsibility? How do we ensure a shared vision by all?

The Kenya Plastics Action Plan, with all its main actors that is, Industry and Government, has started to piece together the answers to the questions above at a primary level. It paints a roadmap towards realizing a Circular Economy for plastic use and waste management in the country. It looks at the formation and regulation of Extended Producer Responsibility schemes and establishment of re-cycling value chains and standards.

As we do this we are conscious that we have just started to lay the foundation for something bigger. In doing this we must we must equip ourselves with innovation, technology, progressive regulations and policies, to continue to advance the solutions in step with the needs of our country, and the world.

I speak for the Association in saying that we are committed, and are at the forefront of driving the establishment of a circular economy, towards sustainably managing waste, and conserving and restoring our environment.

Sachen Gudka
KAM Chairman

Executive Summary

Context

The government, through the Ministry of Environment and Forestry, has shown a strong commitment to stop the pollution of the environment which is particularly worsened by poor plastics waste management. This commitment is marked by the ban on the use, importation and manufacture of plastic carrier bags for both commercial and household packaging. Following the ban, the National Environment Management Authority (NEMA) pronounced its intentions to extend the ban to plastic bottles. However, the Ministry of Environment and Forestry has indicated their desire to encourage manufacturers to develop plans to recycle plastic bottles.

The private sector, through the Kenya Association of Manufacturers (KAM), embraced the initiative to come up with substantial solutions to come up with substantial solutions to curb plastic waste and to tackle management gaps and other challenges faced by the sector. The Kenya Plastic Action Plan is a private sector-driven initiative, with the aim to involve policy makers, the general public and the industry itself in safeguarding a clean environment and together to pave pathway to a green economy in Kenya.

The Kenya Plastic Action Plan written to foster concepts of circular economy, to the benefit of both the environment and the people. It proposes the creation of a model of Extended Producer Responsibility (EPR), as implemented successfully in many places all over the world. The EPR model establishes an intermediary organization, the Producer Responsibility Organization (PRO), that is financed by mandatory membership of all companies that utilize plastics for packaging within the Kenyan market. It utilizes the collective funds to operationalize waste management strategies which ensure that plastic waste is managed appropriately – with the goal of maximizing the recycling rate moving towards a circular economy.

Currently, the waste management structures fail to address the magnitude of the waste problem in Kenya, both in rural and in urban areas. In the capital region of Nairobi, roughly a fifth of the solid waste of around 3,000 metric tons per day is recovered for recycling. Around four fifths of the waste volumes are littered on the streets – eventually entering water bodies – burnt onsite or disposed of at dumpsites. Existing dumpsites and landfills have by far exceeded their capacities to safely dispose of the waste volumes, thereby degrading the environment and adversely affecting human health. Fuelled by rapid urbanisation and changing consumer patterns towards more packaged goods, the challenges are only going to increase.

The Kenya Plastic Action Plan outlines measures and proposes concrete actions for all stakeholders to overcome existing waste management problems. Taking the best examples worldwide into consideration and building on existing value chains and pioneering actors within the country, the measures not only target improvements towards a clean and healthy environment, but also showcase how the circular economy can contribute to economic growth and welfare. All plastics that are consumed and processed in Kenya are imported one way or the other. Therefore, the responsibility to manage them properly must be taken jointly by all entities putting plastics on the market, including both local and international companies.

Objective of the Study

By building an understanding of the Kenyan context regarding waste management, including existing legal and regulatory framework, the Kenya Plastic Action Plan provides in-depth research into the Kenyan plastics sector. It incorporates the entire plastics value chain, spanning from imports of raw material to manufacturing processes to uses and subsequent recycling of different plastic fractions.

The study followed a qualitative approach and included a literature review, online questionnaire, face to face interviews throughout the whole country, focus group discussions and a stakeholders' forum. All findings are supported by the extensive local and international experience of the consultancy consortium. Thus, the Kenya Plastic Action Plan aims to document local plastics waste management practices, highlight global best practices for extended producer responsibility as well as sketch a unified private sector position on an Action Plan specific to the Kenyan context. Most importantly, this report is meant to inform the development of a suitable and sustainable policy framework on plastics in Kenya.

Summary of strengths, weaknesses, threats and opportunities for private sector engagement in tackling waste management challenges

Strengths	Weaknesses
• Private sector commitment to manage plastic waste • Strong support for need an EPR expressed by public and private sector • Functioning recycling value chains for certain plastics • Product design decisions made within the country • Most consumer products processed domestically	• Plastic waste spread throughout the country • Practically no tradition of waste segregation • Slow growth in formalized waste collection • Insufficient waste management infrastructure • Gaps in regulations and laws on plastics waste management
Opportunities	**Threats**
• Government tax incentives to investors into plastic recycling (15% Corporate Tax for investor operating a plastic recycling plant for the first 5 years and VAT Exemption on services offered to plastic recycling plants and supply of machinery and equipment used in the construction of the plants • Rising awareness among the population on plastic waste management • Affordable labour cost and high need for employment particularly on recycling sector • Improvement on International standards on plastic manufacturer and waste management	• Unpredictable legislative framework to plastics waste management in the country • Disjointed efforts in management of plastics wastes by various stakeholders in the Industry • Voluntary measures on plastic waste management which in most cases may fail to deliver results • Market highly price competitive

Key Findings

The research revealed that the regulatory framework concerning plastics in Kenya is currently under intense development. Tax incentives discussed by the National Government showcase, among other examples, the commitment of the public sector to improve on private sector engagement in Kenya's waste management. Yet, within the given framework, existing recycling companies have shown to be unable to sufficiently meet the requirements for proper plastic waste management. Three areas have been identified as suitable for legislative and regulative intervention.

1) Recycling infrastructure – consisting of grassroots businesses as well as formal enterprises – exists within the whole country. Visionary enterprises and committed individuals offer an opportunity to play a significant role, also in the further development of a stringent framework. As the sector progresses and redefines itself, informal players – who played a significant role in the successes that have come about so far – need to be incorporated as well.
2) Awareness campaigns amongst citizens need to be further developed. This will ensure that all citizens, no matter their social and economic status, are able to embrace better waste management and adapt behaviour accordingly. Particular focus needs to be placed on better segregation practices at source, reducing waste generation and enhancing recyclability. Therefore, the need for environmental protection education needs to be instilled from an early age onwards.
3) The evident challenges of existing waste management practices in Kenya require immediate action. With a strong private sector dedicated to taking this action, Kenya is in a position to implement the needed changes through coordinated action from both the public and private sector. The key element is the setup of an Extended Producer Responsibility (EPR) framework.

Proposed Measures

In order to tackle the challenges highlighted above, the researchers recommended that:

- An Extended Producer Responsibility (EPR) model led by the private sector should to be set up, with one independent Producer Responsibility Organization (PRO) as its focal actor.
- The Government should support the private sector to take responsibility for managing plastic waste. The PRO should therefore be a private sector entity enshrined in an appropriate regulatory and legislative surrounding.
- Membership of the PRO should be compulsory by law – for all companies releasing plastic packaging on to the Kenyan market, be it from imports or domestic production.
- Within the legislative and regulatory framework, provisions should be set to support the circular economy. This may include tax incentives as well as set quota for recycling and/ or disposal.
- PRO members should pay a fee based on the volume and type of plastics they use. This fee covers the associated waste management costs.
- Non-members of the PRO such as informal businesses, should participate in waste management by being surcharged at the last interface with the formal sector, e.g. when liaising with the raw material supplier.
- The PRO collaborates with waste management operators in building incentives in order to achieve certain collection and recycling quotas.
- Existing waste management structures, including the informal sector, are involved from the beginning and need to scale up to increase their role in the growing circular economy.
- The PRO builds a forum connecting all involved stakeholders – government, importers, manufacturers, distributors, consumers, collectors, aggregators, recyclers, converters, etc.
- Activities of the PRO should include awareness and capacity building among the general citizen on better waste management practices.

Phyllis Wakiaga
KAM Chief Executive


RAW MATERIALS
DESIGN
PRODUCTION, PROCESSING
DISTRIBUTION
USE, RE-USE, REPAIR
COLLECTION
RECYCLING
CIRCULAR ECONOMY
WASTE REMAINS

1. Introduction

Plastics are one of the most versatile materials of our modern society. Their unique combination of light weight, inert properties and high durability gives them an essential role in most economic sectors such as building and construction, automotives, food and beverages, agriculture, health and pharmaceuticals. Plastics have developed from a material used for niche applications in the first half of the 20th century to an essential and ubiquitous element of our global economy [Plastikatlas, 2019]. Represented in numbers, the global plastics production increased from 2 million mt (metric tonnes) in 1950 to 381 million mt in 2015. Cumulatively, the world had produced 7.8 billion mt of plastics by 2015 [Geyer et al., 2017].

However, concerns about negative impacts caused by increased leakages of plastic waste into our environment are rising globally. Through improper forms of waste handling, which are happening worldwide, plastic waste has become a ubiquitous part of our environment, transported by wind and water to places far off from any human settlement. This accumulation of plastic waste in the environment is highly problematic; not because of aesthetics, but because of the multiple harmful, often lethal consequences for animals, such as entanglement, digestion of plastics and other effects caused by the hundreds of hazardous chemicals found in littered plastic waste [Kühn et al., 2015; Rochman, 2015].

The Kenya Plastic Action Plan proposes measures favouring the implementation of circular economy concepts for the environmentally sustainable use and recycling of plastics in order to catalyse action tailored to Kenyan conditions.

As most of these negative externalities eventually result from a poor, improper and socially as well as environmentally damaging waste management, creating sustainable waste management for plastics is the first logical step to solve this issue. However, as the sustainable use of plastics requires measures throughout the entire value chain, a more holistic approach is the most suitable solution.

Objective of the study

As a means to reduce plastic degradation and pollution in Kenya, the Ministry of Environment & Forestry banned "the use, manufacture and importation of all plastic bags used for commercial and household packaging" in 2017 and proposed to expand this ban to PET bottles. Nevertheless, the Ministry of Environment & Forestry indicated that they would encourage manufacturers to propose plans to recycle as opposed to the potential ban.

Thus the Kenya Association of Manufacturers (KAM), as the representative organisation for manufacturing value, commissioned the present report to document local plastic waste management practices, global best practice on managing plastic waste, as well as to articulate a unified position of the private sector and a "Kenya Plastic Action Plan" and inform the preparation of a suitable and sustainable policy framework on plastics in Kenya. In particular, this Action Plan incorporates policy suggestions and sustainable funding mechanisms to enable circular economy concepts for the environmentally sustainable use and recycling of plastics in Kenya. Therefore, the plan pursues three main goals:

i) To offer inclusive and broad stakeholder engagement,
ii) To propose policy recommendations to catalyse the transition towards a circular economy on all governmental levels, and
iii) To deliver achievable and relevant actions leading to tangible results of reduced environmental pollution, increased investment and more effective circular economy financing mechanisms.

Methodology

To address this objective systemically, a qualitative case study methodology is used to explore the current situation and its possibilities from several possible angles. This approach allows us to understand an individual case and its respective problems.. Thus, literature research, an online questionnaire (see annex 8.7) and face to face interviews are chosen as suitable methods. Together, they serve to triangulate the information needed.

As a first step, a literature review was undertaken to gain familiarity with the contextually relevant legal and regulatory frameworks, as well as conditions and practices of plastic waste management in Kenya and other selected countries. Special emphasis is given to the distribution of responsibilities between the National Government on the one hand and the devolved functions carried out by the Counties on the other.

Secondly, the theoretical part has been complemented by empirical insights gained from key informant interviews, the focus group discussions and the stakeholders' meeting. The interviews and discussions regarding the effects of the legal and regulatory framework on the plastic sector value chain, the plastic waste management practices as well as opportunities of a circular economy applied to the plastics sector in Kenya (incl. the economic, environmental and social dimension) were conducted through personal meetings by the local partner AHK Services Eastern Africa Ltd. All on-site interviews were attended by two interviewers.

Interviews were conducted in Kisumu, Nakuru, Naivasha, Eldoret, Mombasa and in the Greater Area of Nairobi, which includes Thika/Kiambu and Athi River/ Machakos. In addition to the interviews, two focus group discussions and a stakeholders' meeting covered key informants mainly from the Greater Nairobi area (see Figure 1). The interviewees and participants in the focus group discussions and stakeholders' meeting included players from all levels of the plastics value chain. Additionally, an online survey to gain a more holistic understanding of the plastic mass flow in Kenya was conducted.

The interviews, the focus group discussions and the stakeholders' meeting, together with desk research, form the basis for the Kenya Plastic Action Plan and the proposed policy framework: the local knowledge from the stakeholder interviews allow the Action Plan to be tailored to the present contextual conditions in Kenya. The Action Plan thereby entails an inclusive, holistic and broad private sector-led roadmap approved by the stakeholders across the whole plastics supply chain.

Figure 1 : Locations of on-site interviews

2. Plastic Waste Management Practices

The following chapter briefly introduces plastics as material and its recycling practices. More information on plastic consumption and waste generation on a global scale, with particular reference to different polymer types, can be found within the annexes. Concepts on how to handle plastic recycling effectively within the framework of different circular economy implementations are also outlined there.

2.1 Plastics consumption and waste generation on a global scale

The term 'plastics' describes a huge group of polymers, which form the backbone that enable the creation of various fractions of plastics with very different characteristics for a vast range of applications.

The most commonly used materials for plastic packaging are thermoplastics, a group of diverse materials that melt when heated and harden when cooled in a reversible manner. Polymers of this group are, for instance, polyethylene (PE; widely used in the form of either "low density" = LDPE or "high density = HDPE"), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), and polyethylene terephthalate (PET).

For manufacturing any plastic material, so-called monomers have to be produced through separating the hydrocarbon chemicals from either fossil sources like natural gas, petroleum or coal (called fossil fuel-based plastics or fossil-based plastics) or renewable sources like corn or sugar cane (called bio-based plastics). These monomers form the building blocks for the polymers.

Due to its suitability for a vast range of products, the plastics value chain has become a global network.
Looking at the African continent, the daily plastics consumption generally ranges between 0 to 0.2 kg per person; with South Africa being the only exemption. Kenya's daily plastics consumption is estimated to be 0.03 kg per person (Figure 2), which is at the lower end of the spectrum and roughly represents a tenth of the total municipal solid waste volume [Jambeck et al., 2015].

'Plastics' is an umbrella term for a wide range of different materials with very different properties. They can originate from both fossil-based as well as bio-based sources.

Generally, all plastics consist of polymer chains, which vary in their composition and structure. There are two major groups: the thermoplastics that can be reversibly heated, melted and cooled down, and the thermosets which cannot be re-melted once they have cooled down.

This distinction has important implications for the recycling of plastics.

As plastics are used across all kind of sectors, the plastics economy has become a global business. However, the plastics usage by sector and the plastic waste generation by sector vary significantly, which is rooted in the different in-use phases of the product. As packaging has the shortest in-use phase, it is the biggest contributor to plastic waste.

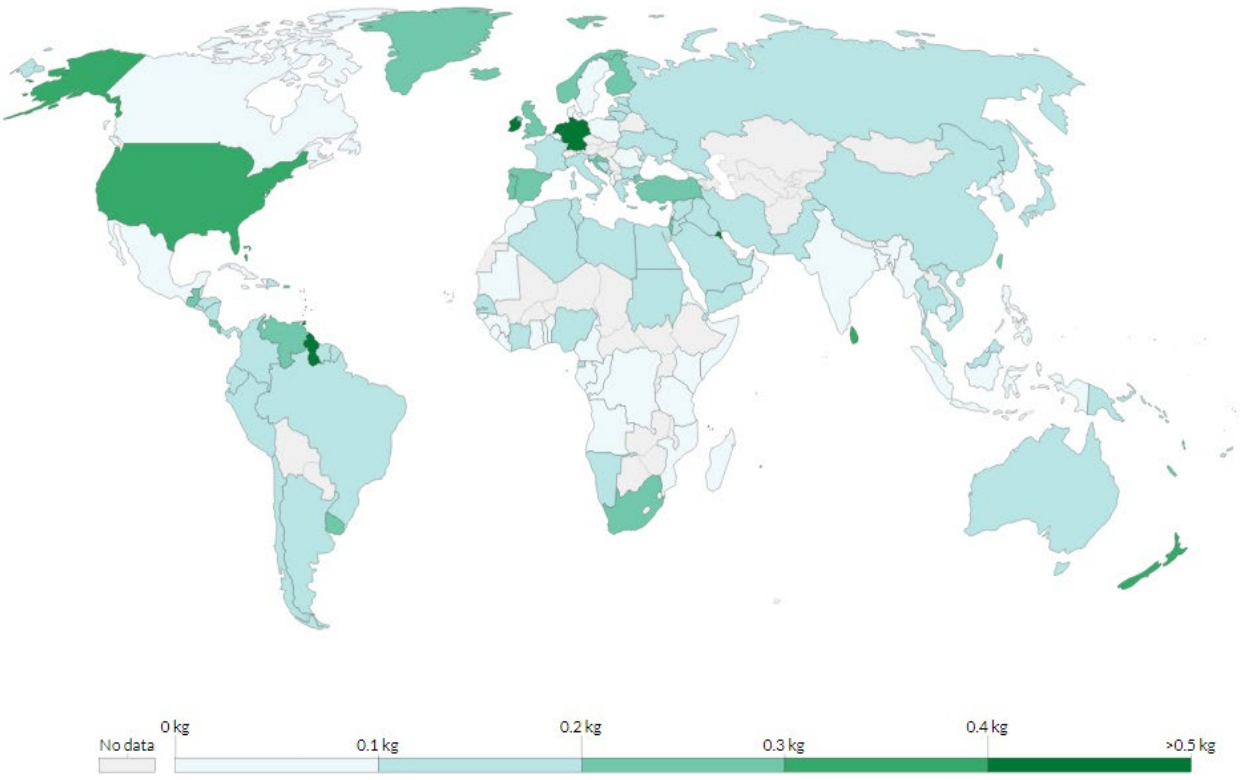

Figure 2: Global plastics consumption per capita per day [Jambeck et al., 2015]

Examining the plastics production on a deeper level by looking at plastics use per sector, the following picture emerges (Figure 3): in 2015, the highest proportion (36 %) of all plastics was manufactured to produce packaging, while building and construction were ranked second with 16 %.

When it comes to plastics, many terms are used in a vague manner. To clarify the following definitions are used in this report:

Plastics products is the umbrella term for any items which consist of one of several plastic types, regardless of purpose, properties and duration of in-use phase. Packaging refers to products made from any materials for the reception, protection, handling, delivery and presentation of goods which may range from raw material to processed product and which are passed on by the manufacturer to the user or consumer.

Single-use plastics (SUP) - often also referred to as disposable plastics - are items which are intended to be used only once before they are thrown away or recycled. This includes plastic packaging such as bottles and containers but is not limited to packaging. Other items are grocery bags, straws, cups and cutlery, among others.

However, plastic production does not directly reflect plastic waste generation, as the waste generation is shaped by the polymer type and the lifetime of the end product (Figure 4). This is why packaging, with its very short 'in-use' phase of, on average, six months, also constitutes the biggest share of waste generation (~47 %). In contrast, building and construction are responsible for 4 % of the generated waste as the average in-use phase is 35 years. Total annual waste generation equals approx. 75 % of the annual plastics production [Geyer et al., 2017].

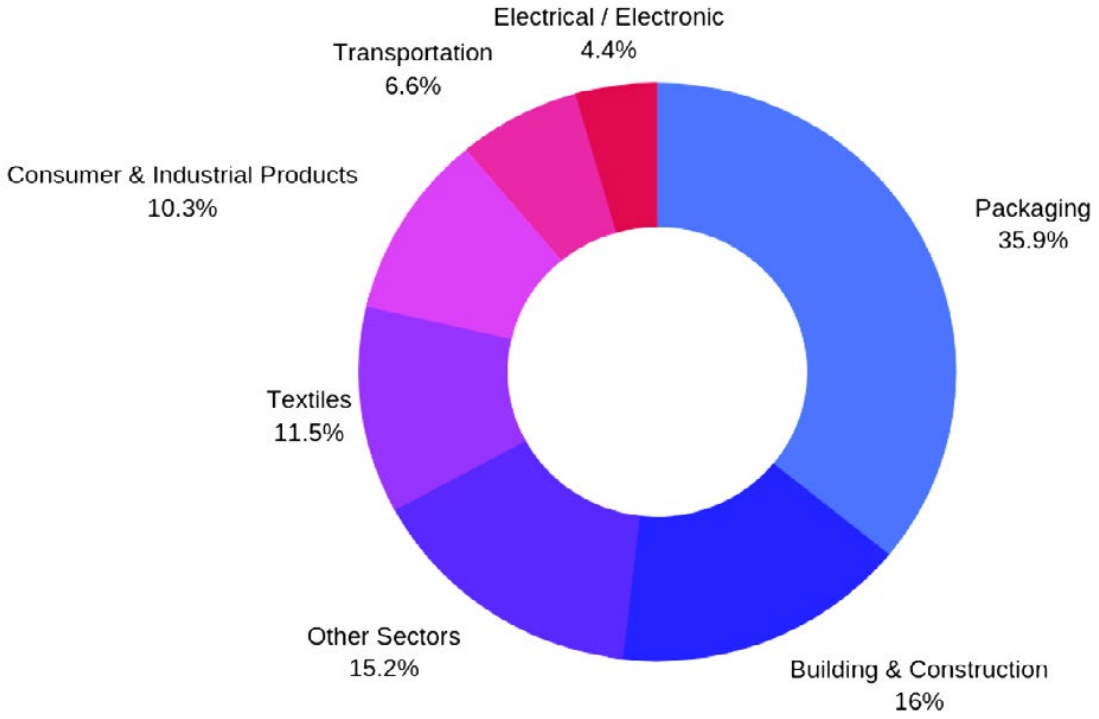

Figure 3: Primary plastics production by industrial sector, 2015, [Geyer et al., 2017]

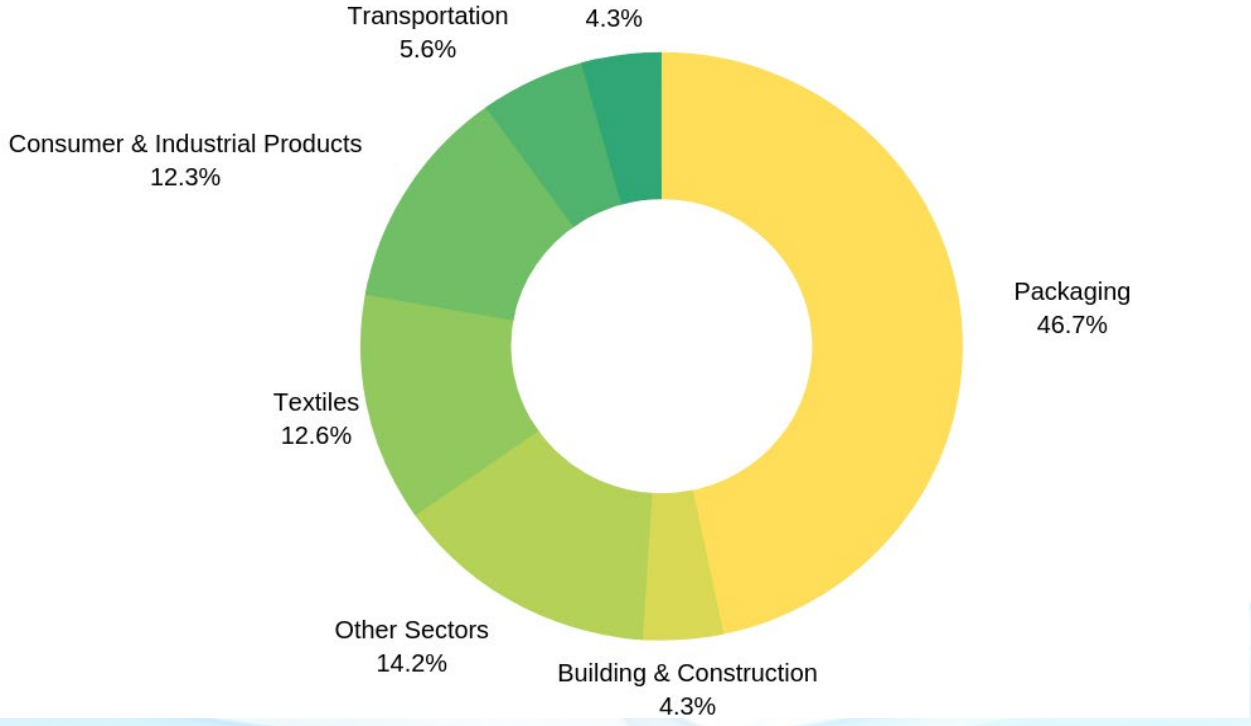

Figure 4: Plastics waste generation by industrial sector, 2015, [Geyer et al., 2017]

2.2 Recycling Plastics

To improve the waste management situation, basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery are a crucial prerequisite for explaining when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products.

The central concept for proper waste management and recycling is the waste hierarchy as anchored in the European Waste Framework Directive (Figure 5): It is a set of priorities for the efficient use of resources and waste treatment listing the most preferred to least preferred option starting with prevention (measure before a product becomes waste), preparation for reuse, recycling, energy recovery, and disposal. The aim of this hierarchy is to ensure that waste management takes place at the highest level possible.

Recycling means any recovery operation by which waste materials are reprocessed into products, materials or substances, whether for their original or other purposes. There are two main types of recycling: material recycling describes recycling processes in which waste is mechanically reprocessed into a product with equivalent or lower properties. Feedstock recycling refers to recycling processes in which the material is transformed into its original building blocks.
Recycling includes the reprocessing of organic material but does not include energy recovery. As recycling is not possible for all plastics waste, energy recovery is still a suitable and appropriate waste treatment. form for many plastics waste items.

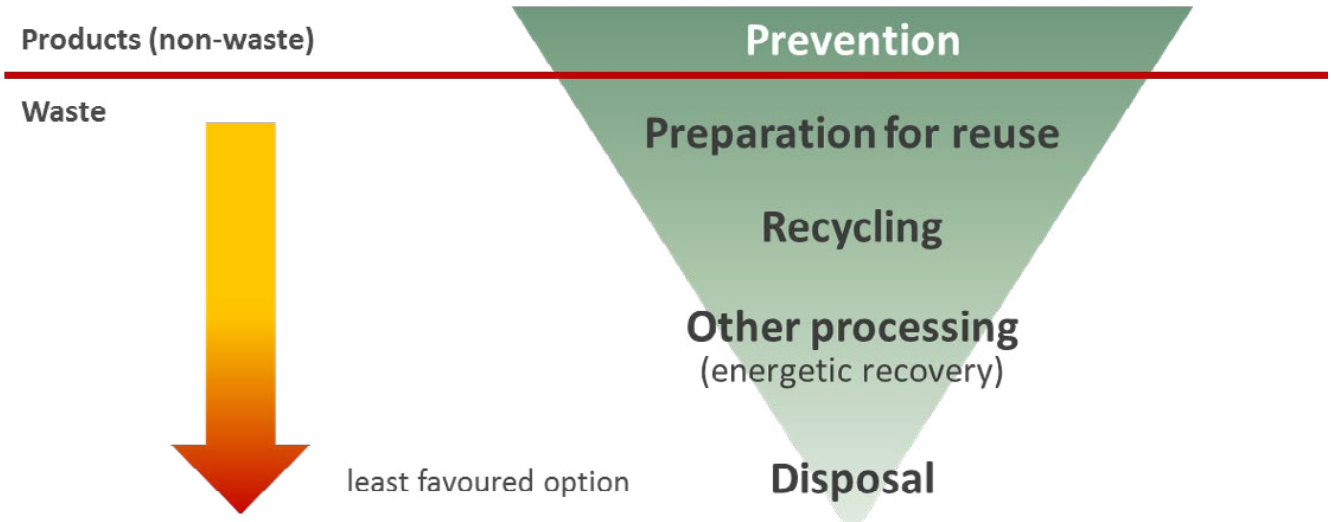

Figure 5: Waste hierarchy

Recycling requires a specific definition, as there are often different definitions across countries and sectors about which processes are considered recycling and which are not. Generally, recycling describes the process of using recovered material to manufacture a new product. This definition can be further differentiated into material and feedstock recycling.

Material recycling describes recycling processes in which waste is mechanically reprocessed into a product with equivalent properties – also referred to as closed-loop recycling – or a product which requires lower properties.

Feedstock recycling describes the de-polymerisation of plastics into their chemical constituents [Hopewell et al., 2019]. Following the definition of the European Waste Framework Directive, energy recovery (sometimes called energy recycling) is not a recycling process.

Recycling plastic polymers is highly dependent on the purity of the waste polymer fractions. Purity refers to the presence of contaminants from other waste materials and other polymer types as many plastic polymers are not suited to creating recyclates.

If a plastics product or good is truly recyclable is eventually determined by two criteria: the compositional quality of the object and the real recycling options after usage. In practice, recycling is only possible if there is corresponding, appropriate infrastructure. Otherwise, the product or packaging is only "ready for recycling". To turn it into a recyclable product or packaging, a comprehensive expansion and further development of collection systems and recycling processes are prerequisites – defining general requirements for a product design. These processes aim at enabling the product to be recycled after use.

Recycling plastics is also emphasised in the EU as a crucial part of its circular economy strategy, which is why the plastic sector and the usage of recyclates fulfil a central role in the transition towards a circular economy. Increasing recyclate usage is rather a 'quality instead of quantity' problem, as the two central problems identified are the

i) difficulty to meet the required quality and
ii) difficulty to have a consistent, reliable supply of high-quality recyclates [EuPC, 2017].

From a circular economy perspective, plastic recycling is recognised as a key concept. However, due to quality problems, it is not yet used to its fullest potential. To overcome this challenge, suitable collection and recycling infrastructure, incentives as well as suitable legal and regulatory frames are needed.

2.3 The Circular Economy Concept

2.3.1 Introduction

The 'circular economy' is a theoretical concept that stands in contrast to currently dominating practices that are described as 'linear economy'. Contrary to the traditional model in which resources are extracted, processed, distributed, consumed, and eventually disposed, the circular economy concept advocates a circulation of resources within the economic system. Instead of disposing of waste, it is reintroduced as a resource into the processing stage, thereby closing the loop. Thus, in a circular economy the material remains circulating within the system [Ghisellini et al., 2015; Wilts, 2016]. According to the Ellen Macarthur Foundation "a circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems" [EMF, 2017a]. Applying elements of the circular economy offers solutions to the current improper plastic waste management and the associated negative externalities.

Due to this circulating character, the circular economy offers a more efficient resource use, which has economic, environmental, and social benefits. The circular economy concept is based on three overarching principles: reduce, reuse, and recycle [Ghisellini et al., 2015; Wilts, 2016]. As the name implies, the reduction principle pursues the maximum reduction of raw material and energy demand. It aims to minimize waste during production processes as well as waste incurring at the point of consumption. The reuse principle describes how products or components of products that are not waste should be reused again, or – if they have turned into waste – should be prepared for reuse [Ghisellini et al., 2015].

The circular economy is defined as an economic model within which resources like plastics are used in a more efficient manner through the three guiding principles of reduce, reuse and recycle to close the loop. Shifting to such a system has economic as well as social and environmental benefits through reduced import dependence, employment creation, reduced litter, less resource extraction and improved human health. Putting the circular economy principle into practice requires measures, which need to be taken at all level of the supply chain. Thus, a good collaboration among the different stakeholder to align measures is crucial.

This offers especially environmental benefits as it decreases the resource demand and in most cases also the energy demand since the product is not newly manufactured [Castellani et al., 2015]. The last principle, the recycle principle, refers to any process in which waste is recovered through reprocessing the material or its chemical constituents, thereby making it available for new manufacturing processes [Ghisellini et al., 2015, Hopewell et al., 2009].

Taking circular economy concepts into consideration has important implications for all steps of the product value chain. The respective measures cover a broader field than just waste management and are operationalised at different scales – ideally done in a complementary fashion (Figure 6). However, this is usually not the case: most initiatives, despite often being promising, remain fragmented and measures across scales are often poorly aligned with each other [WEF, 2016].

Shifting towards circular economy concepts creates more revenue and thereby also more jobs in fields of designing circular products, collecting and sorting, all crucial for reusing and recycling. This requires both high-skilled as well as low-skilled labour.

Figure 6: Circular economy conceptualisation

2.3.2 Plastics in a Circular Economy

As mentioned, plastics as material have become a ubiquitous part or our daily life due to their versatility. However, since littered plastics waste has also become pervasive in our environment, great concerns and discussions about the multiple negative impacts of the improperly managed and littered plastics waste have arisen globally. Shifting towards a circular economy as a response to this current situation would focus on closing the loop by increasing the amount of plastics that are recycled.

Reducing the overall amount of plastics used while increasing the reuse and recycling of the generated plastic quantities are the key elements for transitioning the plastics economy into a circular one.

Putting this into practice requires multiple measures which need to be taken at all steps along the plastics value chain and adopted by multiple actors, for instance Extended Producer Responsibility (EPR) schemes, product designs for enhanced recycling, a well-developed recycling infrastructure, appropriate end-of-life options as well as waste segregation.

Moreover, implementing the circular economy for plastic waste opens the door to increased revenues and employment creation:

- The global plastics recycling market value equalled US$ 31 billion in 2015 and is expected to reach US$ 57 billion worldwide by 2024 [TMR, 2017]. This is estimated to be approx. 8 % of the total plastic market volume, which is expected to be worth US$ 654 billion by 2020, and US$ 721 billion by 2025 (Figure 7) [Grand View Research, 2019a].
- The plastic-to-fuel market is expected to grow significantly in the next years as a response to rising energy demands. Processing waste plastic would offer a suitable solution to respond to the need for fuel while processing the increasing quantities of plastic waste; releasing pressure from the depletion of natural resources [Grand View Research, n.y.].
- In 2018, the global PET recycling market stood at US$ 7 billion and its compound annual growth rate is estimated to be 7.4 % until 2025, resulting in a value of US$ 11 billion. The increasing consumer awareness regarding environmental sustainability is a key driver together with the increase of landfill bans worldwide. Demand for recycled PET is created by several industries such as the textiles industry, consumer goods, automobiles and food and beverage packaging [Grand View Research, 2019b].

Hence, incorporating circular economy concepts will generate more revenue and thereby more jobs in the fields of designing circular products, collecting and sorting; all of which are crucial factors for reusing and recycling. This requires high-skilled as well as low-skilled labour.

Figure 7:

Expected development of the plastic and plastic recycling market

2.3.3 Global Circular Economy Examples

Worldwide, several countries have initiated shifts towards a circular economy to address their waste situation. While their approaches have several similarities, they also exhibit noticeable differences due to the different conditions present in the respective country.

To push circular economy also on a global scale, there are several global commitments driven by both governments as well as private sector initiatives to transit to a waste-free circular plastics economy. More detail on these global practices is presented in annex 8.5.

Belgium 

In Belgium, waste management is a devolved responsibility which is organised at the regional level, putting the three regions Flanders, Wallonia, and Brussels-Capital in charge. In 1996, to ensure a comprehensive packaging waste collection system and a respective EPR system, the three regions jointly agreed on a nationwide packaging law to establish a strong, legal basis. Since then, Belgium has developed an extensive collection system across the country, which is reflected in the high recycling and recovery rates of Belgium, among the highest in the whole European Union (EU) [Eurostat, 2019].

Additionally, to increase recycling rates, Belgium is addressing the issue of a better waste prevention by developing comprehensive plastics waste strategies that contain dedicated policy instruments for waste prevention [EEA, 2019].

The Producer Responsibility Organization (PRO) of the Belgian EPR system is called Fost Plus; it operates as a non-profit organisation. Fost Plus was founded in Belgium as a voluntary initiative of the private sector. Although there are no competitive restrictions, only one PRO has been created so far. Thus, Fost Plus enjoys an operational monopoly. It comprises approximately 5,000 members, each paying participation fees. Today, there is a packaging law that compels every company putting more than 300 kg of household packaging annually on to the Belgian market (for consumption in Belgium) effectively to become members of Fost Plus. Each of these companies is obliged to pay for the collection, sorting, and recycling of packaging that is brought into the market. Fost Plus is responsible for all packaging sales according to specific definitions and publishes a respective criteria catalogue. Fast food packaging and packaging from online sales also fall under this. Aside from the funding of waste management, Fost Plus uses 10 % of its annual budget for education and awareness campaigns focusing on litter.

From a circular economy perspective, the Belgian system is overall running well. The Belgian system started with only separately collected valuables like plastic containers and bottles beside metals. Other packaging like flexibles, films and mixed plastics were collected together with mixed municipal solid waste for later incineration.
Due to the increase of recycling quotas set by the EU, Belgium is now expanding its separate collection to all packaging for subsequent sorting. and recycling.

The results of this system are good in terms of collection, sorting and recycling. However, mixed plastics and foils are not collected within this system throughout most of Belgium. From 2022 onwards, it is planned to expand the system to cover all other packaging materials. By 2022, 90 % of beverage packaging waste generated in the region of Flanders is meant to be collected and recycled. As the next step, by 2023, 65 % of all plastic packaging waste is set to be recycled. By 2030, the government aims to raise the recycling rate to 70 % of all plastics packaging waste. These quantitative targets are laid down in the agreement with the sector [EEA, 2019].

Denmark

In January 2018, the EU introduced its European strategy for plastics including goals to make all plastics packaging recyclable by 2030, to reduce single-use plastics where applicable and to restrict intentional use of micro-plastics. Moreover, binding regulations are planned which oblige manufacturers to use a certain amount of recyclates in their products and obliges Member States to recycle 50 % of their plastic packaging by 2025 and 55 % by 2030.

Despite extensive waste management frameworks in place, the majority of Danish municipal waste is still incinerated. In Denmark, it is assumed that per 1,000 metres of recycled – not incinerated – plastic waste, three to four permanent jobs and an economic value of roughly US$ 900,000 can be created.

The current waste management system in Denmark has a comprehensive waste collection infrastructure. However, according to a study by the Danish Ministry of Environment and Food [2018], the majority of this waste, 63 %, is incinerated while only 36 % of all plastics and only 18 % of all plastics packaging are recycled. Thus, the Danish government introduced their new strategy to transition to a more circular economy and meet the goals set by the EU plastics strategy. In their Action Plan (Figure 8), the Danish government portrays a holistic approach with measures all across the value chain. In particular, they highlight six focus areas and 27 reinforcing action measures in order to transition into a more sustainable, more circular economy. The six focus areas are:

- To strengthen enterprises as a driving force for circular transition
- To support the circular economy through data and digitalisation
- To promote circular economy through design
- To change consumption patterns through circular economy
- To create a proper functioning market for waste and recycled materials
- To increase recycling of material used in buildings and biomass

All stakeholders in the value chain of plastic packaging are included in these actions. To increase recycling of plastics from households, a standardised waste collection is planned, as well as a mandatory EPR system. Also, better plastics waste handling is part of the goal to transition into a more circular economy. Danish companies are encouraged to develop sustainable plastics solutions for design, reuse, recycling, circular business models and recycling technology.

VEmbracing a more circular approach also offers great economic benefits as it is estimated that for every 1,000 mt of recycled plastic waste (which are not incinerated), three to four jobs are created along with additional revenue of 6 million Danish kroner (equalling approx. US$ 900,000). The Danish government has set aside EUR 16 million to implement these initiatives [MFVM, 2018].

Figure 8: The Danish Plastic Action Plan

Chile 

Pushed by an OECD report of 2016 that listed Chile alongside Turkey at the lowest end of OECD member states with regard to recycling quotas, the country has initiated a change towards a circular economy through several measures. One of the key factors driving this change is the establishment of a sound legal basis: in 2016, a long-awaited waste management law entered the congress and has been officially passed as the 'Waste Management, Extended Producer Responsibility and Recycling Incentives Bill' [Ley N°20.920, 2016].

This bill defined clear goals and requirements for several circular economy-based measures. As a central part of the law, Extended Producer Responsibility (EPR) systems for six product categories are defined: tires, packaging, lubricant oils, waste electrical and electronic equipment (WEEE), automotive batteries, and portable batteries.

Through this law, an instrument for producer responsibility was created, obliging the producers of these product categories to create Producer Responsibility Organisations (PROs) or deliver proof of take-back. A corresponding producer register has already been established. This law will gradually start to come into effect, as the specific regulations and targets (collection and recovery rates) are defined and published in the present and coming years [dated June 2019] to tailor them to local conditions. Moreover, most of the Chilean population lives in urban areas, while vast parts of the rural areas are only scarcely populated. As a response to this, waste segregation and collection of the recyclables will first be introduced in urban centres and then gradually expanded to other areas. The advantage of this approach is that the first quantities will already be collected while the necessary infrastructure, like accessible roads, will be built later.

As another key factor, the law considers the inclusion of the informal recycling sector, mainly waste pickers, through a formalisation as accredited waste operators once they obtain the corresponding certification [Ley N°20.920, 2016]. Collection and recycling have to be tendered separately and informal recyclers and municipalities are treated with preference by the PRO. Through including and formalising the informal sector, Chile chose an inclusive approach rather than taking away the livelihood of the workers, which reflects the social dimension of the circular economy approach [Ministerio del Medio Ambiente, 2019].

Comparing these three countries, it appears that the following are requirements for success:

- Sound legal basis
- Holistic approach with measures all across the value chain
- Inclusive approach which integrates all actors (including the informal sector)
- Focus on comprehensive and extensive waste collection and sorting to increase recycling
- Establishment of an EPR system as a sustainable financing basis

2.3.4 African Circular Economy Examples

Complementing to the global examples, there are also examples of circular economy concepts which have been implemented in African countries.

Kenya

TakaTaka Solutions is one of the prominent examples of companies actively present in the country's garbage collection and recycling space in Kenya. As a leader in waste collection in Nairobi and on a smaller scale in neighbouring cities, it is successfully collecting and sorting waste from major waste sources like notable hotels and malls as well as national and international institutions (Figure 9).

Figure 9: Waste sorting at Taka Taka

To reduce the amount of waste ending up in dumpsites, TakaTaka recycles 95 % of the waste it collects; this is partly undertaken by themselves or, predominantly, by one of the numerous recyclers and converters that feed sorted and pre-treated fractions from TakaTaka into their production processes. Waste is sorted into more than 45 fractions within their two sorting sites in Nairobi.

As part of its recycling strategy (Figure 10), the company makes composts out of their separated organic waste, which is sold to farmers.

Figure 10: The Business of Taka Taka

Mr. Green Africa is another example of an innovative business model aiming to introduce circular economy concepts in Kenya. The company works with informal waste collectors (pickers) by integrating them into their value chain. The company collaborates with these informal waste pickers and accepts the collected waste at one of 25 trading points, predominantly set up in Nairobi's low income areas. With the use of digital applications, Mr. Green measures and keeps a record of each of its suppliers. Through the app, the company also informs about the rates plastic wastes are sold at, thereby assuring transparent prices paid to the suppliers. The company has managed to build a relationship with their suppliers by giving fair and stable prices but also by offering supplier loyalty programmes and services (see Figure 11).

Mr. Green focuses on the collection of plastics, specifically PET bottles, HDPE, PP as well as aluminium and papers like cartons. The recycled plastics are sold as flakes, both locally and internationally. Raising awareness plays an important role in Mr. Green's operational model. Continuing their social and environmental approach, Mr. Green Africa partnered with the international consumer goods company Unilever on a plastics recycling programme for primary schools. The aim is to entice children at an early age to become environmentally conscious and to help lead society towards behavioural change (see Figure 12).

Figure 11: The Business of Mr Green Africa

Figure 12: Awareness rising in schools

Rwanda 

Rwanda is a pioneer in Africa in terms of maintaining a clean environment. It is well known for its zero tolerance policy for litter, which is still a problem in other parts of Eastern Africa.

For over ten years now, the country's economy has been running with an active plastic bag ban in place. To understand and learn from this example, Rwanda has:

i) Banned the use of single use plastic bags in 2008
ii) Put in place a heavy fine on the banned items
iii) Made it easy to package stuff with paper, which are available in shops and stalls
iv) Invested in education and awareness
v) Drafted a bill on the ban of all single-use plastics in the country.

Rwanda has successfully managed to promote awareness amongst its population in environment related topics. In 2011, the Rwanda Environment Management Authority initiated a Greening Schools Programme [REMA, 2019]. In addition to tree planting, greening school grounds, using improved handwashing facilities and making children aware of the importance of the harmful effects of improper waste management the country has managed to educate its citizens on the importance of a clean living environment.

Rwanda has successfully managed to promote awareness amongst its population in environment related topics. As one measure, the Rwanda Environment Management Authority initiated a Greening Schools Programme in 2011.

Within the framework of the UN Education for Sustainable Development (ESD) programme, a consortium of two local organisations with the support of the British development agency, DFID, enhanced awareness building around the topic of the environment through the development of Eco-School Rwanda. The aim of the Eco-Schools project is to promote environmental education in the country starting at an early age. This is achieved by using education to help reduce poverty levels, as well as develop environmental protection and climate change mitigation knowledge amongst the children [Foundation Saint Dominique Savio, 2014].

Rwanda has been successfully able to keep its streets clean with help of the legal framework and heavy fines put in place once the plastic bag ban was implemented. Rwanda has one of the stringiest and strictest fines on this in place, which all people living in Rwanda adhere to. It ensures clean streets within and outside of the capital Kigali and beyond.

Compliance with authority is a culture in Rwanda. Therefore, regulations put in place by government are quickly adopted by the population. The way the citizens have adopted the policy shows that a ban can be quickly assimilated by a country.

Early 2019, the country also drafted a law to ban all single-use plastic which, undoubtedly, will affect the industry. If this passed as legislation, companies affected will have to adapt to this.

The country's infrastructure still remains inadequate as the population is fast growing. There are projects to develop further the city's infrastructure and residential buildings. The country has an extensive programme to construct high density buildings by 2040, by multiplying the medium rise row houses as well as the multi-storey apartments by more than three times the number (State of the Environment and Outlook Report 2015, REMA, 2015).

2. Plastic Waste Management Practices

Even though streets and roads in Rwanda are clean, recycling remains a practice with an insufficient infrastructure. Some categories of waste cannot be recycled in the country due to lack of financial and technical capacities. The number of companies in the sector is insufficient and therefore the infrastructure is not functioning sufficiently. Thus the recycling industry is not entirely developed.

With increase of the population in City of Kigali, there has been a rise in the amount of waste being generated on daily basis. Solid and liquid waste (SLW) are collected from households and transported to Nduba landfill to the tune of 300 tonnes par day and only 2 % of solid waste is recycled. The main landfill, Nduba, does not have a waste segregation system.

Just as it is the case in many developing countries, a dumpsite constructed in Kigali is quickly filled. The city therefore closed down its Nyanza dumpsite and is now operating the landfill [Office of The Auditor General of State Finances, 2016].

As much as the country has an efficient way of ensuring the streets and the public environment are clean and from free of waste, the final handling of the waste is still a challenge. Mandatory monthly street cleans are done which in addition to the regulatory framework helps to keep the streets clean. But the sector of waste management still needs to be improved in order to apply more circular practices in waste management.

Tunisia

In 2004, Tunisia set up several systems for the collection, treatment and valorisation of certain categories of waste, such as ECO-Lef. To foster the development of the sector, the Tunisian government encouraged the creation of microenterprises by awarding contracts together with the municipalities.

The system was financed by an eco-tax, although it was labelled as an EPR system (for difference see chapter 5.1.1). A fee of 5 % on the net added value has to be paid for imported plastic, including empty packaging and raw materials. For the import of already packaged goods, no tax needed to be paid.

The funds collected via the eco-taxes were (partially) used to;

- Finance the ECO-Lef system,
- Cover part of the operational fees of the municipal and hazardous waste infrastructures, and
- Cover part of the functional costs of the National Agency for Waste Management.

ECO-Lef is a public system for the recovery and recycling of packaging waste, implemented in partnership with local authorities. It includes the collection of packaging waste and recycling of plastic waste according to the conditions set by the National Agency for Waste Management. The Eco-Lef system covers only specific packaging types, namely PET bottles, milk bottles made of HDPE, plastic films and bags made of PP as well as metal cans – cardboard packaging is excluded.

The collection of recyclable materials is done by approved and authorised companies. These usually small companies can also buy material from informal collectors, which play a major role in the recovery of recyclables in Tunisia. In turn, the collections companies (can) sell their collected quantities to ECO-Lef; however, this is not mandatory. Eventually, the material is sold to recyclers. Despite their great importance in the recycling system, the informal sector is not visible in the ECO-Lef system.

After an initial success, which peaked in 2008 with collection of 15,700 mt of packaging, collection and recycling gradually but significantly decreased to 5,400 mt of collected packaging waste in 2017. The reason of this significant decline was rooted in the mismatch between funds generated from the eco-taxes and the actual packaging waste quantities and the lack of adequate steering function of taxes on the actual collection and recycling infrastructure. This was exacerbated by further structural weaknesses, as the decrease of the profitability of certain parts of the system was diminished due to the decrease in collection activity. Further causes for the poor outcomes include a lack proper control, complaints over the quality of the recyclers and proliferation of non-approved recycling companies, long transport distances connected to relatively high costs, and, last but not least, limited domestic recycling value chains.

To improve their system, the National Agency for Waste Management is currently making revisions to transform it into an actual EPR system.

2.3.5 Alternatives to Plastics

In light of the growing wealth and consumption and therefore also increased resource demand required to meet this growth, efficient and effective waste management has become more important than ever before and plays a central role for nature and resource conservation.

As part of the reduction pillar of the circular economy, it is important to consider the alternatives to plastics, i.e. the substitution of plastic material with other materials in packaging and other products. As will be described in the following chapters, there is currently no comprehensive waste collection and treatment infrastructure for waste in general and plastics in particular in Kenya. In light of the prevailing waste management conditions (predominantly landfill, low recycling structure for glass and plastic, no relevant reusable systems), the use of resources, for instance in the form of packaging, should be reduced as much as possible in order to minimize resource losses and unorderly deposits with the associated ecological consequences.

Against this background, it is important to compare plastics vis a vis alternatives and analyse their feasibility and impacts in regards to a multitude of impact categories. Such a comparison and analysis has been done as part of the research and is presented in annex 8.9. In particular:

- carbon emissions (expressed through the global warming potential (GWP)) and water footprint as ecological indicators
- health, safety, collection and recycling situation as economic indicators

These comparisons are based on Life Cycle Analyses, which compared different material solutions for the same purpose at item level. Life Cycle Analysis (LCA) is a technique to assess the environmental impact associated with all the stages of a product's lifespan (from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, to disposal or recycling). In doing so, the prevailing framework conditions in each case are considered. LCAs indicate the product's impact regarding climate change or global warming potential, acidification, photo-oxidant formation, ozone depletion potential, terrestrial eutrophication, aquatic eutrophication[1], particulate matter, total primary energy, non-renewable primary energy, use of nature, water use (related to water input).

Generally, it is not possible to derive a general rule stating that a specific alternative is better than plastics; as such a statement is always item-specific and dependent on a multitude of contextual factors such as the availability of a proper waste management system. Thus, from a resource conservation point of view, the development of an orderly and comprehensive recycling structure is the preferred alternative to simple substitution. In the foreseeable future, substitution will largely not be able to replace the specific and for many purposes favourable attributes of plastics.

[1]Aquatic eutrophication describes the process when an aquatic body becomes over-enriched in nutrients, which causes excessive algal blooms, potentially leading to oxygen depletion and a shift in species composition often associated to detrimental effects on the aquatic ecosystem [Chislock et al., 2013]. Terrestrial eutrophication is based on a similar process and outcomes, although the enrichment of nutrients caused by air pollution [EEA, 2018].

2.4 Kenyan Plastic Mass Flow

2.4.1 Quantification of plastic volumes

To quantify the flow of the various polymer types in Kenya, the finished goods import, use and export, as well as the per capita consumption in Kenya, the plastics material flow at every step of the value chain have to be verified. The approach (Figure 13) considers that plastic material is introduced in Kenya either through;

The researchers conducted a mass flow analysis by combining: modelling of national data sets on plastics and plastic packaging consumption from 2016 inflated to 2017 with a survey of Kenyan recyclers regarding the quantities of recycled plastics and plastic packaging waste.

i) imported raw material for plastic packaging (raw material for resins and plastic resins),
ii) imported packaging material as well as plastic goods, or already as
iii) waste material

Within Kenya, the raw material for plastics is converted into plastic packaging and plastic products, which – together with the imported packaging and products – are sold to companies and/or consumers and eventually become waste. This waste is subsequently prepared for reuse, recycled, disposed of or dumped through formal and informal channels, or potentially even exported to other countries. Other possibilities for material outflow of the country are through the export of plastic packaging and plastic products to other countries as well as the export of raw materials.

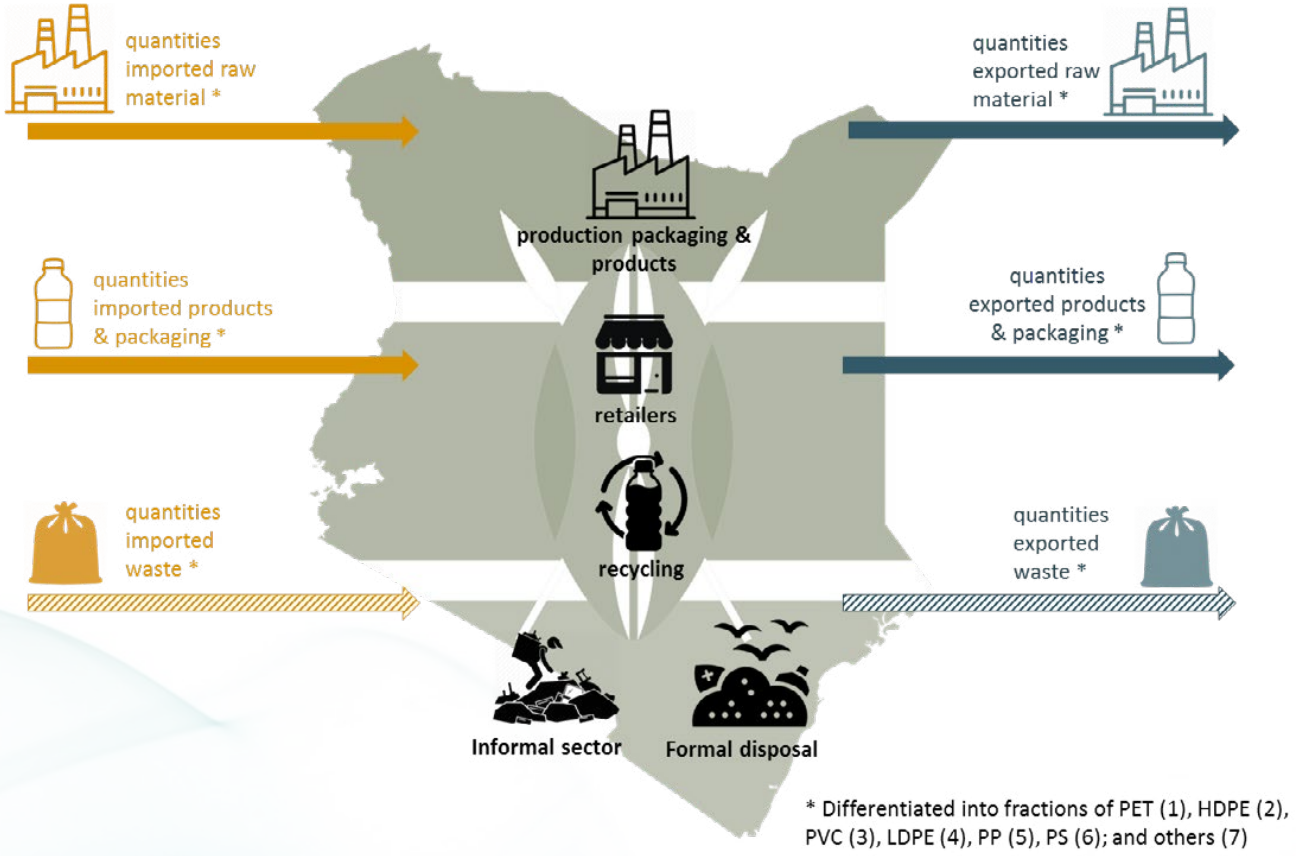

Figure 13: Mass flow of plastics material within Kenya

To identify the flow of plastic material at every step of the plastics value chain, an online survey *(see annex 8.7)* was conducted via KAM with relevant actors from all steps along the value chain. In this survey, the interviewees were asked to indicate their activities in relation to plastic use and fractions according to the seven, internationally coded fractions (see annex 8.2), the respective volumes purchased and potential challenges they face.

This is complemented by insights derived from the key informant interviews conducted for the Kenya Plastic Action Plan's research.

The results of the online questionnaires have been compared and complemented with results of previous studies conducted in this field to increase the accuracy of conclusions. In particular, two studies were used. The first was a study undertaken by Eunomia [2018] which identified the quantity of plastic packaging waste annually generated in Kenya. Eunomia's research is based on the assumption that the quantity of plastic packaging put on the market equals the quantity of waste generated, due to the very short in-use phase of packaging. However, it has to be considered that this assumption is not fully accurate in the Kenyan context. An important share of packaging is reused either for the same purpose or for a different one. Thus, the in-use phase is prolonged. The main research method is interviews of different stakeholders in the value chain. The numbers presented as results can therefore rather be considered estimates. The second important study considered here was undertaken by Ipsos [2019] with focus on PET bottles: within the course of the market assessment, a mass flow analysis of PET material in Kenya was also conducted, based on data from 2017.

Import of plastics

Although Kenya possesses crude oil, there are no plans to set up a refinery in Kenya in the foreseeable future. Domestic crude oil is therefore not (yet) used for the generation of plastic material, i.e. every plastic material and/ or product must have been imported to Kenya at some point (including imported as resins and raw material for resins). This assumption matches with the approach of the other studies [Eunomia, 2018; Ipsos, 2019]. Thus, quantifying this interface is the most relevant one.

According to Eunomia [2018], an estimated 567,000 mt of primary and non-primary plastics was imported into Kenya in 2017. The Ipsos-study reports 453,781 mt of imported primary plastics in the same year (and 469,400 mt in 2016). Due to the lack of primary plastic production, it is assumed that this number consists of both primary plastics in the form of granulates, resins, etc. and processed plastics in the form of film, empty containers and other plastics products. In 2017, the plastic industry processed around 240,000 mt of primary plastics with the balance, roughly half the total imported volumes, and assumed to be pre-processed plastics. The import of plastics in the form of already packed goods is, however, not accounted for [Ipsos, 2019]. Although the numbers of the two studies are not fully congruent, they are generally close to each other indicating a scale of 450,000 to 570,000 mt of primary and non-primary plastic imports for 2017. The differences are based on the different nature of the data, as one is an estimated value, based on the previous year's data and previous developments. Moreover, it also shows the uncertainty of the market with reliable data difficult to obtain. Putting into perspective that Eunomia also includes packed/made products in its estimates, representing around 20 % of all goods consumed in Kenya, the gap shrinks – making both assumptions quite congruent.

The numbers on imported plastics of the two reviewed studies are not fully congruent, but they are generally close to each other indicating a scale of 450,000 to 570,000 mt of primary and non-primary plastics for 2017.

The main countries from which the material is imported are China, India and the United Arab Emirates. For instance, 86 % of imported PET originates from China and India alone [Ipsos, 2019].

The interviews revealed that sorted plastics fractions are also occasionally imported, for instance from Uganda or Tanzania, to be recycled in Kenya as the prices for waste material are significantly cheaper in these neighbouring countries [Kenya Plastic Action Plan Interviews, 2019]. These amounts seem to be relatively negligible in comparison to the domestic volume flows, altough no exact quantities could be assessed. Another aspect, which could not be assessed, was the illegal import of plastics in any form. Thus, the magnitude of this remains widely unquantified.

Domestic processing of plastics and production of packaging

As the domestic production of plastics material and products is dependent on the import of the required raw materials, the material flows from the previous step to this one are inevitably interlinked and hence serve as an important verification of the mass flow.

As briefly mentioned in the previous section, the domestic production of plastics material is non-existent; the import therefore covers the whole demand. Around half (equalling 240,000 mt) of total plastics imports are processed domestically. These locally processed plastics have to compete with oftentimes cheaper prices from China, India and the UAE, for example [Ipsos, 2019]. The results of the online survey display, particularly raw material for LDPE, HDPE and PP is imported, while the quantities for PVC and PS are only of minor importance – which is also reflected in their low recycling numbers (see below 'Waste management and recycling').

The numbers on imported plastics of the two reviewed studies are not fully congruent, but they are generally close to each other indicating a scale of 450,000 to 570,000 mt of primary and non-primary plastics for 2017.

In Kenya, the domestic packaging, supposedly linked to domestic production, is significantly higher than the import of packed/ made goods. According to Eunomia [2018], around four fifths of packaging materials' volume is used locally from imported packaging, imported virgin material (processed into packaging domestically) and, to a lesser extent, domestically recycled materials. Only around a fifth of packaging is imported in the form of packed/made products. The Kenyan private sector comprises a diversified structure of both locally grown and multinational consumer goods companies that serve Kenya and surrounding markets with a wide range of products. With production and packaging operations on site, they together represent the clear majority of packaging material consumed in Kenya [Kenya Plastic Action Plan Interviews, 2019].

Export

Just as the with the import group, this group is an umbrella for three different forms of export: the export of raw materials (both made virgin materials as well as recyclates as secondary material), export of plastic products including packaging, and the export of waste. Regarding the export of raw materials, Eunomia [2018] reported that 4,691 mt of recycled plastics have been exported. Exported plastic products are estimated at 51,000 mt for 2017 [Eunomia, 2018; Ipsos, 2019], although the primary source of export data does not clearly indicate if the volume of all packaged products and plastic goods is included in this number. Information about exports of plastic waste could not be identified.

Around 80 % of packaging materials volume is used locally from imported packaging, imported virgin material processed into packaging domestically and domestically recycled materials.

Waste management: recycling quota

To analyse the quantities of the plastic fractions which have been consumed in Kenya, the export quantities of exported raw materials (only primary, not secondary) and exported products are deducted from the quantities of plastics introduced on the market (either imported or produced locally).

As presented by the Eunomia study, a total of 36,193 mt of plastic waste were recycled in 2017(see Table 1), meaning processing plastic waste through washing, flaking, shredding, grinding, pelletizing and/ or using recycled plastics in the production of new products. The volume forwarded to recyclers was higher at 42,950 mt, indicating that only parts of the recovered materials met the criteria for recycling [Eunomia, 2018]. The amount of plastic packaging recycled was 23,006 mt. The remainder, 13,907 mt, was therefore sourced from plastics applied for different purposes. Whereas practically all PET recycled in Kenya is derived from packaging, significant percentages of other recycled fractions HDPE, PP and LDPE were originally not used for product packaging. Differentiated according to the seven plastic fractions, the numbers are as follows:

Table 1 : Quantities of recycled plastics and plastic packaging acc. to fraction in 2017 [Eunomia, 2018]

	Plastic waste forwarded to recyclers (mt / year)	Amount of plastics recycled (mt / year)	Amount of plastic packaging recycled (mt / year)
PET	Specific data not available	5,778	5,778
HDPE		10,943	4,407
PVC		177	0
LDPE		8,091	4,998
PP		6,806	4,873
PS		0	0
Others		4,398	2,950
Total	**42,950**	**36,193**	**23,006**

Reflecting on all steps of the mass flow and the plastics consumption in Kenya, it becomes visible that the recycling capacities regarding the different plastic fractions vary significantly: On the one hand, this is related to the difference of the in-use phases based on the sectoral uses, as explained in the previous chapter; some fractions, for instance, are utilized for longer periods, e.g. in construction. They are therefore not counted as waste yet. On the other hand, it is also based on the differently developed recycling capacities currently existing in Kenya; for instance, no PS recycling infrastructure has been identified, indicating just one gap in closing the recycling loop.

Overall, **the quota for recycled plastics equals 7 % according to the data of the Eunomia study** [2018] coupled with export data from the Ipsos Study [2019]. Putting these two sources together, the assumption for the recycling quota is based on the following calculation:

$$\frac{\text{36,193mt plastics recycled}}{\text{(567,000 mt plastics imported - 51,000mt plastic products exported}}$$

The underlying data shows certain amounts of uncertainty. Therefore, utilizing alternative input numbers, the resulting recycling quota varies. Nevertheless, even taking into account different data sources, it is safe to say that the recycling quota for plastics in Kenya stands at less than 10 %.

However, different to the above, the quota can also be estimated by analysing the generated waste. According to the World Bank [2018], every Kenyan generates 0.39 kg of waste per day. The portion of plastic has not been evaluated for the whole country. For Nairobi, the percentage ranges from 9 % for low income over 12 % for middle income to 15% for high income households; 11.8 % for the whole of Nairobi [UN Habitat 2019]. Data obtained by JICA [2010] assumes the portion of plastic at the lower end of this, with 9.5 % of the total municipal solid waste volume.

Estimates for plastics used in Kenya range from around 500,000 to 800,000 mt per year. Less than 10 % of these plastics are currently recycled.

Taking a total population of approx. 50.2 million inhabitants in 2017 [World Bank, 2019] into account of which each person generates 0.39 kg municipal solid waste per day [World Bank, 2018], the equation comes to a total of almost 20,000 mt of waste generated daily; and around 7 million mt annually. Utilizing data from Nairobi that 11.8 % of the municipal waste streams are composed of plastics [UN Habitat, 2019], around 820,000 mt of plastic waste are generated annually in Kenya. This estimate is significantly higher than the one from Eunomia [2018]; amounts of imported plastics are supposed to be higher using this method. The overall plastics recycling rate would thus be significantly lower.

Closing the gap related to recycling and a circular economy depends on several contextual factors such as current waste management practices, recycling possibilities and demand for recyclates as well as the political and legal framework.

Waste Management in Kenya

Kenya counts a population of around 50 million people. The metropolitan area around the capital Nairobi mainly includes neighbouring counties Kiambu and Machakos and comprises a population of up to six million people; the city Nairobi itself houses around 4.6 million inhabitants [UN Habitat, 2019]. The second biggest city, Mombasa, counts more than one million inhabitants and forms another major economic and logistical hub, particularly apparent in its role as the main harbour for several countries in East Africa. Other economic centres like Kisumu, Eldoret and Nakuru exist in the more densely inhabited highlands towards the Western and Central parts of the country. Especially in the agriculturally productive highlands and a narrow stretch of the coastline, population density is quite high even in rural areas, while particularly northern and eastern parts of the country, towards the borders of South Sudan, Ethiopia and Somalia, are scarcely populated.
Kenya's characteristics as a rapidly developing country are also present in the waste generation data. **On average, 0.39 kg of waste per capita occur daily,** compared to 2.7 kg per capita in Germany [World Bank, 2018; OECD, 2017].

In the Greater Nairobi areas, Kenya's political and economic hub, 3,000 mt or 0.64 kg per capita of municipal waste occur daily from residential areas, industry and other private companies as well as public institutions [UN Habitat 2019], a slight increase since the estimates by JICA [2010]. All in all, the waste is mainly organic compost plus minor amounts of glass, paper, metal and others. According to JICA [2010], plastic fractions account for 9.5 %. Recent data collection carried out by UN Habitat [2019] assumes plastic content in a range of 9 % to 15 %, specified as per different income levels in Nairobi; countrywide data is not available. Lower income areas count relatively lower volumes of plastics on the one hand. On the other, high income areas account for the highest volumes of plastics. Middle income areas are, by far, the most relevant areas in terms of absolute volume of plastics in municipal solid waste. Due to its function as the economic and political hub, a significant number of Kenya's high-income areas are concentrated in Nairobi.

Roughly a tenth of municipal waste volume in Kenya comes from plastics, mainly packaging material.

Putting all these findings together, plastics account for the largest share of municipal solid waste after organic waste and paper. These volumes predominantly originate from plastic packaging including traded and locally manufactured goods [Eunomia, 2018].

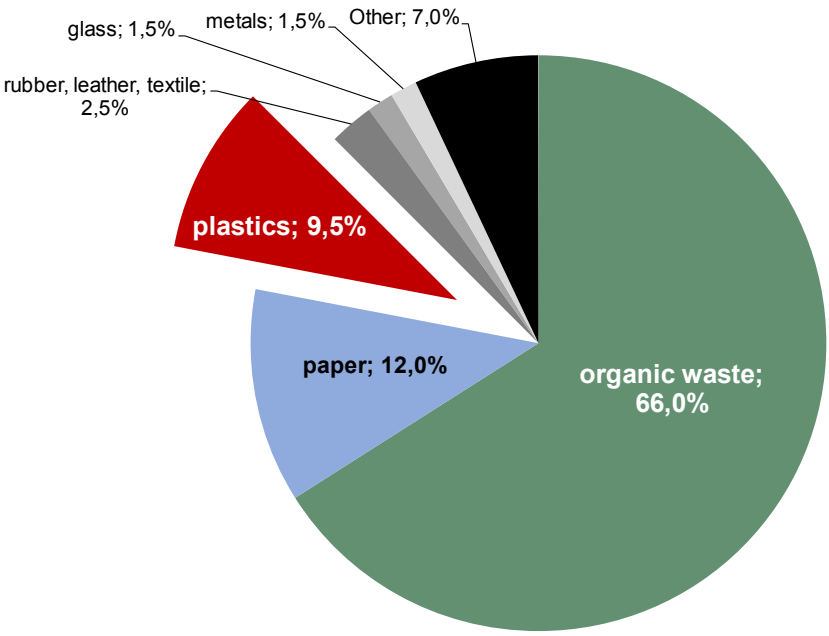

Figure 14: Composition of waste generated in Nairobi [JICA, 2010]

2.4.2 Collection Systems

The public sector as a stakeholder steers the general direction of Kenya's waste management in strategies and actions plans. Institutions like the National Environmental Management Authority (NEMA) issue licences for operation in the field. Additionally, some rules and regulations are set by the County Governments, which are responsible for executing national law by implementing waste management infrastructure accordingly [GoK, County Government Act, 2012]. A detailed overview of relevant legislation and the institutional framework is provided in chapter 3.

In Nairobi, economic activities and services relating to waste management are mainly undertaken by the informal sector.

Within its legal boundaries, Nairobi City County Government is in charge of collecting waste effectively. However, inefficient public services led to the rise of a dominant informal stakeholder group ranging from waste pickers (also called scavengers), collectors and sorters to recyclers [UNEP, 2015]. Private collection, segregation and recycling happen without restrictions, based on an open competition of buyers and sellers, and is a largely cash-based economy [UNEP, 2015]. Waste collection undertaken by the informal sector also plays a major to dominant role in all other Counties of Kenya, though the respective levels may vary [Kenya Plastic Action Plan Interviews, 2019]. Collection systems, run officially in some Counties by the public or private sector, are nevertheless shown to have many irregularities or are simply non-existent, hence country-wide data is only limited or not available at all [Kenya Plastic Action Plan interviews, 2019].

Thus, systematic waste management infrastructure is lacking. A recently undertaken study by UN Habitat [2019] estimates that around 75 % of Nairobi's waste volume is collected in a matter that could be described as 'limited' at best. The remaining roughly 25 % of waste volume ends up being dumped in the rivers or the respective neighbourhoods or self-treated, i.e. incinerated on site [JICA, 2010].

To the contrary, some professionals in the waste management value chain assume total collection rates of only around 25 % to be more realistic [Kenya Plastic Action Plan Interviews, 2019]. About 75 % of residential waste is collected in high-income areas, whereas it is respectively lower with declining income. A general observation, confirmed in both studies, is that collection rates are significantly higher in high-income areas; with the reverse being true in low income areas. UN Habitat [2019] assumes a collection rate of 100 % in high-income areas, referring to 13 % of Nairobi's population. The collection rate is estimated at 66 % in both medium- and low-income areas, representing around 35 and 52 % of the total population, respectively.

Waste segregation at generation of source is generally absent in Kenya.

At generation of 'domestic' source, mainly households but also public and private offices, waste is usually not segregated. The same is true for waste from streets and public areas where it is literally picked; hence the informal part of street collection does not clean the environment but results in the collection of valuable waste only. In general, if collected, waste is transported in a mixed collection lorry. During transport, casual waste workers segregate materials and pick out items that seem of value for the subsequent recycling chain. When reaching a dumpsite, some resalable items like metal, rigid plastics, PET bottles and glass have been put aside. According to UN Habitat [2019], the respective recovery rate before reaching a dumpsite stands at slightly more than 20 % of the total waste volume or slightly less than 30 % of the collected volume. After this first segregation on the collection lorry, waste pickers further sort out materials at the dumpsite. Particularly on the dumpsite, the health of workers, the surrounding population as well as the environment in proximity and downstream of the water bodies is adversely affected. Both on the collection lorry and on the dumpsite, sorting capacities are limited. This is mainly due to lacking segregation at source and declining value of dirty and moist materials [JICA, 2010; Kenya Plastic Action Plan interviews, 2019]. These secondary recovery activities at the dumpsite barely cover 1 % of Nairobi's total waste, or around 2.5 % of the waste volume that has reached a dumpsite, i.e. roughly 97. 5% of the waste volume offloaded at a dumpsite will never be recovered [UN Habitat 2019].

Putting these numbers into proportion: In Nairobi, around 3,000 mt of municipal waste occurs daily. 2,250 mt of these are collected, 750 mt are directly disposed into rivers or burnt on site. 640 mt of the total waste are recovered either before or on the collection truck and another 40 mt from the dumpsite, out of a total volume of almost 3,000 mt. The recycling rate of municipal solid waste in Nairobi can therefore be assumed at around 22 % of the total waste or 30 % of the collected waste volumes.

Aside from the above mentioned "domestic" waste (including private and public offices), waste is also generated on a more industrial scale, usually by private enterprises. Some manufacturing industries organize their own waste management by either contracting private companies to collect – whereby the further treatment is usually unknown – or by managing it internally. Small scale baling, shredding and recycling is common to move production waste back into the loop as raw materials or to sell it to (usually small scale) companies that resell it for secondary use. To a limited extent, incineration is practised as well; particularly in the case of hazardous waste. Some industrial steam boilers have the capacity to burn plastics as a by-product and one pyrolysis plant exists, however both business models are not realized at scale and are operating only as pilots yet.

Some companies prove to be especially innovative as they expand to different markets and products, based on their by-product; hence closing materials loop within own operations. The general observation is that the manufacturing sector has applied proper solid waste management practices in its production processes by feeding back most fractions into the production processes and selling remaining fractions to secondary users/ recyclers. [Kenya Plastic Action Plan interviews, 2019].

2.4.3 Recycling Infrastructure

Recycling infrastructure in Kenya is composed of private companies that access waste through market mechanisms and subsequently convert it into secondary materials that can then be fed into new production processes/be used for a new purpose. Materials that are recovered by waste collectors, including waste pickers, are usually sold to a waste recycler. After undertaking some material processing steps, depending on the material and including processes like e.g. sorting, washing, shredding, etc., the segregation at the recycling yard is usually undertaken by hand, enabled by relatively cheap cost of labour.

Rigid plastic recycling (like recycling of PE bottles, PP cups or PET bottles) is common with a large number of small-scale recyclers throughout Kenya. In bigger economic hubs, recycling infrastructure for HDPE and PP is in place; other areas are yet to attract recycling businesses.

The secondary resources are then resold to material converters that produce new products. Converters are part of the recycling value chain but are usually not regarded as recyclers themselves. The whole picture, nevertheless, also consists of many companies whose business areas overlap into several parts of this recycling value chain.

Organic Material

With around two thirds of the volume, organic matter accounts for the vast majority of municipal solid waste in Kenya. Composting for organic waste is undertaken usually on a small scale and rather for agricultural and horticultural waste, whereas only one industrial composting facility exists in the country, in Nairobi. Particularly in urban areas, most of the collected organic waste is disposed on dumpsites. Some of the organic waste is fit for animal consumption and especially pigs are fed and bred both in rural areas and in the proximity of dumpsites. Especially pork that is produced in the surrounding of dumpsites is deemed as potentially contaminated and only limitedly suitable for human consumption.

Paper, Glass and Metal Recycling

For paper recycling, several processing facilities that convert waste paper into material like sanitary papers and carton boxes form value chains that recycle high percentages of waste paper, both from domestic sources and from neighbouring countries. A fair number of paper segregators are located throughout the country, with the converting facilities mainly concentrated in the Greater Nairobi area; one exception being a newly set-up paper plant in Kisumu/ Western part of Kenya.

Only two companies have the capacity to properly recycle glass bottles. According to market insights, their existing recycling capacity is barely sufficient to supply the two main existing take-back-schemes with recycled glass; one is located in the capital Nairobi, being run by the market leading brewery. The market for secondary glass is dominated by the second one. Based on the coast, this company buys glass waste from all over the country. The glass recycling plant is therefore both a focal point and a bottleneck for local value chains in sorting and aggregating glass waste. Seen from a closed-loop perspective, the limited recycling capacities for glass connected with the supposedly high inflow of import glass result in poor recycling rates. The shredding of glass for subsequent use as e.g. filling material in construction is a commonly exercised practice.

Due to the relatively high value and good recyclability, the scrap metal recycling value chain seems to generally fulfil its requirements. Metal is used in relatively low quantity for packaging in Kenya, accounting for around 1.5 % of household waste in Nairobi [UN Habitat 2019]. The two main applications include beer and, already to a lower extent, soft drink cans as well as tinned foods with both commanding relatively low market shares. There seems no recycling facility for canned beverages operational in Kenya; recycling value chains are supposedly directed abroad which due to its value-weight ratio seems to be a feasible practice. Packaging for tinned cans is recycled domestically.

Plastic Recycling

Rigid plastic recycling is common with a large number of small-scale recyclers throughout various areas of Kenya. Rigid plastic items are stable in form, e.g. PET-bottles, PP cups, plastic pipes (in contrast to flexible plastic items such as film) and more easy to collect. For the main fractions, HDPE and PP, a recycling infrastructure converting waste materials into flakes is in place within the bigger economic hubs and particularly in the surroundings of bigger dumpsites. Newly urbanised areas outside the traditional towns are lagging behind. As much as local value chains for the mentioned plastics do exist in e.g. Eldoret, Kisumu and Nakuru, other areas such as Nyeri, Meru and Kisii, among others, have yet to attract recycling businesses and build local value chains consisting of several recycling companies.

Figure 15: The hierarchy of the plastic waste recycling chain

Especially outside of areas with functioning recycling value chains, so-called aggregators or collectors, usually small businesses by nature, serve as focal points for informal waste pickers. They undertake manual segregation and subsequently send the fractions for recycling into other parts of the country. Due to logistical costs associated, recycling happens more selectively and recovery rates are lower.

Similar to the above described practices for rigid plastics, recycling is undertaken for flexible plastics as well, namely LDPE. Recycling rates seem to be lower and the recycling value chain counts fewer active companies, mainly due to more logistical challenges in collecting the relatively light and unstable material.

Mechanical processes mainly include baling, shredding, washing, flaking and palletizing. The injection or blowing into new products usually happens after the primary recycling at plastic converters; here, secondary materials can be mixed with virgin materials to produce rigid plastics, mainly for household items, e.g. buckets, basins and related products.

PET plastic recycling is done by a small number of companies on few locations throughout the whole country; recycling sites have been identified in Kisumu, Nairobi and at the Coast. Recycling ratios are therefore low, also because of economics of logistics, e.g. lack of decentralized baling facilities at points of collection in combination with the low volume-value ratio; similar metrics are found for any LDPE (flexible) plastics. If recycled, output is often exported for fibre production in Asia. Currently, a single project to deepen the value creation from PET recycling is being undertaken. With newly set up infrastructure, PET is envisioned to be used for garments. Despite scattered existing and upcoming recycling infrastructure, most PET currently ends up being dumped [Kenya Plastic Action Plan interviews, 2019].

Recycling value chains for PVC and PS have not been identified within this assignment. Currently, these fractions seem not to be recyclable domestically. They are, however, of less importance for packaging value chains than the aforementioned materials. Mixed packaging materials, e.g. 'Tetra Pak" but also other flexible material with specific attributes, e.g. coffee or tea multilayers, lack recycling facilities. Currently, the setup of a recycling facility converting 'Tetra Pak' packaging into building material is underway [Kenya Plastic Action Plan interviews, 2019].

2.4.4 Disposal Practices

The current disposal practices in Kenya are described best by initially shedding light on the characteristics of Kenya's biggest waste disposal site by volume, the Dandora municipal dumpsite (see Figure 16). The Dandora dumpsite is located eight kilometres away from Nairobi city centre and spreads across an area of at least 30 acres. It was originally designed as a temporary disposal site, but was declared an official dumpsite in the mid-1970s. Dandora's capacity stands at around 500,000 cubic metres. Since the year 2001, this limit has been exceeded with 1.8 million cubic metres estimated in 2016 [JICA, 2016]. Dandora has a limited official status, dumping there is unrestricted and all kind of industrial, agricultural, domestic and medical waste gets offloaded [UNEP, 2015]. A 2010 estimate stated that between 1,200 and 1,500 waste pickers work at Dandora, some of them independently, others organized in still informal, often unethical structures [JICA, 2010]. According to the estimates of the local operators, 2,000 mt of waste are disposed of at Dandora on a daily basis, while 30 to 40 mt of valuables are picked, collected and transported out of Dandora to recyclers and converters. This corresponds mostly with the figures from UN Habitat [2019].

Around 70 other smaller dumpsites are spread across Nairobi. None of these have an official status as a landfill to dispose waste. In addition to dumpsites, dumping of waste on the roadside or in vacant spaces is common, more so in low-income residential areas. Already polluted upstream by inappropriate waste disposal, Nairobi River later flows through Dandora, causing downstream water used for domestic and agricultural purposes to be highly contaminated [UNEP, 2015].

The waste disposal practices in the second biggest city of Mombasa, with more than 1 million inhabitants, are similarly dysfunctional. Here, the collected volume of around 800 mt of solid waste daily represents a collection rate of around 68 % [UNEP, 2015]. Semi-formal and informal dumpsites exist throughout the whole county, particularly in the proximity of urban areas. The problems described for Nairobi usually apply in a similar way in all other urbanized areas, with their respective sizes always being smaller. With the potential exception of an ongoing setup of a new dumpsite in Murang'a County (due to its distance and its size not feasible for Nairobi's waste), no dumpsite in Kenya is operated according to international standards for landfills.

All in all, the absence of formal waste management services, insufficient treatment facilities and unsafe dumpsites operated in an unregulated environment bring severe societal and environmental consequences. Several issues exist which are yet to be overcome in order to enable an effective waste management infrastructure in organisational, logistical as well as legal terms. The current organisational structure demonstrates an improper management, insufficient monitoring, lacking legal enforcement as well as very limited data availability. A lack of land zoning fuels conflicts when new residential areas appear close to industry and illegal dumping spots. In terms of the collection and transportation system, the formal and informal private sector operates in a rather unorganised and inefficient way. Collection and transportation are usually beyond the control of the County governments, hence so far not organisable, resulting in illegal dumping scattered throughout all areas in all parts of the country [JICA, 2010].

Figure 16: Dandora dumpsite

2.4.5 Challenges for Plastic Recycling in the Waste Management Ecosystem

Segregation

Systematic segregation at source, i.e. mainly at the household (and office) level, would provide better recovery rates for recyclable materials. Several factors contribute to this finding, among them are limited awareness, lacking infrastructure, informal waste collection services, a loose regulatory framework and, compared to worldwide figures, low plastic waste generation due to low consumption of packaged goods due to low income. The high portion of organic waste makes the recovery of valuable fractions difficult. Additionally, due to moisture and dirt, the value of the fractions is lowered further, affecting the economics of segregation.

Challenges in the Recycling Value Chain:

- Segregation
- Logistics
- Licencing/ Regulatory Framework
- Product Design
- Secondary Market
- Awareness/ Education

Logistics

The value of the potentially recycled material in its unprocessed form is often insufficient to cover the aggregated costs of collection, segregation and transport, due to the low volume-value ratio. Recovered materials often have to be transported over far distances to certain hubs to be fed into the recycling value chain; facilities for upfront baling or shredding are missing. Only the areas around Nairobi and, to a more limited extent, Mombasa offer possibilities to recycle all main fractions (not to speak of completely missing value chains for certain fractions) whereas logistics have to be organised in order to ship certain fractions over large distances.

Licensing/ Regulatory Framework

The regulations and policies related to solid waste management are outlined in chapter three. As they are generally loose, the currently biggest hurdle for the recycling value chain are licences that are required for moving waste, i.e. secondary materials. The attributed costs and frequent time-delays in obtaining these licences damage the economics of transporting waste. Furthermore, there is limited clarity on whether these licences apply also to secondary resources. It is thus unclear if single fraction shipments are considered waste.

Product Design

With certain criteria taken into consideration when designing product packaging, recycling processes can be significantly eased. Currently, some products contain an unfavourable mixture of material which lowers the recycling value. Additives like filling chemicals, partially applied in rigid plastics, are difficult to identify for the collector and likewise the recycler and may only be noticed by the customer of the secondary product (usually the converter). By then, all costs within the recycling value chain have already occurred whereas no value has been created. The change of material for a certain packaging, e.g. from HDPE to PET, can also distort the recycling value chain as casual collectors and workers are not aware of the respective differences. For many fractions, different colours imply different value; e.g. the recycling value for coloured PET is currently significantly lower than the already marginal one for clear PET.

A bottler of carbonated drinks in Kenya is currently harmonizing its product design by shifting to clear PET and utilizing PET labels. This is exemplary for a producer's action to create more value for recyclers.

Secondary Market

The current plastic recyclers are by and large small companies processing relatively small volumes of plastics waste, thereby usually building the transition point between the informal and formal sector. Both recyclers and, subsequently in the value chain, the converters face a number of hindrances to scale up operations and increase recycling. Two main factors are unpredictable and unreliable: mass flows and the quality of the input material. The efficient utilization of fixed assets can only be assured if the input material is available. Due to the largely informal collection and aggregation structures that are sensitive to price changes, larger-scale investments bear a certain risk of not recovering their costs. The oftentimes low quality of input materials is rooted in rudimentary sorting practices, unfavourable composition of fractions (e.g. through filling material or different colours) as well as the lack of waste segregation at source (dirt, moisture). The use of recycled plastics is therefore limited to a narrow range of applications that only require low qualities, which is why the recycling sector almost exclusively practises "downcycling" towards end-of-life solutions. Recycled material therefore faces stiff competition with virgin material – in regards to price, quality and availability. Thus, the vast majority of business models for the Kenyan recycling sector are disabled at this moment. This is also proven by the low actual recycling rate.

Awareness/ Education

Awareness and Education are identified as one of the key hurdles for better waste management in Kenya. Littering in public at a small scale or the irregular disposal of waste on a larger scale is still practiced widely and spans multiple generations. Some programmes and activities in schools and the general public are undertaken; drivers of those are non-profit organizations, private companies including those in the recycling value chain as well as the public sector. Despite these numerous efforts, education on waste management lacks a clear base in the school curricula.

Nevertheless, the current lack of a proper recycling infrastructure also creates limits for better education on managing waste; despite some behavioural changes when it comes to littering, polluting water bodies and similar related activities, by and large there are just no best practices in place that can possibly be undertaken currently.


re-use

3. Legal and Regulatory Frameworks affecting the Plastic Sector

Following the previous description of Kenya's waste management situation, the following chapter elaborates on the underlying legal and institutional framework. The legal analysis includes the identification of regulatory gaps which have to be addressed to achieve a proper waste management system. Currently, differing strategic directions and goals are stated by a variety of policies and plans. Looking at the overall picture, some areas are under-, others rather overregulated.

In Kenya, waste is defined as 'any matter prescribed to be waste and any matter whether liquid, solid, gaseous or radioactive, which is discharged, emitted or deposited in the environment in such volume, composition or manner likely to cause an alteration of the environment' – according to the National Environment Management Authority (NEMA).

3.1 Review of Kenyan (regional, national and county) legislation formulation on plastic and waste management

Plans and Strategies

In 2007, Kenya's government published a strategy that described the pathway towards developing the country into a middle-income industrial nation by the year 2030 [GoK, Vision 2030, 2007]. This Vision 2030 recognizes the need for a sustainable waste management system in order to handle industrialization in line with its social pillar. The latter one claims in paragraph 5.4 to realize 'a just and cohesive society enjoying equitable social development in a clean and secure environment.' In particular, the strategy calls for reducing pollution and establishing waste management systems through economic incentives. Regulations regarding plastics bags and hazardous products are one of its figurehead projects [AWEMAC et al., 2019]. The Big Four Agenda is the medium-term strategy of the Vision 2030, set by the current government after its election in 2017. While the Big Four Agenda does not state waste management and circular economy in particular, it implies the need for it to enable its goals in regards to food, health, manufacturing and housing in coherence with the long-term vision [GoK, Big Four Agenda, 2017].

The Third Medium Term Plan 2018-2022 (MTP III) and Green Economy Strategy and Implementation Plan 2016-2030 (GESIP) comprise specific reforms, programmes and projects for the realization of the overarching government strategy. With regards to solid waste management, they call for separation at source as well as the establishment of new collection infrastructure, treatment facilities and disposal sites. It is planned for new urban programs to build these in respective areas. The goal for 2030 is a nationwide quota of 50 % for waste recovery, in the form of recycling and composting. The implementation of extended producer responsibility (EPR) and landfill legislation is stated within GESIP. Financial incentives to support functional markets for waste management shall be established. This relates to the promotion of recovering and utilizing more secondary materials and recycled products. Furthermore, the national and County Governments are obliged to enforce and monitor the total ban of plastic bags [GoK, GESIP, 2016; GoK, MTP III, 2018]. Despite pointing out certain goals for improving waste management practices in Kenya, the mentioned documents remain vague in setting out implementation measures.

Kenya's plans and strategies on waste management are guided by Vision 2030. Vision 2030 calls for reducing pollution and establishing waste management systems through economic incentives. In light of the pillars of the Big Four Agenda, it will be important that waste is managed in a manner that creates jobs and allows the manufacturing sector to flourish.

The National Environment Policy requires the development of an integrated National Waste Management Strategy with economic incentives to entail cleaner production, waste recovery, recycling and reuse [GoK, 2013]. The Solid Waste Management Strategy of the National Environment Management Authority

(NEMA) translates this into the 7R Zero Waste Principle, applicable at the County level to achieve 80 % waste recovery and 20 % landfilling by 2030. The latter strategy links EPR to e-waste, making electronics producers accountable for their products and end of life. However, it mainly triggers public awareness campaigns. Plastic recycling is not specifically mentioned.
For medical waste, the National Health Care Waste Management Plan guides the planning, implementation and monitoring of waste management across the health sector. Emphasis is placed on segregation, recycling and safe disposal [Ministry of Health, 2016].

To ensure a holistic, clean and healthy environment, the Kenya Environmental Sanitation and Hygiene Policy 2016-2030 (KESHP) claims to reduce solid waste and, in particular, to minimize the use of plastics. Solid waste management systems and mechanisms shall be established and enforced by national and county governments in every city, municipality and town. Especially the use of plastic bags shall be regulated with market-oriented incentives. The private sector is invited to provide services for realization [GoK, KESHP, 2016].

Another relevant legislative document is the National Climate Change Action Plan 2018-2022 (NCCAP). Under Priority No. 5: Health, Sanitation and Human Settlement, the Plan calls for circular waste management 'to substantially reduce waste generation through prevention, reduction, recycling and reuse' [AWEMAC et al., 2019]. By 2023, five waste management plans and regulations shall be developed on county levels, in line with NEMA's National Waste Management Strategy 2015 [GoK, NCCAP, 2015]. The latter one claims for a countrywide integrated solid waste management system that follows the principle of the waste management hierarchy: reduction, reuse, recycling, resource recovery, incineration, and landfilling [NEMA, 2015].

Laws and Regulations

Kenya's Constitution states that every individual has the right to a clean environment. In that respect, all waste generators, transporters, recyclers and institutions that own disposal facilities are obliged that their activities do not threaten citizens' rights. Refuse removal, refuse dumping and solid waste disposal is assigned to the County governments in order to ensure environmental conservation [GoK, Constitution: Article 42, 2010].

According the Constitution of Kenya, every Kenyan has the right to a clean environment.

Urban areas and any physical planning needs to manage and dispose of waste effectively, offer designated sites and bear responsibilities for adherence according to the constitution [GoK, Physical Planning Act, 1996; GoK, Urban Areas and Cities Act, 2011].

The Environmental Management and Coordination Act 1999 (EMCA), with its specific publication on Waste Management Regulation from 2006, sets the applicable rule of law. The act directs anyone whose activities generate waste to implement mechanisms for reducing and appropriately treating remaining waste; it prohibits dangerous handling of waste, denies the disposal of any waste in a way that causes pollution and delegates the responsibility for pollution to its producer. The principle that the polluter pays needs to be considered when exercising jurisdiction [AWEMAC et al., 2019].

Moreover, the transportation of waste and any disposal operation need licences from NEMA, which come with standards for operations. Effective from 2017 onwards, a ban was enacted that prohibits the use, manufacture and import of all plastics bags used for commercial and household packaging. This ban covers the categories of carrier bags and flat bags made from polyethylene (PE). Bags for industrial packaging and garbage bin flat bags are exempt from the ban, if clearance is issued by NEMA.

A majority of those interviewed welcome laws and regulations, however they would prefer that implementation is phased and predictable. This would allow the industry to be better prepared for changes and plan their strategic investments accordingly.

Clearance approval is subject to exerting producer responsibility, e.g. in the form of a take-back scheme or similar measures; labelling needs to enable traceability of the plastics and sufficient documentation of the inventory and dissemination needs to be provided [Gazette Notice No. 2334 &2356, 2017; AWEMAC et al., 2019].
The plastics bag ban was expanded by Gazette Notice No. 4858 in June 2019 to the use of plastics bottles, straws and other single use plastics in protected areas, i.e. National Parks, Forests, Reserves, etc. It will take effect in June 2020.

County governments are responsible for the implementation of waste management policies set at the national level. However, counties are free in their decision on how effectively to implement them. Counties have to publish a pricing policy that sets tariffs for public waste management services that shall include the collection and recycling of waste [GoK, County Government Act, 2012].

Draft Policies and bills

Several legislative documents that affect plastics are in the pipeline or are being ratified. The Bill for the Sustainable Waste Act, 2019, opts for a more sustainable, circular economy in which waste is recognized as a secondary resource. Therefore, Zero Waste Principles are applied. Within the Bill, EPR is defined as 'measures that extend a [...] firm's financial or physical responsibility for a product to the post-consumer stage of the product'. EPR is stated as being a key pillar for policy development and implementation by the National and County governments in order to prevent causing waste and to enable re-use initiatives.

The Ministry of Environment is tasked with developing regulations to expand the recycling market, possibly via tax incentives and government procurement preferences [AWEMAC et al., 2019]; the National Government has to come up with a milestone timeline to improve waste management and design necessary regulations; private entities are obliged to apply clean production principles and are fined if not compliant; citizens are obliged to minimize waste generation and apply recycle, reuse and recover measures for the remaining consumed materials. Waste has to be disposed in accordance with the Act; prosecutors will be held liable including the possibility of imposing fines [GoK, Sustainable Waste Management Bill, 2019].

The draft policies emphasize recycling and recognition of waste as a resource that should be harnessed and exploited for the purposes of jobs creation and cleaning of the environment.

Within the budget statement for fiscal year 2019/2020 it was proposed to lower the corporation tax rate for plastics recycling companies from the usual 30 % to 15 % for the first five years of operation. Services offered to plastics recycling plants as well as the supply of machinery and equipment used in the construction of these plants are supposed to be exempt from Value Added Tax. These proposals are provided for in the Finance Bill 2019 that is yet to be passed.

Another draft Environmental Management and Co-ordination (Plastics Bags Control and Management) Regulation, 2018 refers to plastics bag control and management. Every manufacturer and importer of legal plastic bag packaging has to propose and uphold a recycling plan to support the collection and recycling of plastic brought into the market. The plan can be developed individually or in collaboration with other producers. It needs to be submitted to the authority in charge (NEMA) for publishing and documenting previous activities and achievements. Each manufacturer and importer has to submit a Recycling Program Report to NEMA with details on plastics mass flow and treatment activities. Due diligence is required throughout the plastics value chain. The government requires a recycling rate of 30 % for the manufacture of any plastic bag, with respective labelling. A list of all plastic collection sites shall be published by NEMA. NEMA is also accountable for regular inspections of the mentioned and all other facilities that handle any plastic packaging material throughout their lifecycle [GoK, Draft Environmental Management and Co-ordination Regulations, Plastic Bags Control and Management, 2018].

3.2 Discussion of the existing regulatory gaps

Whereas some forms of EPR such as take-back schemes are already in place, public awareness and necessary infrastructure for waste recovery are non-existent. Moreover, several regulatory gaps were identified across all three framework dimensions, i.e. policy, legal and institutional, that hamper an actual creation of a functioning waste management system in Kenya. The following descriptions are based on interviews conducted with several stakeholders along the plastics value chain. Research undertaken by AWEMAC et al. in 2019 on behalf of KAM is additionally taken into account. The following collection assesses existing local and global practices for post-consumer plastic packaging EPR schemes in Kenya.

Policy Framework

Currently, certain provisions in the policy framework contradict one another. For example, on one hand, bans on the import, manufacture and use of certain materials have been declared or announced [Gazette Notice No. 2334 & 2356, 2017] whilst on the other, the business operation of recycling is promoted [e.g. GoK, National Environmental Policy, 2013]. Investments into recycling infrastructure are at risk of sinking if respective input materials are banned. Moreover, policies are not aligned. For instance, different bills state differing recycling rate targets. Some policies, like the Sustainable Waste Act, proclaim EPR schemes. However, roles are not clearly allocated among the plastics value chain and hence the financial and/or physical responsibility in the system lacks definition. Uncertainties, unspecific statements and vagueness of the timeline for enacting draft policies, particularly the awaited National Sustainable Waste Management Policy, 2019, discourage the private sector from engaging and building value chains that entail the capacity of a functional waste management ecosystem.

Currently, a number of political documents are tackling waste management practices. Nevertheless, different policies have little interconnection to each other, resulting in an overall blurry, partly self-contradicting framework.

Legal Framework

The definition of the term 'waste' in Kenya is currently done by NEMA. It does not consider the reclassification of waste. The concept of transforming waste into secondary resources once value is added, e.g. by segregation or further steps in the recycling process, does not exist. This situation creates challenges especially when it comes to transport during the process, as the trucks are subject to the same standards, costs, and requirements as waste collection transporters (dump trucks).

Waste segregation is mandatory by law, but in reality applies only to the separation of hazardous from non-hazardous waste. There are no consumer obligations and regulations to segregate waste at source. In most areas, the local authorities fail to provide infrastructure for adequate littering prevention. Willingness of consumers to segregate waste in any terms is difficult to enforce. A comprehensive strategy on building awareness through e.g. campaigns or insertion into curricula is lacking. Last but not least – regarding the legal framework of overall waste management at County levels – laws and infrastructure are not harmonized. For example, transport levies at every county border impose costs that discourage value adding processes and hinder the closure of waste value chains. Putting the mentioned circumstances together makes waste recovery a hard goal to achieve, as the economics of collection, transporting and processing of waste hardly build viable business cases.

In respect to plastics, first responsibility for the plastic life cycle is allocated to manufacturers and importers of end market goods only; the role of other stakeholders in the plastics value chain, like certain raw materials importers, retailers, collectors and consumers, among others, remains undefined. Secondly, it is obligatory by law to set up appropriate recycling plants either individually or jointly. However, regulations to provide certain directions on how to set up and implement any of those do not exist. Also, the lack or the inconsistency of collection and recycling targets for obliged companies hinder monitoring processes.

Regarding the establishment of an EPR system, existing laws and regulations do not specifically outline requirements and the potential setup of an overarching EPR system. So far, NEMA guidelines as well as the draft Environmental Management and Co-Ordination Act on Plastics Bags lay out control and management schemes – exclusively focused on polythene bags, with other plastics fractions/ product categories being fully left out. The National Sustainable Waste Management Bill also claims to set up measures and necessary rules and regulations for EPR, take-back schemes and deposit systems. In reality, it neither gives sufficient details on concrete measures to be taken, nor does it provide a timeline by when those rules and schemes have to be enacted or implemented.

Moreover, no measurement in respect of to 'how to identify the plastic volume put into the market' is defined. The enforcement of a potential EPR is therefore made difficult. Despite provisions in the law, monetary and non-monetary incentives are not sufficiently aligned to spur changes. This applies to minimizing waste generation at production and packaging, as well as putting minimum collection rates in place for different fractions. Current laws allow 'cherry picking', and do not properly outline how to increase recycling rates; space for 'free-riders' avoiding contributions to a potential EPR throughout the value chain is still provided. Voluntary EPR schemes therefore imply rising costs and worsening competitiveness for participants/ contributors.

Institutional Framework

Any enforcement and monitoring by the government and the authority in charge (NEMA) is lacking due to unclear co-ordination mechanisms. Standards of KEBS for recycling products are currently missing. The same applies for NEMA guidelines that could promote circular production patterns, i.e. through labels etc. These could encourage or oblige the manufacturing sector to participate and actively engage in waste recovery and recycling processes. Counties are limited in their capacity to implement waste management practices adequately. For instance, the segregation and responsible waste disposal/ treatment is demanded by law on the one hand. On the other, adequate infrastructure to comply with these regulations is not provided, neither for littering consumers nor for the disposal industry. Additionally, implementation of supervision measures and compliance enforcement are difficult considering the double burden from both national and county level laws, requirements and regulations. This is especially the case with regards to licensing requirements and non-harmonized rules, fees and charges.

Within the plastics sector, more so recycling, there are different government agencies in charge for regulations. Harmonization of the enforcement efforts between the different government agencies would greatly benefit the plastics industry. For instance, with no clear standard from KEBS on plastics waste, the transition from waste to resource cannot be specifically defined.

4. SWOT analysis of the Kenyan Plastics Value Chain

The following Strengths-Weaknesses-Opportunities-Threats analysis evaluates the status quo of the Kenyan plastics value chain.

Strengths

- Strong and well organised private sector which is ambitious to take action on better, 'smart' plastic waste management practices
- Strong need for an EPR expressed by both public and private sector
- Relatively well working individual recycling value chains for certain fractions, e.g. HDPE, PP, paper, etc.
- Plastic packaging value chain does exist in Kenya and can take joint action/product design decisions which can be effected within the country

Weaknesses

- Spread of plastic packaging throughout the country/ limited local recycling infrastructure at point of consumption paired with high cost of transport/ logistics
- Lack of awareness and culture on proper waste management practices among citizens and especially in the part of the lower income class living above the poverty line
- Practically no tradition of waste segregation especially in households
- Little experience in formalized waste collection systems
- Insufficient general waste management infrastructure: lack of waste bins, formal dumpsites and organised collection; poor roads etc.
- Little legislation concerning waste management/ many relevant areas not sufficiently covered by current legislation
- Enforcement of existing waste management regulations partly deficient
- Lack of clear definitions, responsibilities, roles, etc., leading to different interpretations and waste management practices across the country

Weaknesses

- Growing industry of local consumer goods manufacturers with continuing need for packaging
- Strong multinationals with strict internal targets on better managing waste who can serve as forerunners
- Lack of alternatives to plastic packaging for a range of applications/ banning certain plastics would cause more problems than solutions
- Rising awareness of some parts of the population with regards to better waste management
- Low cost of labour/ high demand for employment enables business models for collecting, sorting and recycling
- Raising the value of disposed plastics even marginally is a viable mechanism to increase collection/ recycling rates due to high need for even marginally paid employment/ income generation
- Adaptation of circular economy concepts can create "green jobs" while increasing Kenya's recycling rate from currently low rates.
- Waste management is a devolved responsibility, hence allowing pilot projects in certain parts of the country through local decision making

Threats

- Unpredictable regulatory frameworks
- Risky environment for investment due to uncertainty of coming legislation
- Fragmented opinions within industry on the way forward
- Industry may not find a common voice/ voluntary EPR schemes not viable
- Voluntary take-back schemes would cause competitive disadvantages due to high price sensitivity of the market
- EPR organization may not be recognized by all relevant stakeholders/might become a victim of conflicts of interest with competitive disadvantages and free riders

The insights from the analysis of the Kenyan waste management situation, the identified legal and regulatory gaps as well as the SWOT analysis are considered for creating tailored measures reflecting the Kenyan situation in the subsequent Action Plan.

5. Proposed Measures and Initiatives for the Action Plan

Based on the analyses and evaluations in the previous chapters, this chapter will introduce specific action steps, initiatives and measures to accelerate Kenya's transition towards a circular economy for the environmentally sustainable use and recycling of plastics. In particular, it focuses on policy suggestions and sustainable funding mechanisms to create a sound basis for further actions. Thus, the first part will focus on establishing the necessary organisational and financial basis while the second part will introduce specific measures to be taken for action.

5.1 Establishing a Financial and Organisational Basis

Economic instruments are crucial to establish a sound financial and organisational basis for sustainable waste management and recycling. Generally, there are three different types of economic instruments;

- Revenue-raising instruments which create a direct income from the industry and/or households through taxation or charges as, for instance, a landfill tax
- Revenue providing instruments which create an indirect income for industry and/or households through reduction of charges or subsidies, like tax rebates or variable VAT rates
- Non-revenue instruments which do not create revenues but motivate the industry and/or households to improve their individual waste performance, as it is done for example through EPR systems as detailed in chapter 5.1.2 below
- Ideally, instruments from all three categories are implemented in a complementary fashion to achieve ideal results.

5.1.1 Tax incentives

Generally, taxes can be raised on several products at several steps along the value chain. It is most important to avoid unfair double taxation and use taxes which are complementary to the EPR levies that will be explained in the next chapter. Thus, the most important taxes to consider are the landfill charges and the refunded virgin payments.

Landfill Charges

Generally, landfill charges are composed of the gate fees imposed by the operator of the landfill and the landfill tax imposed by the authority: The gate fee is charged in order to generate revenues for keeping the landfill in a working order and finance the provided services. The landfill tax is a levy charged by public authorities (usually on a national, but also on a regional or municipal level) for waste disposal on a landfill site; the cheaper the landfill tax, the lower the incentive to recycle waste. Thus, there is clear and linear correlation between the total landfill charge and the percentage of recycled waste, i.e. landfill charges are a key driver for diverting waste from landfills.

To allow the system and the relevant authority to adapt to raising landfill taxes, the landfill charges should be increased gradually. However, it is crucial to have clear commitments to increase these costs, while giving the municipalities and the (informal) industry time to adapt. From a long-term perspective, legislative regulations such as landfill restrictions or bans may be effective in redirecting waste into a recycling process. This requires waste segregation at source and a corresponding collection system.

Refunded virgin payments

Refunded Virgin Payments is a two-part measure: producers of products which solely consist of virgin materials pay a fee that is used to refund producers whose products consist of a specified amount of recyclates. Thereby, producers using more recyclates than their peers become net receivers of the refund, while producers who predominately use virgin materials become net payers in this system. This tax has an upstream steering function on recyclate usage.

To avoid double payment, this tax should only be applied to plastic products that cannot be covered by an EPR system. So far, Refunded Virgin Payments are piloted in Sweden to incentivise textiles recycling.

5.1.2 Extended Producer Responsibility

Extended Producer Responsibility (EPR) is an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle, i.e. when a product turns into waste. In the approach, already during the production and sale (and export), producers are responsible for the disposal of their packaging. Producers/ importers pay a fee for later disposal of packaging already when their packed goods are placed on the market. The contribution/ fee is used for collecting, recycling and disposing the packaging waste and other costs arising from maintaining the system. It is not used as a contribution to the general public budget of a state.

The concept of Extended Producer Responsibility and its basic principles

The concept of an extended producer responsibility (EPR) was developed in Germany in the late 1980s. It is based on the idea that the producer responsibility, which e.g. determines that the producer is responsible for their products regarding aspects of safety, health and environmental impacts, is extended until the end-of-life stage. 'Producer' in this context describes companies that put plastic goods (product and/ or packaging) on the market for consumption, which are usually referred to as 'users' in the Kenyan context.

This means that in the EPR scheme, the producer (or user) is responsible for all waste management related to tasks like collecting, sorting and recycling. Thus, the EPR involves producers in the management and financing of packaging waste and gives them the obligation to assume responsibility for their waste. Although EPR systems vary across countries with regard to certain aspects of their set-up, EPR schemes should be designed to manage the obligation of producers while balancing the mandates of environmental policy in the light of the 'polluter pays' principle. Accordingly, the basics of EPR are almost the same in every country:

- Every obliged company pays a fee when introducing a packaged good on the market.
- The fee serves for the collection and further processing of the packaging waste.
- Collection, sorting, recycling, or energy recovery of packaging waste remains the responsibility of the obliged companies.

This basic concept is illustrated in the Figure 17 on the next page.

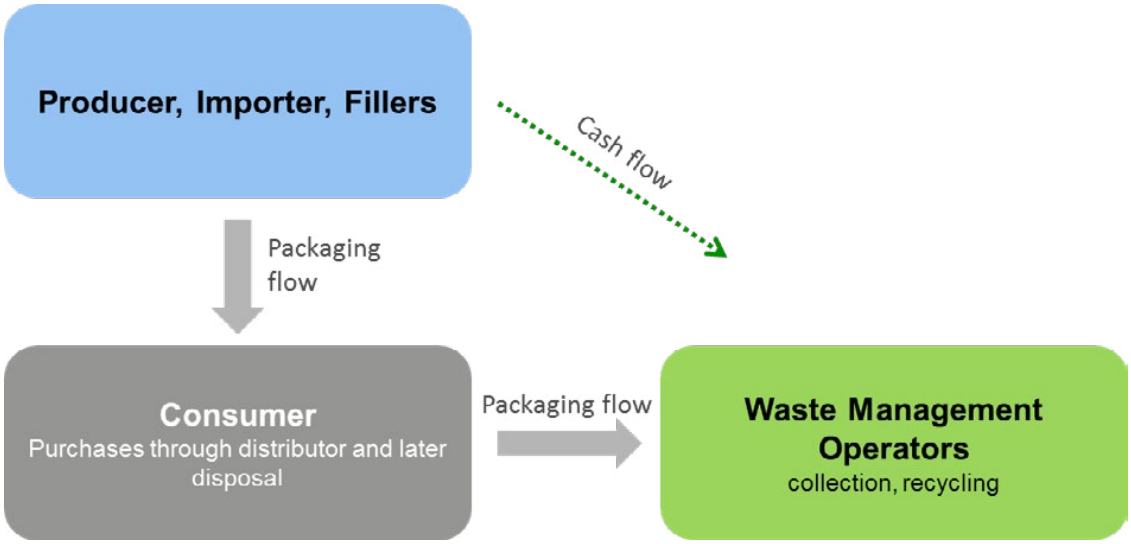

Figure 17: Basic idea of an EPR system

In its simplest form, EPR is rooted in an individual responsibility through a direct interaction between the users, importers, fillers and the source of waste generation; meaning that they will directly collect or pay someone to collect their waste and take it back. This very simple form of EPR is already applied in Kenya as the current legislation obliges producers to organise a take-back scheme for the waste of their products. However, this model is only practicably applicable to a limited extent as it requires the producers/users to have knowledge about the exact spreading of their packaging and how to access it. Furthermore, logistical challenge arise especially if products are distributed in small quantities, still requiring similar logistical infrastructure and attributed costs as applicable with bigger volumes.

Collective responsibility through Producer Responsibility Organisation

As it is, from a practical perspective, not possible for each producer/user to assume an individual responsibility, a transition to a collective responsibility is needed. As a key element to achieve this transition, an EPR organisation is needed as a central element. It takes over the take-back responsibilities of the obliged companies. This organisation is referred to as the Producer Responsibility Organisation (PRO; sometimes also referred to as system operator) as it allows the producers/ users to assume responsibility by combining their efforts and jointly managing the arising waste. Thus, the PRO becomes the central element for the organisation of all tasks associated to the EPR system. In particular, this means that

- The PRO is the most important stakeholder (organisation).
- This organisation is responsible for setting up, developing and maintaining the system.
- This organisation is responsible for the take-back obligations of the obliged companies.

As the compliance of the PRO with all its tasks and responsibilities is necessary, a third party like a public agency is responsible for supervising the PRO in this regard. The following graphic (Figure 18) shows the basic principle of an EPR system with the PRO as central organisation for a collective responsibility.

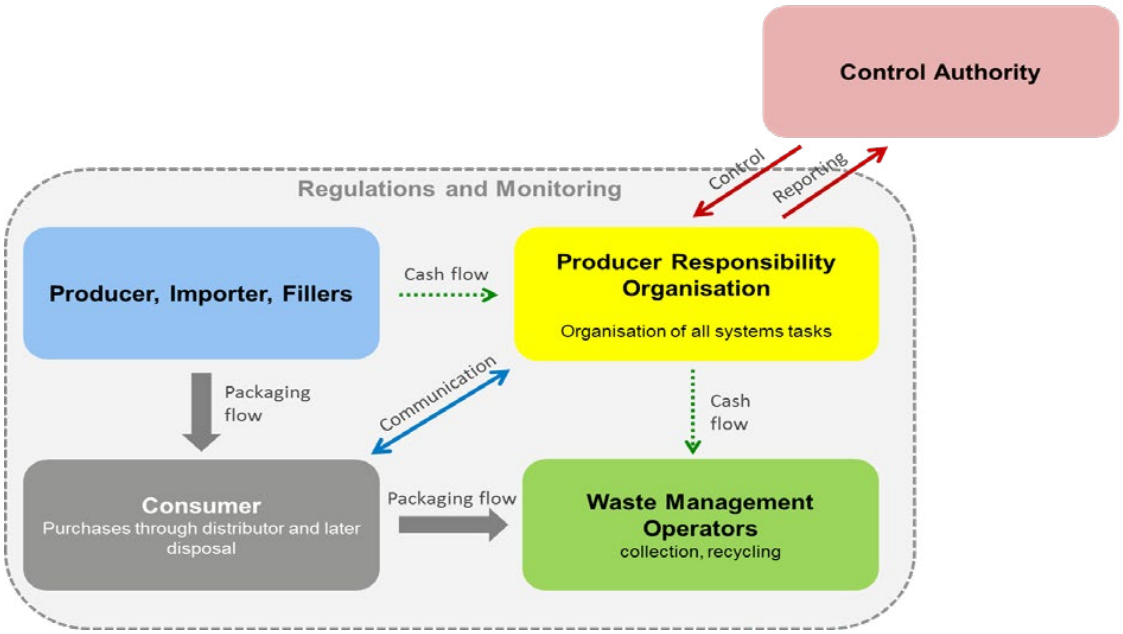

Figure 18: Basic scheme of an EPR system based on a collective responsibility

Figure 19 emphasises the organisational differences between the collective and individual EPR system:

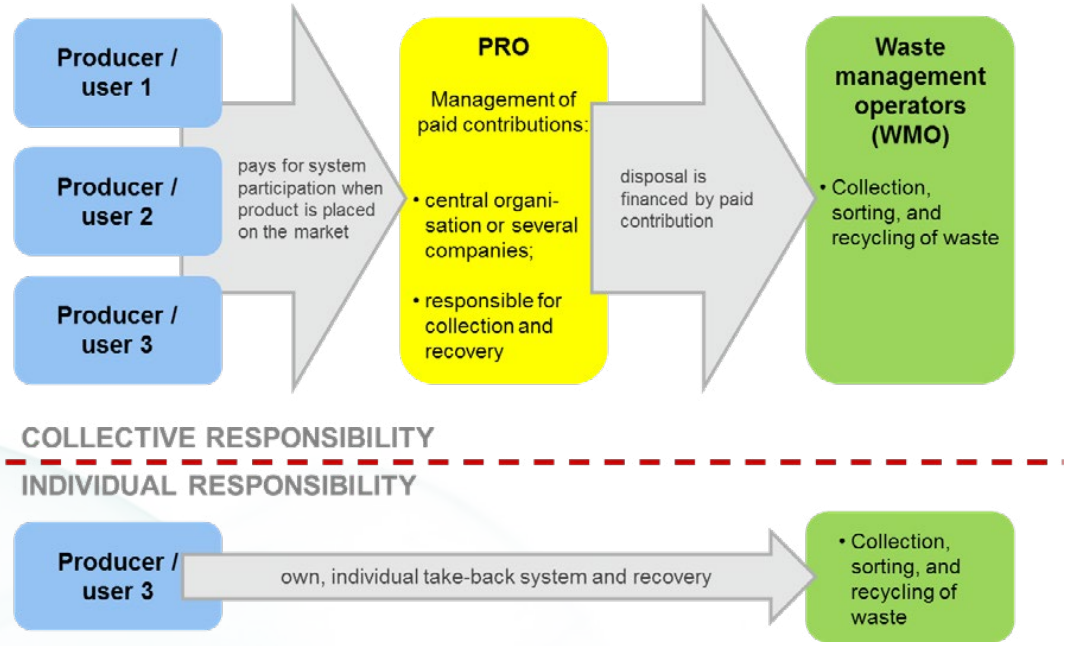

Figure 19: Comparison of collective and individual EPR system

Another specific form of EPR system is a deposit-refund system (DRS): In a deposit-refund system, the waste collection is based on consumer participation. In a DRS, packaging or other items receive an economic value by obliging consumers to pay money as deposit when purchasing the item. Upon return of the purchased item, they get back the same amount they paid as deposit. Thus, consumers are incentivised to bring these items to take-back stations instead of just disposing them as waste. DRS are systems based on consumer participation which reduces littering of these items. Moreover, as the DRS focuses on specific goods (like PET bottles), they allow well sorted material fractions to be collected in large quantities. Such collection systems thereby allow for high quality recycling of these items. Furthermore, DRS also increase the competitiveness of reusable items such as bottles in supermarkets or cutlery in food stores, thereby contributing to another key principle of the circular economy.

A return of the items takes place at designated take-back stations, such as retailers or specific automats, where the consumer receives the reward. In most cases, this reward is monetary and is received per each single item: The specific product is sold to the consumers with a deposit amount meaning that the price of an item (for instance $ 1.25) is the sum of the price of the single item ($ 1) and the deposit amount ($ 0.25). Once this item has been returned, the consumer is repaid the deposit amount or a voucher with the amount ($ 0.25). However, other rewards are also possible, such as vouchers for services.

Creating DRS as form of EPR is limited to specific, easily identifiable items like beverage bottles. Thus, it is not suitable to cover a broad range of plastic items.

Successfully implementing an EPR system requires a system which can be put into practice being economically, environmentally and socially sustainable as well as guaranteeing a level playing field. This demands clear and unambiguous legislation coupled with a multi-stakeholder cooperation between all involved actors from the value chain. Crucial actors include governments, local authorities, producers organised in business member organisations (BMOs) and waste management organisations. The legal framework has to determine objectives, responsibilities, enforcement mechanisms and a timeline for implementation complemented by a framework for the PRO.

The Producer Responsibility Organisation

Since the PRO is responsible for operating the entire system, it is the most important actor. Its tasks comprise the following:

- Registration of all obliged companies (in cooperation with the supervisory authorities): These are the companies introducing packaged goods onto the market, which are consumed in the country meaning that their packaging needs to be disposed in that respective country (financed by the importers, fillers, and producers)
- Collection and administration of all funds from all obliged companies while ensuring fair costs and therefore not harming the competitiveness of a participating company
- Tendering and contracting for collection and recycling of packaging waste
- Documentation of collection, sorting and recycling of packaging waste
- Informing all waste producers/ consumers about the importance of separate collection
- Controlling all services that have been awarded to service providers, specifically services relating to the fulfilment of collection and recycling by waste management companies
- Financing all tasks with funds provided by the obligated companies
- Documentation and verification to the supervisory authorities: the PRO has to prove that it has completely fulfilled all its tasks and aims and used the money of the obliged companies accordingly. This can be done for instance in form of a report, which is verified by a third party or the authorised public agency.

Fulfilling these tasks can be achieved through different PRO setups. The main differences with regards to the setup are based on

i) whether the PRO is a private organisation or a public authority,
ii) whether the PRO is a non-profit organisation or a for-profit company, and
iii) whether one PRO or several PROs exist in competition (see Figure 20).

Experiences in European countries have shown that there is no singular most successful setup, but that the success is determined through an effective and efficient organisation, financing, administration and controlling of the system.

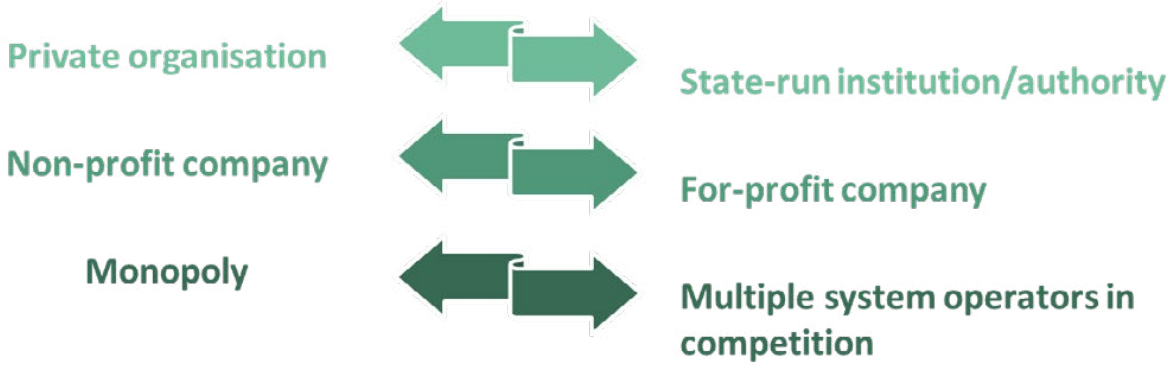

Figure 20: The different set-up conditions of the PRO

The most distinguishing characteristic is whether the PRO is set up as a for-profit or non-profit organisation.

- PRO (system operator) as non-profit organisation: Such PROs are in the hands of the obliged producers and industry, as for instance in Belgium, the Czech Republic, Ireland, Italy, France, the Netherlands, Norway, Portugal and Spain. The obliged industry creates one common non-profit entity that collects the necessary funding.
- PRO (system operator) as for-profit corporation: The legal framework can require direct competition between several PROs instead of having a single monopolistic PRO. Such models exist e.g. in Germany and Austria where the EPR systems have evolved from having a single PRO to competition between several PROs.
- Other distinctions can create the following PRO set-ups:
- Dual model: Industry has full operational and financial responsibility over collection, sorting and recycling. There is a separate collection system delegated to local authorities but their influence is minimal (Austria, Germany, Sweden).
- Shared model: The responsibility is shared between industry and the local authorities based on common agreements regarding collection. Municipalities are responsible for collection, and often for sorting of packaging waste arising at the municipal level, while industry's financial responsibility differs from country to country (Belgium, Czech Republic, Italy, France, Netherlands, Slovenia, Spain).
- Tradable Credits Model: There is neither a link between industry and municipalities nor differentiation between commercial packaging and packaging arising at the municipal level (UK).
- Competing on the infrastructure: Every PRO offers its own container to inhabitants (Estonia).
- Each PRO in a separate district: Each PRO signs up with as many municipalities as needed to fulfil targets according to market shares (Poland, Romania, Bulgaria, Slovakia, Malta, Latvia, and Lithuania).

Who is obliged to pay?

The fees paid for the EPR participation are to be paid exclusively for the waste management related costs and only for the products that are consumed and will become waste within the country, i.e. for an EPR system in Kenya the fees only have to be paid for the products that will be consumed and turn into waste in Kenya. This therefore includes both domestically produced products as well as imported products equally in order to ensure a level playing field. However, products manufactured for export are not included as they will be consumed and subsequently turned into waste in another country.

To determine who is obliged to pay for the operation of the EPR system, a clearly identifiable interface needs to be determined. In most countries, this is the interface where a product is put on the market for consumption in the country as it will turn into waste in this respective country.

The fees that need to be paid are dependent on several factors, which all influence the total costs and thus need to be covered. These factors include:

- Type of collection system
- The waste composition
- Organisational structures
- Contractual constellations
- Financial contributions of the municipalities
- Recycling quotas
- Recovery and disposal infrastructure
- Existence of deposit-refund systems
- Distribution of costs across different material fractions
- Where applicable: modulation of costs reflecting the degree of recyclability (as for instance in France, see 'global examples and success stories')

Roles and responsibilities of the involved actors

Although the set-up of the EPR systems and PROs are different in each country, the involved stakeholders and responsibilities assigned to them are, in principle, the same.

Table 2: Roles and responsibilities in an EPR system

Stakeholder	Responsibility
Raw materials suppliers, manufacturers and converters of plastics	Should **enable reuse & ensure recyclability** of materials and should use secondary raw materials where possible
Consumer goods companies (fillers and importers)	Obliged to **pay fees for the EPR system** proportional to the products, which are covered by the EPR system
Distributors/retailers of packaged goods	Can be obliged to take waste back and to ensure its proper handling. Should also ensure that their suppliers are participating in the EPR system
Consumers	Have to be informed about strategies for waste reduction and proper return or disposal of packaging; should buy as many unpackaged goods and products as possible and reuse packaging as often as possible
Waste management operators	Receive funds from the EPR system for their services in handling packaging waste. Should try to recycle packaging according to the highest standards possible to ensure **high quality recycling**; includes the informal sector
Government and other public authorities	Legislation & supervision of the EPR system
Municipalities or Counties	Linkages between consumers and waste management operators, main responsibilities for implementation of EPR on the local level through organizing the collection

Thus, an operationalised EPR system can be outlined as outlined in Figure 21:

Figure 21: Operationalised EPR scheme

Legal basis

EPR systems can be operated on a voluntary basis only to a limited extent. Thus, mandatory EPR systems are the preferred choice in light of effectiveness and efficiency to transition to a sustainable waste management and circular economy. A mandatory EPR system in turn requires a respective legal basis to ensure compliance of all stakeholders, which is why a sound legal basis is a crucial element. As a first introduction step for a mandatory EPR system, voluntary systems are, however, a suitable measure to push the introduction through such self-commitment.

The legal framework is usually established on the national level through a framework for waste management and, hence, the Ministry of Environment therefore takes a leading role. In particular, the legal foundation can be laid down through environmental protection law, a specific packaging law or a packaging ordinance – depending on the legal context. To ensure a successful implementation, the process of drafting the legislation should involve all key stakeholders from the public and private sector as well as from civil society.

The legal framework should outline clear objectives, responsibilities, enforcement mechanisms and a timeline for implementation. In particular, the legal frame should determine:

- How to set up a PRO (as aforementioned)
- Which companies are legally obliged to take on responsibility
- Who is responsible for financing and organising the system
- Who registers all legally obliged companies
- Which items should be included in the system
- What are the requirements and quotas for collection and recycling
- What the role of the municipalities is
- How can the informal sector be integrated
- What kind of public supervision is required and how can this be organised

There are also some additional requirements which do not need to be mentioned in the law but can be defined by the PRO. This includes:

- **Upstream:** modulated fees based on recyclability (see chapter 5.2.1), recyclate usage, usage of mono-materials, preferred materials
- **Downstream:** Recycling and recovery processes, quota and how they are calculated; waste stream specifications, collection infrastructure

What can be financed by an EPR system?

First of all, an EPR should cover all costs which will arise in the course of achieving the pursued goals for the waste management. This also includes efforts for e.g. data management and administration. Furthermore, complementary measures could also be financed, such as:

- Linking plastic producers to recyclers in terms of design, recyclability, awareness (e.g. through a forum or guidelines)
- Coordinating, giving incentives to improve collection and recycling while keeping a level playing field
- Educating recycling and collection businesses and actors
- Raising awareness, especially in the middle class (above the poverty line)
- Adapting school curricula; technical education at universities
- Running pilot projects (e.g. in certain geographic areas, special sectors like tourism) and researches
- Using labelling on products

The PRO can also contract third parties to carry out certain tasks, like awareness-raising campaigns.

Measurements based on legal frame

The goal is to build an EPR strategy which is proactively discussed with the government. The basis for a mandatory EPR system is a corresponding law. Through such a law, the following targets can be achieved:

- Fair financial burden for all participants as the EPR fees are proportional to the amount of products which are part of the EPR system. Thereby, the competition on the market between the EPR system participants is not impacted
- Enabling the implementation of nationwide solutions
- Requirements for a gradual system implementation and recovery targets can be legally defined
- Establishment of control mechanisms and penalties in case of non-compliance

Thus, the setup of a legal frame is the preferred solution for the implementation of a successful EPR system.

Voluntary measures

In smaller regions, it is possible to establish voluntary initiatives or voluntary commitments as pilot projects to collect and utilise plastic waste. Aside from geographical boundaries, these pilot projects may focus on individual types of packaging, particular points of origins, specific brands and also on defined timely frames. Manufacturers, importers and other stakeholders may work together to implement these voluntary projects. However, the effectiveness of pilot projects is limited due to the following issues:

- Only a few companies (and not all) will participate in voluntary measures
- The financial contribution of each company is low compared to the contribution companies have to pay in an EPR scheme
- Extent of the single activities is small and usually comprises only smaller projects
- Impossible to establish a nationwide collection system based on voluntary measures
- No official controlling systems
- Voluntary initiatives may prolong important decisions regarding the setup of a nationwide EPR

Voluntary initiatives should rather be used as a preliminary basis for the system operator of an EPR system to help develop the respective legal basis of the system. Voluntary initiatives can help to gather individual experiences through pilot projects.

Global examples and success stories

As aforementioned, EPR systems can be implemented in many different ways. In Europe, there are currently 30 countries that have implemented EPR in their legislation, with the industry having respectively set up PROs. Outside of Europe, such organisations have been established as well, for instance in Israel, Turkey and Japan. Below the systems of Germany, France and the Netherlands are presented, which all have different set-ups.

In Germany, the legal framework allows a direct competition between several PROs instead of having a single monopolistic PRO. Since the PROs are private companies, they are not in the hands of the obliged industry, but each obliged company has to contract a PRO of their choice for the management of their waste. Therefore, the exact fees are not disclosed. Furthermore, the EPR system exists in parallel to municipal waste management and municipalities are not part of the EPR system.

This setup has achieved very good results with regards to collection, sorting and recycling. However, this system requires intense monitoring and supervising due to the complex and partially unclear structure, which is why some companies exploit this system to participate inadequately or avoid participation in the system. The 'Central Agency Packaging Regulation' was established after the passing of a new packaging law, which entered into force in January 2019 as a new controlling authority.

In 2003, Germany established a compulsory deposit-refund system by law for one-way beverage packaging made from glass, plastics, metals or composite materials. From 2003 to 2006, the deposit-refund system was built on a direct relationship between consumers and retailers. Empty one-way beverage bottles could only be returned at the original point of sale. After 2006, the deposit-refund system was transformed. Since then, the law obliges every retailer to take-back deposited one-way beverage packaging made of materials they supply through their own product range. Thereby, Germany implemented a uniform, nationwide system for deposit-refund with clearing. As a clearing organisation, the Deutsche Pfandgesellschaft (DPG) was established, owned by the German Retail Association and the German Food Association. Through employing clearing service providers, the producers and importers of deposited beverages receive the record data of returned deposited beverage packaging and reimburse the respective amount to the retailers. The return rate of deposited beverage packaging was 98.4 % in 2015.

In France, Citeo (until 06/2017 named Eco-Emballages) was developed as the dominant EPR system that is exclusively responsible for end consumer packaging. Eco-Emballages was founded by a coalition of several industrial parties (manufacturers). A second EPR system, Adelphe, was established by the wine and spirits industry to meet the take-back obligations for glass bottles. Today, Adelphe is fully owned by Citeo, yet continues to operate as an independent company.

Citeo is a non-profit joint-stock company with approximately 240 shareholders from manufacturers, distributers as well as the print, services and related supply chain sectors. In total, Citeo is the PRO for approx. 50,000 members. The fees of Citeo are based on the weight of the packaging, a fixed price per packaging unit, a malus system for non-recyclable packaging (e.g. fees for non-recyclable plastics as packaging material are twice as expensive).

The producers finance approx. 80 % of the system and the local municipalities finance the remaining 20 %. Moreover, the municipalities are also responsible for performing disposal services.

The system achieves good results with regards to collection, sorting and recycling. However, mixed plastics and plastic foils are not included in the system throughout most areas in France. It is planned to expand the system to comprise all types of packaging waste by 2022.

In the Netherlands, the Afvalfonds Verpakkingen (packaging waste fund) was established jointly by manufacturers and importers to fulfil the extended manufacturer responsibilities. It is a non-profit organization which is managed by a management board, which is itself appointed by producers and importers. The tasks include the maintenance of the waste management system, collaboration with communities and other stakeholders to organise collection, and recycling of packaging. Other tasks are the mitigation of packaging waste, monitoring and reporting on collection and recycling of packaging materials as well as defining and receiving compulsory financial contributions from manufacturers and importers.

A noticeable feature is that the tasks of collection, sorting and transportation of waste to recyclers are exclusively done by the municipalities. In turn, Afvalfonds pays compensation for the collection and sorting of packaging waste.

Since December 2007, Nedvang, a non-profit organization, acts as mediator between manufacturers, importers and retailers as well as recovery companies, municipalities, and national authorities. Moreover, Nedvang monitors the packaging market and the recovery of packaging waste. Nedvang works for the waste fund and makes contracts with municipalities regarding the reporting of packaging waste, which is collected, sorted, and recycled. Nedvang reviews this information and, following their review, dispatches approval through payment from the waste fund.

Overall, this system achieves good results with regards to collection, sorting and recycling. However, the costs are high compared to other EPR models.

Local examples and success stories

In Kenya, there is no mandatory EPR system. Thus, organisations that operate as a take-back organisation follow the principles of an EPR system for selected materials only. These organisations are based on the voluntary participation of their members. In particular, there are PETCO and Clean Green Kenya.

The PET Recycling Company Ltd. (PETCO Kenya) registered in December 2017 and started operating in June 2018 with its organisational scope being limited to PET beverage bottles. Through self-regulation mechanisms for the industry, PETCO aims to create value for post-consumer PET and encourage a change in consumer and industry behaviour towards recycling PET beverage bottles which is supposed to help in creating more employment possibilities in the recycling industry.

Currently, the organisation has 14 active members. The main financial sources are the membership fees, grants from retailers, plant owners and bottlers. The grants are obtained through negotiations with members.

For the PET bottle collection, PETCO has contracted two companies as of now, WEECO Limited and Karsam Limited. The plan is that WEECO Limited collects and recycles 4,800 mt, while Karsam Limited collects and recycles 1,000 mt annually. Overall, PETCO aims, together with other partners, to collect and recycle 6,000 mt or 300 million PET bottles by 2019. Through its collaboration with retailers such as Naivas Kenya and other members, PETCO Kenya aims to set up drop-off points to enhance the collection of recyclables.

To raise awareness and promote consumer education, PETCO targets stakeholders which can bring maximum returns to the consumer awareness programs. Some initiatives aim to couple media coverage with school recycling initiatives.

Clean Green Kenya (CGK) is also a voluntary system with the set goal of developing a circular economy, bringing awareness of proper waste management to all sectors and becoming a hub of information in the recycling sector. The companies Alternative Energy Systems Limited, RAMCO and King Plastics subsequently founded CGK as an NGO in 2017. The idea of CGK is to establish a platform through which collectors, recyclers and manufacturers across different industries can interact and create synergies.

Key activities include the collection of funds through a monthly 'EPR fee', which is invested in enhancing the waste management capacities. CGK also aims to secure collectors' supply chains based on a pricing model that incentivises the collection of post-consumer waste. The organisation currently has 22 companies registered on a voluntary basis. These include manufacturers, recyclers and end consumers. They have committed to a monthly levy which is calculated based on their monthly plastics production. The collected levy is mainly used for collection and sorting of waste plastics (done at dumping sites), pre-processing activities (transportation, cleaning and compacting of waste plastics) and educational campaigns and capacity building in schools.

5.1.3 Comparing tax incentives and EPR

In many cases, measures are referred to and published under the label of EPR. However, in light of the definition of an EPR scheme, these are mostly green taxes and environmental charges or eco-taxes. These environmental taxes or import duties are charged on raw materials and goods. In these cases, most of the funds usually flow into the general public budget, so there is no producer responsibility fulfilled as defined in an EPR system.

The following table compares the fees paid within an EPR system by the obligated companies with green taxes and environmental charges.

Table 3: EPR fees and green taxes in comparison

EPR fees for packaging	Green taxes / environmental charges
The fees are determined by the PRO or - in case of for-profit corporations - negotiated with the obliged companies.	The tax is defined by law or through other public regulations and acts.
The PRO receives the fee.	The responsible public agencies receive the tax.
EPR describes extending the producer responsibility: Those who introduce certain goods on to a market are also responsible for the subsequent waste management and disposal of the arising packaging waste.	Eco-taxes can be charged without being directly related to a specific responsibility of a producer. The duty is fulfilled through payments.
The fees are precisely related to the products covered by the EPR scheme, which are introduced on the market of the respective country in which they will also turn into waste.	Eco-taxes do not have to be related to the consumption in the respective country. For instance, they can also be related to raw materials or imports.
There is a direct relation between the EPR fee and the quantities of arising waste in the respective country.	There is no relation to the arising packaging waste quantities in the respective country.
The EPR fees are meant to be exclusively used for collection, sorting and recycling of the waste. This also includes a corresponding communication and public awareness work.	Eco-taxes usually contribute into the general public budget, so there is no 'polluter pays'-principle in the sense of an EPR system.

Generally, both EPR fees and green taxes can have a steering function. Green taxes can steer raw materials, materials and goods which are newly introduced onto the market; for instance through taxes which are staggered based on ecological criteria such as the recyclability, usage of recyclates, or origin of the material (upstream impact).

The steering function of EPR fees also covers the part when raw materials, materials and good are newly introduced onto the market, but expands beyond this as EPR fees also impact the establishment of an operative system, meaning EPR can finance, amongst other things, infrastructure, communication, and campaigns against littering (up- and downstream impact).

Thus, EPR fees – if they can be applied to a specific product – are the preferred choice with regards to their steering function.

5.2 Action Measures

5.2.1 Recycling and/or End of Life Options

The End of Life (EoL) options for waste plastics are geared to the waste hierarchy (see chapter 2.2), which is a set of priorities for the efficient use of resources and waste treatment, listing the most preferred to least preferred option. Based on the waste hierarchy, the following EoL options exist for waste plastics:

Prevention refers to measures taken before a substance, material or product has become waste. These measures reduce the quantity of waste (including through the re-use of products or the extension of the lifespan of products), reduce the adverse impacts of the generated waste on the environment and human health, or reduce the content of hazardous substances in materials and products. **Prevention measures are taken before a product becomes waste!** Examples for prevention measures include resource-efficient processing leading to less material being manufactured (thinner wall thickness of bottles, cans) or multiple use applications. (cans or baskets used for the same or another task and therefore remain within the utilisation phase).

Preparation for re-use describes materials and items which have become waste, are cleaned, refurbished and remanufactured for reapplication.

Recycling means any recovery option by which waste materials are reprocessed into products, materials or substances, whether for the original or for other purposes. It includes the reprocessing of organic material but does not include energy recovery (which is part of recovery!). Recycling also includes re-granulation as well as production of flakes and agglomerates out of plastics.

Other recovery processes, e.g. energy recovery: For this purpose, the energetic content of the plastics are used to generate heat, cold and/ or electric energy; mostly through incineration.

Disposal describes any operation which is not recovery, even where the operation has a secondary consequence for the reclamation of substances or energy. Thus, disposal does not count as recovery measure. **Disposal does not mean littering or the landfilling in unsuitable locations.**

Generally, no comprehensive collection and, further, proper waste treatment (household and commercial waste) is implemented in Kenya, especially with regards to plastics. Considering the waste management practices (improper landfilling in terms of organizational and environmental aspects, low recycling structures for glass, paper, plastics, no relevant multiple use systems), the usage of resources for e.g. packaging should be widely reduced (prevention) to tackle the challenges (loss of resources, littering, improper treatment to reduce negative environmental impacts).

As a recommended, complementary first step, the development of a systematic recycling structure is crucial. This also includes the treatment of plastics which are not recycled at the moment or which are by nature not suitable for recycling (see section recyclability).

Similar to Europe, the long-term goal should be to transfer the current, unsystematic disposal of plastic waste into a suitable form of treatment through planning and reconstructing landfills with adequate safety measures (e.g. waterproofing, gas retention, waste water collection and purification).

This should go along with the requirement only to transport pre-treated waste to landfill sites. Since the beginning of 2006, there is a so-called landfill ban in Europe. It states that waste which is supposed to be landfilled must only have a very small amount of total organic carbon (TOC). This is accomplished when;

- Waste is already separated and collected at source
- Contained recyclable fractions are sorted
- Remains unsuitable for recycling are used energetically

The latter two points are key elements for a circular economy and should therefore be put into focus through the implementation of an EPR system (see chapter 5.1.2) and measures (see chapter 6). However, it should be considered that even with a higher usage of plastic recyclates in production processes, there is still a need for virgin materials, which e.g. are obligatory to fulfil certain quality criteria during manufacturing processes.

Moreover, the recycling processes should not be limited to Kenya location-wise as long as the inland market is not established sufficiently; i.e. export of waste or secondary resources for processing abroad can, at least in an initial phase, be a viable part of the solution.

For a long-term success, structures outside of recycling need to be established as well as structures for waste treatment for non-recyclable plastics. This generally happens through incineration (energy with heat generation as the best option), as the resulting ashes are landfilled. Alternatively, the option of 'catalytic pressurised oiling' and the generation of fuel are conceivable for plastics but still in development to scale them to an industrial level; also in Europe where packaging waste is managed on a comparably high level.

The EPR system shall create financial incentives for more plastics recycling, especially in light of the fact that current disposal options such as unsanitary landfills like Dandora or improper disposal sites in residential, agricultural and protected areas are still the cheaper options compared to recycling.

The creation of recycling targets (such as a certain amount of used plastics which must be recycled within a year) shall result in reduced attractiveness of unsystematic landfills and less waste remaining within the city. The simultaneous implementation of a landfill tax promotes the shift to more recycling at the same time (see chapter 5.1.1).

5.2.2 Segregation at source as best practice and waste collection

Segregation at source and the respective waste collection is a central part of sustainable waste management and recycling. Since segregation and collection systems need to be tailored to the local conditions, they vary globally. Even in European countries with established EPR systems, the collection form of the different lightweight packaging materials varies as shown in Table 4 below.

Table 4: Collection structures for packaging for the individual material fractions in five different countries with EPR systems

	Germany	France	Spain	Italy	Netherlands
Plastic foil (plastic bags) [1]	X[6]	[3]	X[5]	[4]	X[6]
PE and PP	X[6]	X[2)5)6)]	X[5]	X[2)5)6)]	X[6]
PS	X[6]	[3]	X[5]	[4]	X[6]
PET bottles	X[6)7)]	X[5)6)]	X[5]	X[5)6)]	X[6]
PET non-beverage bottles	X[6]	[3]	X[5]	[4]	X[6]
Mixed plastics (rigid)	X[6]	X[2)5)6)]	X[5]	X[2)5)]	X[6]
Mixed plastics (flexible)	X[6]	[3]	X[5]	[4]	X[6]
Beverage cartons	X[6]	X[5)6)8)]	X[5]	X[5)6)8)]	X[6]
Tin plate/ferrous metals	X[6)7)]	X[5)6)]	X[5]	X[5)6)]	X[6]
Aluminium/non-ferrous metals	X[6)7)]	X	X[5]	X[5)6)]	X[6]
Paper and cardboard	X[5)6)]	X[5]	X[5]	X[5)6)]	X[5)6]

1) The target fraction is narrowed down (size > DIN A4) in order to ensure a significant enrichment of LDPE.
2) At the moment: only bottles and/or containers
3) Expected from 2022 onwards
4) It is expected that the collection systems of CONAI (Italy) will be expanded to these fractions as well to fulfil the quotas for 2025 set in the EU packaging directive.
5) Drop off system/'bring it yourself'-system
6) Kerbside collection/pick-up system
7) Deposit system for beverage packaging
8) In France and Italy, beverage cartons are often (estimated 50 % to 80 %) collected together with paper and cardboard and not in the collection system of lightweight packaging like in other countries.

Generally, there are two distinct possibilities to collect waste: either at the household level through kerbside collection systems or on the streets through bring banks (also referred to as drop-off systems or 'bring it yourself'-systems). Some examples from four different countries are presented on the next page (see also Figure 22)

In **Germany,** waste is usually separated into four fractions and collected at the household level through a kerbside collection system. Glass packaging is usually collected through bring banks. The costs arising from collection, sorting and recycling are covered by the PROs. The costs arising from the waste of the "paper, cardboard and carton" fraction are divided between the municipalities and PROs as this fraction includes both paper packaging waste and other printed products for which there is no EPR scheme.

In **Spain,** collection is mainly organised via drop-off containers/banks. Rigid plastic, cans and cartons belong in the yellow containers, and paper and cardboard belongs in the blue ones. In total, there are over 573,000 yellow and blue containers available throughout Spain to collect packaging waste (very high density). From there, packaging is collected and transported to suitable sorting plants that further segregate into more specific fractions.

Figure 22: Waste segregation and collection in Germany (upper left) and Spain (upper right), Japan (bottom left) and Shanghai (bottom right)

The prevalent collection system in **Japan** is a bring system where the waste is sorted in different fractions. Nevertheless, there are also some kerbside collection systems. In several places, the waste collection is complemented by additional collection forms, such as group collections organised by residents. The overall numbers of waste fractions, which are segregated at source, vary across Japan.

In **Shanghai, China**, a waste segregation and colle sction system has been introduced which is based on segregation at source into four fractions: kitchen waste for composting, valuables for recycling, specific waste (like hazardous waste), and residual waste. Inhabitants will be penalised if they fail to segregate properly.

Problems arise when waste management operators do not fulfil the service for which they have been contracted and the collection points are not appropriately taken care of as shown in the examples of Palermo, Italy and Tunis, Tunisia in Figure 23.

Figure 23: Waste collection in Palermo (left) and Tunis (right)

In **Tunis,** several containers for separate waste collection of plastic packaging have been set up in different districts across the city. These containers are built in such a way that the collected plastic packaging is highly visible for everyone and can also be removed by everyone, which is particularly interesting for the informal sector. As a consequence, all valuable plastic packaging (like PET bottles) is removed from the containers and only the valueless, non-marketable plastic packaging remains inside the containers. Another problem is the high amount of litter which is generated as a side effect upon removal at the places where the containers are set up. Thus, the **container design is an important element to consider when setting up a waste collection syste**m (see Figure 24).

Figure 24: Container designs

As the collection costs are covered by the PRO, the following disposal services have to be discussed and negotiated for waste collection:

- Establishment of an infrastructure for the collection of packaging waste
- Documentation of the collection
- Regular emptying of the containers
- Cleaning of the collection points
- Maintenance and care of the containers
- Establishment of infrastructure for the sorting and recycling of plastics waste
- Documentation of recovery and recycling

5.2.3 Product Design for enhanced recycling

Recyclability is the key figure for the qualitative and quantitative behaviour of a product in the post-use phase as it determines it respective recycling process chain for primary raw material substitution. This means, it must be possible that the products after use are collectable via existing collection possibilities and sortable in a qualified manner. Its reprocessability must enable recirculation.

As aforementioned, the recyclability is determined by two factors:

i) the composition of the object, and
ii) the actual existing recycling options after usage, which is why a plastics object is only truly recyclable if an actual recycling pathways exist. Otherwise, it remains 'ready for recycling'.

However, these two factors have a reciprocal connection since the composition of the object often determines whether an object can be recycled through the existing recycling pathways in the respective country. In turn, the existing recycling option can influence the composition and design of a plastic object. There are several steps which need to be considered when designing the product. They are illustrated in a flow chart (see annex 8.11).

The decision about the recyclability is material-dependent – meaning that the decision flow chart has to be applied to each material and the respective item design (bottle or tray).

Based on the prevailing collection and recycling structures in Kenya (see chapter 2.4), it can be assumed that recyclables are aggregated on an item basis both through formal collectors as well as through informal waste pickers and the subsequent, largely manual sorting.

Thus, technical requirements for plastics packaging as well as non-packaging plastics items with regards to their suitability for automatic sorting do not need to be considered. Nevertheless, negatively impacting design trends on the recyclability have been already recognised in the Kenyan context: in particular, this refers to the substitution of PE or PP as valuable and well recyclable polyolefinpolymers with PET (sometimes opaque; see Figure 25), which cannot be recycled by polyolefin existing recycling companies specialized in PE or PP.

Another development leading to reduced recyclability is the usage of filler material (like chalk). This increases the weight, which in turn causes the material to be sorted out as residual waste during the mandatory swim-sink separation (a mandatory step in the recycling process of polyolefin; for more details see *annex 8.3).*

Also, material composites, which are hard to separate, should be avoided as much as possible. For instance, the attached lid on bottles has to be cut off of the bottle and is disposed as residual waste at landfills instead of being recycled (see Figure 26).

Moreover, the combination of incompatible materials (PET bottles with full sleeves made of non-PET) or the usage of fully coloured (opaque) PET material significantly lowers existing PET recycling.

Thus, it is recommendable to create recyclable design standards for selected packaging and non-packaging items.

Figure 25: PET substitution

Figure 26: Attached lids on Bottles

Modulated fees

Incentives for an improved product design for increased recycling can be incorporated into economic instruments like taxes or EPR fees. In France and Italy, for instance, the EPR participation fee for plastics is dependent on the recyclability of the plastics packaging, meaning that the fees for non-recyclable plastics packaging are significantly higher. Thus, using non-recyclable packaging is significantly more expensive for companies putting this packaging onto the market. The criteria for recyclability and non-recyclability are clearly defined and transparent. In the case of France, the EPR participation fee for non-recyclable packaging is twice as high as the fees for recyclable plastic packaging.

The approach of modulated fees is being gradually implemented in other European countries to provide monetary incentives opposing the trend of non-recyclable packaging design and increase actual recycling. Moreover, this instrument is powerful for raising awareness among packaging and product designers for the topics of EoL and recycling, informing them and transferring knowledge about the issue of recyclability upstream the supply chain. A bonus on the EPR levies for recyclable product design is only granted for products which deliver proof of their recyclability. Usually, the recyclability is determined and certified by external institutes and based on regulations and requirements set by the legal frame or PRO.

Moreover, modulated fees can also be applied for the usage of recyclates in the product: If the product contains recyclates, a bonus lowering the EPR levies is granted. This can roughly be verified through the annual production quantities, annual usage of virgin materials and the annual usage of recyclates.

5.2.4 Consumer awareness – communication and education

Complementary to the actions which need to be taken upstream and downstream of the value chain, inclusion of the consumers in the transition to a circular economy has to be targeted. Achieving increased plastics recycling rates is dependent on changing the consumer attitude towards waste. Awareness of the benefits of a proper waste management as well as the adverse effects of an improper waste management is a key element to start this change. In addition, a lack of awareness of waste, its effects on health and on the environment contribute significantly to mismanagement of waste. From communities to schools and universities, to businesses, organisations and governments: All of them play a role in building a culture in which effective waste management systems thrive. There are various means to raise awareness among consumers, such as:

- Guidelines and signs
- Printed media
- Digital media
- Environmental education programs in schools
- Events and campaigns
- Eco-labelling schemes
- Marketing
- Product fees

Consumer awareness starts on an individual level and can be raised through multiple tools. Educating people on the best ways to deal with waste and keeping them updated with the latest strategies and decisions related to waste and waste management can significantly change the way waste is handled. An overview of selected global examples is presented in *annex 8.10.*

School education for long-term impact

One of the most powerful tools to achieve better waste management are environmental education programmes at schools, as it is easier to impact children's behaviour than that of adults. Children can also be an active part in the learning process by transferring their knowledge to their parents, close family, and community. Teaching children from an early age also guarantees a long-term impact, because those children will grow with the knowledge, then pass it on to later generations.

Schools can become a main driver of change needed to achieve a better waste management: The first step is to introduce informative curricula about waste, waste management, and the results of improper handling of waste, as well as the best practices to deal with waste. Integration of waste management curricula in different classes such as science, social studies, etc., helps students to link mismanagement of waste with the effects it has on health and the environment. It also instils in students' minds that waste is inseparable from their lives, and that it can become – if properly treated – a valuable resource for new products and applications offering economic and social benefits, such as introducing different careers in the environment and waste management sectors in the future.

In Ghana, the NGO Environment360 works with schools through programs that focus on teaching children about the proper segregation of waste at source; and introducing them to the green economy and green technology careers. They also collaborate with the Ghana Recycling Incentive Program for Schools (GRIPS) to help schools save money by reducing their waste, and to earn rewards for proper waste segregation.

Moreover, Environment360 runs volunteering programs in which volunteers participate in the initiatives and activities organised by the organisation at schools and communities. An example is the annual Float Your Boat competition, where children design and build boats using plastic bottles and then participate in a race in order to raise funds for environmental education programs in coastal and urban regions in Ghana. 'Float Your Boat' also teaches students how to segregate waste and helps them discover exciting ways to reuse their plastic waste, thereby reducing the amount of waste generated.

In addition to curricula, workshops, events, and campaigns are considered essential tools to practically educate children on waste management. Engaging children in activities that combine theoretical and practical knowledge will enhance their critical thinking and analytic and problem-solving skills which enables students to make informed decisions about waste issues.

Successful examples in other African countries can be found, for instance, in Ghana (see green box).

Product fees as customer incentive for reuse of single use plastics (SUP)

Single use plastics (SUP) are globally recognised as growing problem: due to their convenience, their global demand has been increasing; however, since they are usually only used once and then disposed of, they have a very short in-life phase and generate significant quantities of waste. Solutions to better deal with the arising quantities of SUPs are in demand, such as charging a product fee when selling certain SUPs to incentivise the reuse (one of the three key principles of circular economy) over a new purchase. Although the charges are usually minimal, it is enough to incentivise the reuse as means to save money, which is thus highly effective in countries with price-sensitive consumers.

Generally, it is possible either to increase the price when handing out an SUP (often used for carrier bags) or to give a discount for bringing one's own (reused) SUP (e.g. on coffee-to-go cups). Which of the two possibilities is Kenya introduced a full ban on the use, manufacture and import of all plastics bags used for commercial and household packaging made of PE (see chapter 3.1). For other carrier bags which are sold at supermarkets, the supermarkets collect a fund from the sale of these bags. Other types of SUP products are still available, such as single-use coffee cups.

5.2.5 Biodegradable plastics

The term 'biodegradable plastics' is oftentimes (incorrectly) used in reference to both bio-based plastics as well as biodegradable plastics. However, as described in chapter 2.1, bio-based plastics are derived from renewable sources such as sugar cane and processed into plastic polymers like PE. Bio-based plastics can be recycled just like conventional plastics. In contrast, biodegradable plastics are characterised by their ability to be degraded by microorganisms into water, carbon dioxide (or methane) and biomass under specified conditions. However, biodegradable plastics can be manufactured from both fossil as well as renewable sources [PlasticsEurope, 2018].

Biodegradable plastics are used for a wide range of applications, such as organic waste collection (e.g. as kitchen waste bags), and agricultural purposes (e.g. as films). They can be foamed into packing materials, extruded, and injection-moulded in modified conventional machines. Different types of fillers can be used with the system, such as wood flour, lime, clay or waste paper. Most of the applications for which they are used have a short or very short in-use phase. For instance, there are drinking straws and coffee capsules made of biodegradable plastics available [PlasticsEurope, 2017].

To ensure that biological treatment, such as composting, is a sustainable waste management option, both the biodegradability and compostability as well as the resulting compost and digestate have also to comply with the appropriate standards.

The usage of biodegradable plastics does not pose an advantage over conventional plastics, particularly in comparison to sturdy and long-lasting materials such as cotton or thick plastics suitable for reuse which have more advantages. Repeated usage of the material through recycling is more environmentally friendly than the loss of the material through degradation. For their decomposition, biodegradable plastics require certain temperatures, oxygen content and humidity which would be difficult to achieve outside a laboratory.

However, the critical side to biodegradable plastics is that these plastics can only be degraded under certain temperatures, oxygen availability and humidity, and in the presence of certain microorganisms. These conditions cannot be guaranteed either during conventional composting or at landfills. Biodegradable plastics can contribute just as much to litter and the existing waste problem as conventional plastics as long as there is no proper collection, sorting, and recycling or composting infrastructure.

Even in case of a proper waste management chain, there are several critical issues regarding treating biodegradable plastics in composters:

- Most industrial composters are not able to create the specified environmental conditions, i.e. biodegradable plastics will not be degraded in them and will instead become a contaminant in the compost [DUH, 2018]
- The quality of degraded biodegradable plastics does not fulfil the requirements for compost quality (e.g. European standard EN 13432) leading to contamination [DUH, 2018]
- Biodegradable plastics do not hold many soil substances and merely degrade into water and CO2; therefore, from an environmental point of view, incineration with heat or electricity generation would be a preferred option [DUH, 2018]
- Inaccurate claims over the compostability of biodegradable plastics might confuse consumers or even trick them into thinking that littering these plastics is not harmful to the environment as they are degraded, which is not the case, as was recently shown in research by the University of Plymouth, where biodegradable plastics bags were able to hold shopping items even after three years of being buried in the soil or the sea [Williams, 2019])

Another term, which is often brought up in relation to biodegradable plastics are oxo-fragmentable plastics. Oxo-fragmentable plastics are plastics which can be characterized by the fast fragmentation after usage – however, they are not decomposable. Therefore, the fragmented plastic particles remain in the environment as microplastics litter, contributing to environmental degradation.

5.2.6 Integration informal sector

Informal collectors and recyclers are increasingly recognised for creating value for their cities and countries. They contribute in form of lowering waste quantities, conserving resources, lowering CO2 emissions and especially supplying the local value chain with recyclable material.

The same applies for Kenya, where informal waste pickers collect relevant amounts for subsequent, rather formalised recycling. However, the situation is insufficient both for the people working in these informal relation as well as for the effectiveness of the waste management.

The situation for the informal collectors is highly exploitative as;

- their income is irregular,
- their social situation is insecure,
- they are exposed to high health risks,
- they are vulnerable to unfair business practices and
- they lack access to social security systems.
- from a waste management perspective, a mainly informal system is inefficient as
- only valuables will be collected, while invaluable materials remain uncollected (waste picking, no cleaning service),
- collection occurs only in areas with demand for recyclables (in proximity to the facility and/ or trading point),
- formal collection of remaining waste will become more expensive (because valuables are already removed),
- informal collection and separation often contribute to littering.

This is why informal workers should be integrated or formalised in waste management practices, especially EPR systems. In this context in Kenya, a few initiatives have already been established (see examples of Mr. Green Africa and Clean Green Kenya). Their implementation should be evaluated in relation to positive impact mechanisms for expansion all across Kenya. From a social sustainability perspective, it is necessary that the involved persons keep their source of income.


7
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6.1 Implementing the EPR system

As analysed before, the general waste management structure as well as the plastics waste management structure in particular lack organisational and financial resources in Kenya, which can both be improved through the implementation of an Extended Producer Responsibility (EPR) system. The basic mechanisms of an EPR system were introduced in chapter 5.1.2, complemented by a few global examples. Also, the first steps towards implementing an EPR system in Kenya have already been initiated.

As previously explained, EPR systems allow for a proper and practical strategy to address the plastics situation through their steering function on material usage (upstream) and the operative waste management system (downstream), especially collection and recycling. The first and foremost priority with regards to developing an EPR system for plastic packaging and other specified plastics items is defining the organizational responsibilities to create a sound Producer Responsibility Organization (PRO). The subsequent paragraphs outline the implementation of an EPR system in Kenya under the given contextual conditions in order to define policy recommendations for a policy framework for a transparent and fair system, which ensures that funds are only spent on waste management purposes and competition between the stakeholders along the supply chain is kept alive.
For the waste management practice, this implies:

- Transition from picking and collecting valuables to cleanliness as a service.
- Transition from individual responsibility (take-back schemes) to collective action.

These transitions require that the following aspects are defined in detail, tailored to Kenyan conditions:

What are the first important steps for implementing an EPR system in Kenya?

Against the Kenyan background system, it is crucial to establish a system that is;

i) based on an aligned understanding and planning throughout the private sector, and
ii) robust enough to work, yet quick and easy to implement. Thus, it is essential to establish a system which includes all stakeholders in the supply chain, designates unambiguous rules to the obliged companies and guarantees a level playing field.

As indicated in the name EPR, extending the producer responsibility is initially a purely economic topic. In almost all well-functioning systems, this obligation of the economy is accompanied by the fact that such a system is also initiated and implemented by the private sector. Also in Kenya, the first steps facilitating and influencing the setup of an EPR system should be initiated by the private sector, ideally organised through business membership organizations (BMOs) such as Kenya Association of Manufacturers (KAM) or Kenya Private Sector Alliance (KEPSA), for instance. Moreover, they can ensure that all stakeholders along the supply chain are involved in the process. This applies under the condition that there are external control and validation bodies. The advantage in that is the opportunity for the obliged industry not only to react but also to shape and tailor the system to local and economically viable conditions.

At the same time, political decision-makers need to be involved in the process as well in order to prepare the respective legal framework. As several branches are potentially affected – for instance environment, transport, economics – it is important to include decision-makers from all of these fields. Furthermore, existing political

actions need to be put in congruence and existing legislation clarified in regards to certain aspects as, for example, providing sufficient details on concrete measures to be taken.

Adapting and passing a legal basis is a process which takes time. Thus, it is recommended to found a voluntary PRO, potentially supported by the resources of an existing BMO such as Kenya Association of Manufacturers or Kenya Private Sector Alliance in which companies and organisations can organise themselves, collectively negotiate with the decision makers about the setup of the mandatory system. Voluntary projects related to EPR can be operated in order to gain first experiences. The participation in the PRO will then become mandatory after the law has entered into force. Simultaneously, additional measures based on the legal basis need to be created.

Recommendation on financing the first steps

The first steps are financed through the voluntarily participating companies, which are stakeholders in the plastic value chain. As the process of establishing an EPR system is complex and requires time, it is recommended to support the process (implementation of PRO, first measures and pilot projects, discussions about legal frame) through external third parties. Therefore, a project should be initiated which builds on the Kenya Plastic Action Plan and advances it. Moreover, it is likely to receive funding particularly from European states since the plastics waste issue is currently a topic of high importance. The Kenya Plastic Action Plan is a suitable basis to apply for respective funding.

How should the EPR system be set up?

It is required to ensure the highest level of transparency possible for the EPR system in order to establish a foundation of trust and acceptance. Against this background, it is recommended to start with;

- only one EPR system and one PRO or
- one PRO umbrella organisation uniting the existing schemes like PETCO and Clean Green Kenya

which, in the beginning, exclusively regulates the financing and organisation of defined plastics. Moreover, other complementing economic instruments, such as landfill taxes, should be implemented in parallel for the proper treatment of plastics, covering areas that cannot be covered by the EPR system (see chapter 5.1.1).

One industry owned PRO can be initiated within the organizational resources of an existing business member organization such as Kenya Association of Manufacturers or Kenya Private Sector Alliance. It should pursue – as part of its statutory purpose – a public service mission regarding the collection, recovery, and recycling of the plastics waste covered by EPR. In light of transparency issues, this PRO should be a non-profit organization which acts as a superior institution independently from the individual companies and interests.

The private industry is widely aligned to establish an EPR system which is in the hands of the private industry and a PRO which is run as non-profit organisation; this reflects the ideal setup of a PRO that covers all plastic fractions equally.

It is also possible to establish different PROs for different plastics fractions. However, this comes at the expense of registration, controlling, monitoring and transparency. Moreover, it needs to be agreed upon how to finance joint responsibilities (e.g. awareness-raising and education) and how to balance out the unequal values of the different plastic fractions. In addition, it needs to be defined how the different PROs assume responsibility for the disposal of the residue originating from the mixed collection and subsequent sorting and how the costs for disposal are divided between them.

How are the different stakeholders affiliated with the PRO?

The PRO is the most important stakeholder (organisation) within an EPR system. This organisation is responsible for setting up and developing the system. In order to transform their individual responsibility, which has been fulfilled in Kenya through the various take-back schemes, to a collective one, the producers/users, importers and fillers should give a mandate to the industry-owned PRO. Thereby, the PRO becomes responsible for the fulfilment of all take-back obligations of the obliged companies as the representative entity.

All stakeholders in the supply chain should participate in the PRO. Thus, they should become members in this new organisation. There should be four different forms of participation:

i) **Obliged companies (more details below):** producers/ users, fillers, brand owners who bring their plastic packed goods and plastic products onto the Kenyan market. These companies pay a product-based fee that is proportional to the amount in weight of plastic items they introduce to the market, which is then used to finance all waste management services.
ii) **Members:** Companies which are part of the plastics supply chain. This includes raw material suppliers, plastic packaging and product converters, designers, manufacturers, retailers and traders, and waste management operators for collection and recovery, especially recycling. These companies should pay a membership fee to the PRO for the operation of the PRO.
iii) **Affiliated members (advisory board):** This includes offices of the National government, Counties, universities, NGOs, and other authorities. None of the affiliated members have to pay a membership fee. These institutions and organisations impact the work of the PRO as an advisory board and therefore need to be informed about recent developments, innovations and novelties, as well as similar updates.
iv) **Management (executive board):** The PRO needs an executive board to manage the operative work, financial spending and controlling. This management can consist of one or several persons which can be either chosen by the members or externally appointed. Generally, it is recommended to appoint one chair and a vice chair.

Which plastic items (packaging/ non-packaging) are covered by the EPR system?

In most cases, EPR systems for plastics are set up for plastic packaging, while non-packaging plastic items are usually not covered by the EPR system. However, as EPR has the best steering function both upstream and downstream, it is recommended to include both plastic packaging as well as other non-packaging plastic items in the EPR system to achieve better results in recycling and waste management. Moreover, the EPR system will include all sources of waste generation as it best reflects the Kenyan situation.

Thus, it is recommended that all plastic based packaging (food, non-food, industrial, and transport packaging) as well as composite packaging, which consist of plastics and at least one other material, are included. Quotas for how high the plastic content has to be to be obliged to take part in the EPR system need to be defined. Possible suggestions include at least 50 % of the packaging having to be composed of plastics; however, other percentages are also possible. Since packaging items are consumed quickly and thus have a short in-life phase leading to near-time waste generation, the preferred approach is to cover as many plastic items as possible in the scope of the EPR system. In addition, the collection and recycling structure for the different types of plastics concerned (PET, HDPE, PVC, LDPE, PP, PS, others) will be improved. Generally, it is also possible to create separate EPR systems for household waste and non-household waste (i.e. industrial and transport; secondary packaging) as it is done for instance in other countries such as Germany.

In addition to the plastic packaging, other plastic items which can be covered by an EPR system should be included. This has to be decided on a case-by-case basis by designated decision-making bodies. This concerns particularly plastic items, which are similar to packaging, for instance plastic buckets, plastic hangers, plastic bags and single use plastics (SUPs) (see, for instance, the EU SUP Directive). These additional items also need to be clearly outlined in the legal frame.

It is recommended to clearly label plastic packaging and selected plastic items which are covered by the EPR system and take part in it by paying the fees. Once an obliged company pays, they are allowed to add the label to their packaging and/ or products (comparable to "Green Dot").

Thus, companies introducing plastic packaging (sold to private households, agriculture, industrial and transport packaging) and/or other plastic items covered by the EPR system on to the Kenyan market as laid out in the legal frame, are obliged to participate (they are 'the obliged companies'). Moreover, it means that the following applications are excluded from the EPR scope: packaging for hazardous content, and other non-plastic packaging materials and plastic items that cannot be covered by the EPR system like plastic items for permanent built-in components such as pipes.

As mentioned, other non-plastic packaging is currently not included, while in most countries with EPR systems generally all packaging materials are covered. This is meant to keep a balance between the various packaging materials and thereby avoid undesired, ecologically questionable substitution effects of different packaging materials.

Who are the obliged companies that have to pay for the EPR system?

In an EPR system, it has to be legally determined who has to pay for the system and through which interface these obliged parties can be identified. As aforementioned, the obliged companies are based on the definition of which plastic items (packaging and non-packaging) are covered by the EPR system. Moreover, it is a determining requirement that these plastic items are put on the market in Kenya for consumption in Kenya i.e. will become waste in Kenya. Thus, these companies have to finance the operation of the waste management services. In particular, this includes two groups (see also Figure 27):

- Users (producers)/ fillers for the sale of their packed goods in Kenya for consumption in Kenya
- Importers for the sale of their goods in Kenya for consumption in Kenya

Through which interface can it be ascertained which packaged goods and other non-packaging products are being put on the market in Kenya?

The obliged companies (see definition above) comprise of:

- Plastic packaging which is filled in other countries and is imported to Kenya
- Plastic packaging which is filled in Kenya and consumed in Kenya
- Other non-packaging plastic products which are imported to Kenya
- Other non-packaging plastic products which are produced, sold and consumed in Kenya

To measure the exact amounts of these items, the following criteria can be used: sales revenues (in the respective segment), mass (weight), number of items, filling volume, and area. In most countries, mass has beenproven as the most practical measurement unit; some countries, such as Spain, also have an additional number of item -based fees.

Figure 27 illustrates the most suitable interface for the steps in the supply chain when the items are introduced onto the market.

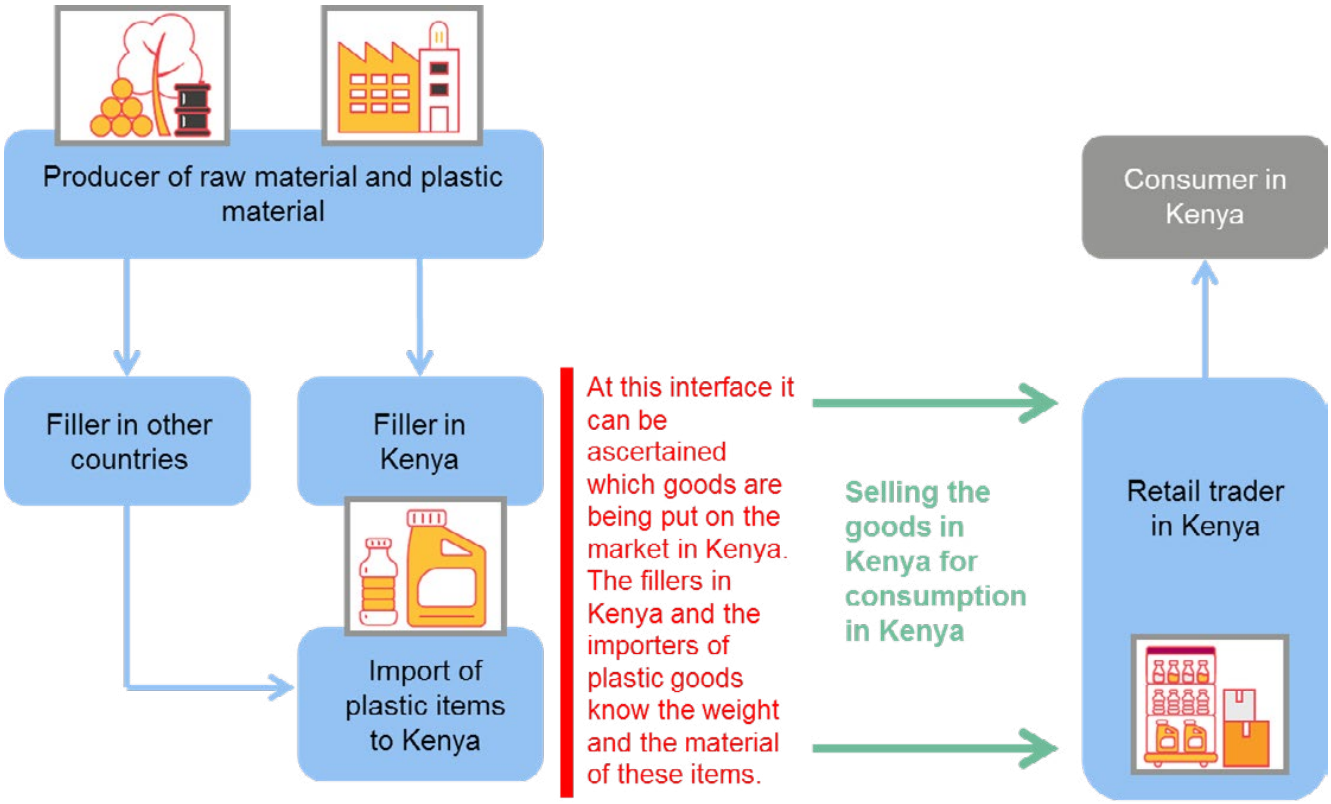


Figure 27: Interface for determining the obliged companies

How to oblige the informal packaging users?

Since the informal sector is not only limited to waste operators but also includes packaging users, it is important to integrate these informal packaging users into the EPR system; it is of major importance as the majority of the domestic packaging users belong to this group. Thus, it is crucial to find an approach which also financially covers these plastics quantities in the EPR system. One possible approach is to oblige the manufacturers that are selling packaging material to these non-licensed packaging users to pay the fees for them, instead of levying informal businesses directly. This should be complemented by a definition of a maximum quantity of packaging per year (e.g. 300 kg per year) per user. In turn, the manufacturers forward the costs for paying the EPR fees to the non-licensed packaging users in form of a surcharge. This economic incentive is aimed at the non-licensed users to integrate themselves into the system in the long run: if a packaging user shows their licence which verifies their participation in the EPR system, no surcharge from the manufacturer is raised as the packaging users pay their levies directly to the EPR system for the packaging used in the Kenyan market.

How much should be paid by the obliged companies?

The exact amount that needs to be paid is proportional to the specific goals which are pursued. To keep the risk of under- or overestimating the costs needed for the waste management task financed by the EPR system as low as possible, it is recommended to pursue specific measures as goals as their costs are the easiest to calculate. Since the PRO should be set up as a non-profit organisation, the total amounts paid by the obliged companies should equal the expenses for all waste management costs. To calculate the costs, it is required to estimate;

i) the amounts of waste which will arise from the plastics items covered by the EPR system, and
ii) the costs needed for the treatment of these amounts of waste.

It is recommended to calculate a defined amount (per material and mass) which will be evaluated after three to five years and adapted to developments and trends. It is also possible to introduce modulated fees to provide a steering function in regards to recyclable product design (see chapter 5.2.1).

To provide an idea on the expected costs, an overview of current EPR fee models is provided. It should be noted that the underlying EPR systems are well established and in some cases comprise only household packaging (H). Others also include commercial and industrial (C/I) packaging, as it is also recommended for Kenya. The fees are ultimately adapted to the prevailing conditions (including underlying infrastructure, measures to be financed, costs, organisation and control).

Table 5: Plastic packaging fees in EU-28 EPR schemes [Watkins et al., 2017]

	Plastic (general unspecified)c		PET/ HDPE	Beverage cartons		Other/Composite Material	
	H	C/I	H	H	C/I	H	C/I
Austria (ARA)	0.6100	-	-	0.5800	-	0.6100	0.1000
Belgium (FOST-PLUS)	0.2823	-	0.2107	0.2455	-	0.2823	-
Bulgaria (EcoPack)	0.0800	0.0800	-	-	-	0.1000	0.1000
Croatia (Eko-Ozra)	-	-	0.0550	0.0550	0.0550	0.1000	0.1000
Cyprus (Green Dot)	-	0.0380	0.1060	0.1230	-	-	-
Czech Rep (EKO-KOM)	0.2060 › 5l: 0.1540	0.0220	-	0.1580	-	0.2230	0.2230
Estonia (ETO)	0.4090	0.1090	-	0.1050	-	-	-
France (Eco-Emballages / CITEO)	0.3120	-	-	0.2470	-	-	-
Greece (HE.R.R.Co)	0.6600	0.6600	-	0.5700	0.5700	-	-
Hungary (Ökopannon)	0.1850	-	-	0.0620	-	0.1850	-
Ireland (Repak)	0.0892	0.0892	0.0892	0.0758	-	-	-
Latvia (Latvijas Zalais Punkts)	0.1490	0.1490	-	-	-	-	-
Lithuania (Zallasis taskas)	0.0810	0.0810	0.0810	0.1220	0.1220	0.1250	0.1250
Luxembourg (Valoriux)	-	-	0.3703	0.2835	0.2835	-	-
Norway (Gront Punkt)	0.3876	0.3876	-	0.1200	0.1200	-	-
Poland (Rekopol)	0.0046	0.0046	-	-	-	-	-
Potugal (Sociedade Ponto Verde)	0.2319	0.2319	-	-	-	-	-
Romania (ECO-ROM Ambalaje)	0.1330	0.1330	0.1330	-	-	-	-
Slovenia (Slopak)	0.1340	0.1340	0.0770	0.0100	0.0100	0.1340	0.1340
Spain (Ecoembedes)	0.4720	-	0.3770	-	-	-	-
Sweden (FTI)	0.2440	0.2200	-	-	-	-	-

H = households; C = commercial; I = industrial; all prices are per kg

It is recommended to price all plastics that consist mainly of mono materials with the same amount. An exemption to this could be made for special cases, e.g. PVC from household packaging, since there are no proper recycling options in place in Kenya. The same applies for opaque PET packaging and PET trays in general. In order to balance packaging fees for beverages, it is also recommended to define a levy for beverage cartons. Otherwise, this could lead to unexpected substitution effects.

The price of composite packaging, meaning packaging made of different materials (e.g. material composites that cannot be manually separated and of which none of the used materials exceeds more than 95 % of the total composite packaging weight) should be comparably high. This is due to the fact they are not or only poorly recyclable, both in quality as well as in quantity.

In an initiating phase of implementing fees, the same prices should be used for both household packaging and additional products as well as plastics packaging and additional products from commercial and industry resources.

Recommendation for modulated fees

Modulated fees are not the first step to be taken when implementing an EPR system. Even in Europe, this approach has been in place for only three years. In the Kenyan context, the initial focus should be on increasing the recycling of plastics. Against this background, a regular forum should be established that acts as a platform for recyclers and collectors to discuss recent challenges and problems and to discuss potential solutions to increase recycling. This step is followed by developing standards for specified products and packaging categories, followed eventually by modulated fees.

As a recommendation for practice, formalised and informal collectors and recyclers should come together to identify the problems which they are facing in the daily business in regards to product design (see chapter 5.2.3) and summarise them in a guide as a basis for discussion with the plastic producers. Based on this guide, a standard should be developed at a later stage. Please note that modulated fees do not equal varying fees for different materials (as the example shows, see Table 5) – modulated fees are a measure to implement an incentive to further advance recycling in an already well running and balanced EPR system.

What are targets of the EPR which should be fulfilled by the PRO?

The overall system of the EPR is the establishment of collecting, sorting, and recycling infrastructure for plastics which are covered by the EPR system. To achieving this, several types of targets are possible:

a) **Quotas (collection quotas, recovery quotas):** These are the most common targets used in established EPR systems. In the current Kenyan situation, the challenge arises that quota attainment is poorly controllable, as e.g. the absolute size of the marketed quantity is unknown and a number of participants are difficult to identify. Prospectively, the inclusion of a quota is possible with further development of the EPR system.
b) **Rate of linkages to system:** This means that within a certain period of time, a certain proportion of the population should be linked to a waste collection structure (for example, after five years, 20 % of the population must be connected to an infrastructure). Again, it is difficult to control the achievement of goals, since a formal collection structure has not been achieved yet in large parts of the country.
c) **Specific waste management measures:** Alternatively, specific, measurable waste management measures can be specified for the abovementioned goals. They can be increased in the course of further development. This has the advantage that the costs can be calculated more precisely (i.e. the financing requirements of the PRO), be better controlled and react more flexibly towards unexpected developments. In Spain, the EPR system was initially implemented with such targets.

For Kenya, it is recommended to use c) specific waste management measures. Regarding implementation, it needs to be noted that some measures need to be reconciled with third parties like the Counties. Deciding on a recycling quota or the increase based on the status quo is not recommended as there is a lack of reliable data. Therefore, determining a specific minimum (e.g. 50,000 mt) of annually recycled plastics, which needs to be achieved within a defined period of time, is more suitable (e.g. 3 a).

The establishment of a reliable reporting and controlling system as basis for monitoring and progressing of the system is essential. The controlling focuses on three dimensions:

i) **Fulfilling the operational services of the PRO:** The PRO structure needs to be transparent. This enables visibility on potential misconduct of single deciders within the organization and allows for the structures to be adapted accordingly (particularly important in the initial phase).
ii) **Prevention of free riders among the obliged companies:** An effective measure is to register all obliged companies to report their amounts of plastic packaging and additional plastic items covered by the ERP system. In other states, it has been proven successful to publish the registered obliged companies (e.g. via website). This way, free riders can be identified by the authorized controlling body and also by competitors. Furthermore, with the published data it is possible to validate plastic amounts at least roughly by gaining knowledge about the sector and revenues of the single companies.
iii) **Fulfilment of operational performance by waste management operators:** It is important that all stakeholders (collectors, sorters, recyclers) which provide services to the PRO are paid correspondingly and are also registered and licensed. This also includes a general suitability assessment. As an additional key element, the mass flows which are handled by them as part of their operative business need to be documented.

Who is controlling and which instruments are suitable?

It has to be anchored in law who is responsible for the success of the EPR system. Three different control mechanisms can be distinguished. It is recommended to regard all three elements with the following tasks, which correspond with the interests of controlling parties:

i) **Self-assessment**: This control is based on the principle that every deviation from the rules leads to market distortion (if one party does not fulfil their responsibilities and duties, all other involved parties have to bear the resulting disadvantages, e.g. free riders). Thus, registration, data gathering, reporting as well as accounting of the funds should be in the hands of the PRO. The PRO installs a controlling mechanism based on self-interest, which specifically focuses on the prevention of free riders.
ii) **Control by a public agency (defined by the state):** The responsible controlling agency has to be explicitly named in the law and needs to be staffed with knowledge and finances. The controlling tasks cover the fulfilment of the operative task of the PRO with regards to achieving the targeted goals (collection and recycling). This can be done through both random on-site controls as well as through controlling the reports of the PRO in terms of the fulfilment of the targets.
iii) **Public control:** This describes well informed consumers, who can recognise misconduct and point out mistakes of the operative management.

For developing a legal framework, only the control by a public agency has to be defined. Therefore, the competent authority has to be specifically named. In most cases, a new section in the Ministry is created which is only responsible for the EPR act. They control and validate e.g. reporting by the PRO that declares the fulfilment of the EPR aim.

Which taxes/ levies should be implemented additional to the EPR system?

In case of a well-running EPR system, no further taxes or levies in the sense of penalties for users, importers and fillers of packaging as well as for additional plastic products are needed, as it would otherwise be a double payment. The monetary steering function of an EPR system is particularly effective if poorly recyclable plastic products and packaging items are significantly more expensive.

For economic impacts that currently burden the Kenyan recycling, it is necessary to implement additional taxes or levies in the long run. This means limiting the possibilities of cheap landfilling and disposal. For this, improper disposal needs to be penalised and the gate fees of existing landfills need to be increased. The raised gate fee has to be used aimfully for redeveloping measures of landfills and dumpsites as well as developing waste management in general. This strategy can only lead to successes if illegal dumping is strictly controlled and prohibited.

How can the Counties/ local authorities be included?

A close partnership between the Counties/ local authorities and the industry-owned EPR organisation is a relevant condition for the success as well as the economic and environmental sustainability of the EPR compliance scheme.

Municipalities/ local authorities have several key roles to play, as they

i) Help to set up the collection points
ii) Agree with the EPR organisation on the most appropriate collection system, taking into account local particularities and the conformity with national requirements.
iii) Cooperate with the EPR organisation in regards to:

- local public communication and awareness programmes
- data gathering and monitoring
- controlling the waste management operators and
- tendering for collection services and pilot projects

How can the licences and fees for waste collectors and recyclers be harmonised?

A fair and transparent EPR system requires the equal treatment of all participating stakeholders nation-wide. This also includes licences and fees for collection, transportation and recycling. Thus, discussions are needed with the competent authority granting these licenses upon EPR implementation. In Kenya's case, the respective entity is most likely the National Environment Management Authority (NEMA). Unequal licences and requirements will inevitably lead to imbalances in the waste management and recycling sector.

At the same time, the already existing registration system for collectors and recyclers can be integrated into the EPR system. For instance, it is possible that only registered companies are allowed to participate. This requires equal treatment and harmonization as well as countrywide integration and formalisation.

In case different fees apply, they have to depend on legal framework conditions. The size of the company (No. of employees), processed amount and/or turnover are possibilities to be defined in this case.

Which responsibility does each stakeholder have in the proposed EPR system?

The following Table 6 summarises the role of all involved stakeholders in the plastic supply chain in Kenya.

Table 6: Role of each stakeholder within the proposed Kenyan EPR system

Stakeholder	Role
Manufacturers of packaging material or of packaging and additional plastics products	• should enable reuse and ensure recyclability of packaging materials and should use secondary raw materials where possible • exchange (forum) with collectors and recyclers in order to improve recyclability and standardisation
Consumer goods companies (users, fillers and importers)	• obliged to pay fees to the EPR system for the plastic packaging material of their packed goods and additional plastic products • need to be registered with PRO
Distributors/retailers	• can optionally be obliged to take packaging and selected plastic items back and to ensure their proper handling
Consumers	• have to be informed about strategies for waste reduction and proper collection (incl. participation in pilot projects for e.g. separate collection) • public control
Waste management operators	• receive funds from the EPR system for their services for handling packaging waste • need to be registered with PRO/ authority
Public institutions	• legislation and supervision of the EPR system • registration of waste management operators • support pilot projects
Counties and municipalities	• support collection and recycling or collect themselves • inform consumers • take part in pilot projects

6.2 Implementing voluntary measures

As the setup of an EPR system is the central element for creating the financial and organisational basis, the proposed measures based on chapter 5.2 are connected to the proposed EPR approach.

For stakeholders along the plastic supply chain, especially companies proposed to be obliged it is beneficial to participate right from the start as this offers them the possibilities to

i) Actively shape the system which will become mandatory
ii) Be connected with the public authorities
iii) Be well prepared instead of only reacting
iv) Give them an indirect benefit compared to their non-participating competitors as they are better prepared

In order to do so effectively, it is recommended to **found an organisation which will act as pre-organisation to the PRO (so called PRO pre-organisation). Voluntary participation is, however, not limited to the obliged companies** – developing a tailored system should be done by **all companies and organisations along the plastic supply chain.**

The following measures should be organised, prepared and financed by the pre-organisation. However, these funds are independent from the fees which are paid within a mandatory EPR system by the obliged companies.

Implementing a pre-organisation is a lengthy process with several tasks and steps to take. Hence, to supporting the development of the pre-organisation through international funds should be discussed. For instance, this includes the implementation of a suitable legal status of the organisation as well as the preparation and development of internal sections and departments.

Which measures on a voluntary basis are recommended?

Prior to the formalised implementation of and EPR system it is recommended to first gain practical experiences on a voluntary basis; these will then be evaluated in regards to the further development. These are voluntary projects and have to be clearly defined in order to keep the costs calculable and the risk low. This is crucial for the voluntarily participating companies. Suitable pilot projects relate to the evaluation and improvement of collection, recycling and monitoring, e.g.

- Separate collection and recycling of plastics or recyclables in general in specified sectors (e.g. schools, universities, retailers/malls, eco-tourism etc.) and/or areas (rural touristic areas, inner city etc.) that serve as a role-model character to scale up nationwide.
- Increase sorting, e.g. through providing technical plants, space and/ or aggregates tailored to the regional conditions.
- Increase of technical equipment and knowledge for the respective operation, e.g. press and fork lifter to optimise transport processes.
- Increase environmental education and communication, e.g. through creating a forum and consumer awareness campaigns with a focus on middle income households.

Promote segregation at source as best practice and waste collection

As waste segregation at source is only done to a very limited extent, it is important to initiate pilot projects for waste segregation to start gaining first experiences and introduce the consumers gradually to this practice. Such pilot projects can be introduced in various fields, as shown below:

- Waste segregation in schools and universities: Schools and universities are ideal places to initiate waste segregation at source as the children and students can be well educated there, can impact their families at home and their community, and ensure a long-term impact if educated at an early stage of life. Moreover, schools and universities offer less anonymous environments. Segregation should be easy yet effective; for instance, by collecting all dry recyclables (plastics, paper, metals) and the rest as residual waste. Such projects have already been initiated in Kenya in several schools (see Mr. Green Africa). The material segregated and collected at the schools needs to be regularly collected by either the counties / municipalities or private companies and verifications about the collected quantities, sorted and recycled quantities and revenues and finances. Simultaneously, a corresponding sorting needs to be developed.
- Companies, organisations, ministries and other public agencies: Similar to the set-up at schools and universities, waste segregation projects can also be initiated at companies, organisations, ministries and other public agencies, which are willing to become role models in this field and educate their employees and members. Also here, these sites offer less anonymous environments (compared to for instance big markets) and the material segregated and collected needs to be regularly collected by either the counties / municipalities or private companies and verifications about the collected quantities, sorted and recycled quantities and revenues and finances.
- Eco-tourism: In the field of eco-tourism, waste segregation projects can be well established in this field with additional focus to reduce plastics as much as possible (where suitable) and collect the remaining plastic waste and forward it to suitable sorters and recyclers.
- Waste collection at the household level in urban areas: It is recommended to initiate pilot projects for waste segregation at source and collection with bring banks, where the containers are set-up in the streets. It is important to set up these containers in sufficient numbers within a defined district so that it is within a comparably short walking distance for the inhabitants so that separating waste is a convenient activity. Moreover, the inhabitants of this district need to be properly informed and educated about the need for waste segregation. Additionally, a few sites for piloting kerbside collection is also recommended.
- Waste collection at the household level in rural areas: Establishing central point for waste collection, from which the waste is collected by trucks and the recyclables directly sorted out on the truck.
- Integration of the informal sector in collection: It is important to ensure that all waste (valuable and non-valuable) is collected opposing to collecting only the valuable waste as this leads to cherry picking (e.g. PET bottles) while non-valuable waste (e.g. mixed plastics) as well as waste, which is difficult to collect (e.g. sweet wrappers), remains littered, i.e. a transition from material picking to cleanliness as service is crucial. As waste collection is mainly in the hands of the informal sector, it is important to include them in this transition. For instance, it is possible to divide a certain area/district and assign parts of this district to informal collectors, which are tasked to collect all littered waste and sort is subsequently after collection. They are paid for the cleanliness of the area instead of the amounts of recyclables they collect. The amount of payment should equal the revenues they would make from picking valuables. It is important to note that implementing such pilot projects require a very high amount of organisation and controlling to ensure that the cleanliness is provided.

In regards to the collection at the household level, it is targeted to establish regular collection rhythm through formal collection. Therefore, both the Counties / municipalities as well as already existing formal collection services need to be included in this.

In case of mixed waste collection, it is important to ensure suitable sorting as subsequent step. Thus, space need to be identified in collaboration with the counties / municipalities, which will be assigned as sorting spaces. These spaces should be located close to the following treatment steps and easily accessible transportation-wise. The technical steps of the sorting should be complemented through manual sorting steps like drum sieves (for separating particles with a size < 40 mm, which should include mainly organic particles). Moreover, the usage of magnetic separators for removing the ferrous metals is recommended; however, this could otherwise be manually done. Generally, the sorting should regard the existing recycling and marketing possibilities of recyclables to generate a residual waste stream, which contains as less valuables as possible for the following disposal.

To increase the effectiveness of the transportation, baling machines that can compress the material should be utilized on site. By making use of these, the volume of the waste is compacted; i.e. more material can be transported per vehicle. In turn, this requires transport vehicles which are suitable for transporting the increased weight and additional equipment to load the bales up on the vehicles are needed (e.g. forklifts).

Last but not least, collection can become also legal defined target of the EPR system, e.g. by defining how many collection bins should be set up within a defined period of time in the public space.

Recommendation on integrating the informal sector

The informal sector plays an important part in Kenya for the collection and marketing of recyclable waste. These pre-recycling activities should be integrated into the EPR system. The affected informal workers should not lose their source of income. Furthermore, these workers are experienced regarding the value of recyclables, possibilities to market the recyclables as well as challenges and problems and are thus well-qualified for formalised companies that need employees for collection, sorting and/ or recycling. The payment for their work in a formalised context should be higher than their revenues from selling recyclables informally. As estimated from the research conducted for this report, their individual revenue marginally exceeds the current minimum wage. Moreover, it is recommended to implement respective pilot projects to gain experiences on how to best integrate them.

As a functioning EPR system offers reliable organizational structures as well as a permanent financing basis, integrating informal workers into the system offers many benefits. Generally, there are two possibilities for how the informal worker can be integrated: either as an employee (see Table 7) or as a business partner, which offers them the possibility to remain independent as a person but formally cooperate with established companies and organisations (see Table 8).

Table 7: Integration of the informal sector as employees

Informal sector	Integration as employees
Irregular income	Regular income
Insecure social situation	Improvement of the social situation
High health risk	Minimisation of health risks
Vulnerability to unfair business practices	Reliable and fair business partners
Lack of access to social security systems	Access to social security systems

Table 8: Integration of the informal sector as business partners

Informal sector	Integration as business partners
Uncertain commercial base	Fixed service agreements
Uncertain marketing conditions	Reliable acceptance of recyclables
Uncertain situation for employees	Improvement of employee situation
High operational risks	Risk minimisation
Vulnerability to unfair business practices	Controlled business practices

Waste collection will become formalised through the implementation of a mandatory EPR system, which will increase the pressure on informal workers to integrate themselves into the system through formalisation. If not, they face the risk of having limited access to the waste. Thus, it is crucial to integrate informal workers from an early point onwards and inform them on possibilities and solutions. In particular, the following aspects are crucial for the integration:

- Confidence building, trust building and highlighting potential benefits,
- Information and professional support,
- Legal advice,
- Employment contracts for employees,
- Service contracts for business partners

Promote recycling

By increasing the amounts and effectiveness of collection and sorting of plastic waste, more and more reliable quantities of recyclable plastic waste become available for recycling. To support the formally registered recyclers, it is possible to apply for grants or support for e.g. equipment (funds, for instance, granted by the PRO). These applications need to be approved by an independent body and consider usefulness and necessity.

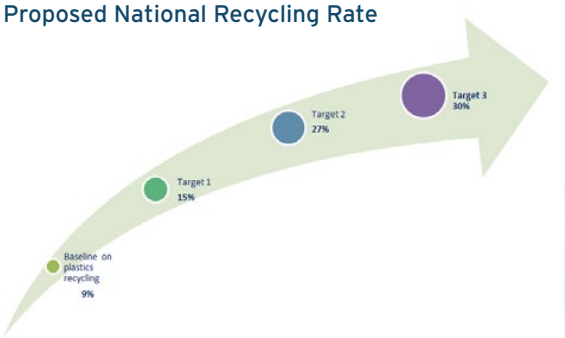
Moreover, it is recommended to identify which plastic converters would use the produced recyclates for non-food packaging and other non-food items as food-grade applications for recyclates are very critical. As long as recycling capacities for plastic waste are not fully developed within Kenya, it is recommended to search for recycling possibilities abroad as an intermediate solution (until the recycling capacities have been sufficiently increased). Please note that **it is recommended to only export sorted plastic fractions which are already prepared for recycling, but no mixed waste.**

Promote product design for enhanced recycling

In light of the current Kenyan situation, it is recommended as a first step to strengthen collection and recycling before measures like modulated EPR fees are introduced. Against this background, a recurring forum should be established which offers a platform for exchange between recyclers, aggregators and collectors with packaging and product designers and converters in order to;

i) share insights on recyclable product and packaging design,
ii) discuss current developments and challenges, and
iii) jointly develop strategies and solutions to increase recycling. Moreover, it is recommended to prepare guidelines which entail the insights on recyclable design. These measures should be financed by the PRO. A suitable contact for exchanging with recyclers is, for instance, 'The Kenya Association of Waste Recyclers'.

Proposed National Recycling Rate



From a mid- and long-term perspective, this should be followed by the development of standards for specific product and packaging groups as well as a modulated fee once the EPR system has been set up.

Recommendation on biodegradable, bio-based and oxo-fragmentable plastics

The usage of biodegradable plastics is seen as problematic and is only recommended for limited application purposes including those which are in a direct connection with organic application sectors (e.g. agricultural foils remaining in the environment). It is crucial to ensure that these biodegradable plastics are degraded under the given climatic conditions within a short timeframe. For all other applications, the biodegradable plastics are not regarded as suitable, as they can only be degraded effectively under laboratory conditions.

The usage of bio-based plastics is not affected by this. However, it is important to note that farming the raw materials for manufacturing these bio-based plastics competes with farming for food. Moreover, they need to equal fossil-based plastics in the sense that they are not obstacles to recycling them.

Since oxo-fragmentable plastics fragment into plastic particles, which remain in the environment as microplastics litter and contribute to environmental degradation, it is highly recommended not to use these oxo-fragmentable plastics for any application; or even enact a ban on them.

Promote consumer awareness

The EPR compliance scheme should involve a strong collaboration with all stakeholders ranging from public authorities to inhabitants and waste operators – each with a designated role to play. Recommendation: Precisely put down in the law that the PRO needs to inform the inhabitants and all stakeholders involved in a proper and suitable way by using various forms of media and publishing on a regular basis. There are multiple channels which can be used for promoting consumer awareness, including social media.

It is also possible to initiate campaigns on different scales (national, regional and/ or local), e.g. in the form of a national clean-up day or "waste week"-campaigns in schools. Waste Week is a programme designed to help schools tackle waste and recycling both on campus and in the classroom. The Waste Week campaign is designed to comprehensively educate and help students see the difference they can make and encourages schools to work towards Eco-Schools accreditation (a formal award). The campaign has unique student-led activities for the classroom and eco-teams – students are informed, inspired and empowered though the campaign to activate change. In 2018, over 1,800 schools took part in international Waste Week. According to an evaluation of the success;

- 84 % of schools said it helped raise students' awareness of the issues
- 70 % of teachers said it helped encourage students to take action outside of lessons
- 98 % of Primary students and 91 % of Secondary students said the campaign made them want to protect the environment.

6.3 Implementation Matrix

Specific measures to start action need to be continued based on the approaches which were developed as part of the Kenya Plastic Action Plan. The central element for the implementation is the outlined EPR system (see chapter 6.1). This revolves around a complex process in which multiple stakeholders need to be included.

Based on the experiences from other countries, it is also a process which takes time and needs a long-term orientation. Thus, we recommend starting with a group of stakeholders working on a voluntarily basis towards the establishment of a legal frame. For participating companies and organisations, this would prove to be advantageous as they can actively engage and therefore shape the implementation process (see also chapter 6.1).

Accordingly, implementation of a mandatory EPR scheme requires three main steps, which are outlined in the following tables:

i) **Establishing a legal basis for a mandatory EPR system** (see): It is recommended that a mandatory EPR system is established through a corresponding law. This requires agreements and discussions between competent authorities and the private industry.
ii) **Establishing a pre-organisation on a voluntary basis** (see Table 10): To initiate this process, a PRO on a voluntary basis should be established as a pre-organisation for a later mandatory PRO, when the law comes into force. Although such a voluntary system is limited in performance and effectiveness, it is suitable in establishing the organisational and regulatory foundation and control mechanisms. Furthermore, this pre-organisation has to fulfil self-set targets (e.g. annual amount of plastic recycled). Besides this, the pre-organisation will conduct essential projects and measures to gain experience on how to best apply certain measures in a Kenyan context (e.g. in terms of collection and recycling as well as creating registers and control mechanisms, determining the fees etc.).
iii) **Improving an optimising mechanism when the mandatory EPR system comes into force** (see Table 11): Even after a legal framework has been established and a mandatory EPR system is in place, steps must be taken to ensure that the EPR system and the PRO are continuously being optimized and evolve.

Short term measures: describe actions that can be taken immediately, given a political consensus. They entail, with respect to the legislative framework, enacting bans and other orders. They also include measures put into place by the private sector, possible within the current framework of policies and laws, e.g. changing behaviours and business practices. Starting projects, discussions and initiatives that enable medium and long term measures are also part of this category.

Medium term measures: describe actions that need preparatory time in order to fulfil their functions. The set-up of a new institution with its tasks, its organizational structure and its role in the given regulatory framework is included here. It also refers to processes of coordination that determine how to share tasks and responsibilities in between different organizations and institutions.

Long term measures: build on discussions started as short term measures and on institutional and organizational set-ups initiated as medium term measures. In addition to the aforementioned, experiences have to be built in order to achieve incremental change and improve structures and processes.

(see Table 11): Even after a legal framework has been established and a mandatory EPR system is in place, steps must be taken to ensure that the EPR system and the PRO are continuously being optimized and evolve.

Table 9: Establishing a legal basis for a mandatory EPR system

No.	Objective	Activities	Target	Actor	Time frame
1	Prepare for legal framework	Present and discuss outcomes of Kenya Plastic Action Plan with relevant stakeholders of plastic supply chain	Align understanding of an EPR scheme, PRO and KPAP across all relevant parties involved (private industry)	KAM (optional with other aligned associations)	Short-term (should start immediately)
2	Prepare for legal framework	Present and discuss outcomes of Kenya Plastic Action Plan with national and local authorities	Align understanding of an EPR scheme and plan across all relevant parties involved	KAM (optional with other aligned associations)	Short-term (after launch of KPAP)
3	Prepare for legal framework	Set up a competent body in order to control reaching the objectives of a mandatory EPR scheme	Prepare for EPR being put into force by a competent government body	National authority (ideally coordinating with the initiating private sector)	Mid-term
4	Prepare for legal framework	Establish knowledge, human and structural resources of the competent body	Prepare for EPR being put into force by a government body	National authority (ideally coordinating with the initiating private sector)	Mid-term
5	Tailor EPR framework to Kenyan conditions	Define - Responsibilities and obliged companies - plastics covered by EPR - targets - control by competent body - exemptions	Create a mandatory EPR scheme that is practical, clearly defined, substantial and measurable	Competent body in cooperation with private industry	Mid-term
6	Tailor EPR framework to Kenyan conditions	- Coordinate with parallel legislation to avoid double payment - Harmonising existing (environmental) law (e.g. transport) - Use existing laws for licensing/registration - Laws to support recycling in general (e.g. landfill tax) - exemptions	Create a mandatory EPR system that doesn't conflict with but is ideally supported by laws	Competent body	Mid-term
7	Tailor EPR framework to Kenyan conditions	Evaluate drafted legal framework and its impact on the private sector	Insights on benefits, upcoming issues and potential future consequences for the private sector in order to observe these after implementation and act accordingly	Competent body	Mid-term
8	Roll out of legal EPR framework	Put developed framework into force	Mandatory EPR system	National authority	Long-term

Table 10: Establishing a pre-organisation on a voluntary basis

No.	Objective	Activities	Target	Actor	Time frame
1	Present and discuss a pre-organisation on a voluntary basis	Present and discuss outcomes of Kenya Plastic Action Plan with relevant stakeholders of plastic supply chain	Align understanding of an EPR scheme, PRO and KPAP across all relevant parties involved (private industry)	KAM (optional with other aligned associations)	Short-term (should start immediately)
2	Set up a pre-organisation on voluntary basis	Identify, connect and combine relevant Stakeholders and obliged companies that are willing to participate Establish parameters for a pre-organisation	Create an organisation that participates actively in the development of a legal framework (see)	KAM (optional with other aligned associations)	Short-term (should start immediately)
3	Set up a pre-organisation on voluntary basis	Define - Responsibilities - Targets and aims - membership - membership fees - reporting	Prepare a pre-organisation that is meant to become the mandatory PROS	KAM (optional with other aligned associations)	Short-term
4	Initiate a pre-organisation	Establish knowledge, human and structural resources of the competent body	Prepare a pre-organisation that eventually becomes the mandatory PRO	KAM (optional with other aligned associations)	Short-term
5	Initiate a pre-organisation	Public relations work and acquisition of members	All companies and organisations along the plastic supply chain can become member in the voluntary PRO, not just the future obliged companies. Developing a tailored system should be done by all companies and organisations along the plastic supply chain.	KAM (optional with other aligned associations)	Short-term
6	Start pre-organisation	Establishing and roll out of pre-Organisation	Implement an organisation that participates actively in the development of a legal framework (see)	KAM (optional with other aligned associations)	Mid-Term
7	Run pre-organisation	Run measures and pilot projects in order to develop an entire and proper plastic collection and recycling and waste data gathering, evaluation of insights	Create a waste management structure that can be scaled up through a multi-step approach and be the basis for a national implementation	Pre-organisation together with partners of supply chain	Mid-term

8	Run pre-organisation	Run measures and pilot projects in order to develop a sound mandatory PRO. This would include: - registering obliged companies - calculating their fees and establishing a controlling system to avoid free riders or false reporting - measures for mass flow validation - raising awareness - integrating informal sector - reporting to measure goal progress	Create necessary mechanisms to prepare for transition to a mandatory PRO	Pre-organisation together with partners of supply chain	Mid-term
9	start mandatory PRO	Transition from a voluntary pre-organization to a mandatory PRO	Create a proper, well-prepared mandatory PRO to achieve aims of the EPR framework	Pre-organisation	Long-term

Table 11: Improving an optimising mechanism when the mandatory EPR system comes into force

No.	Objective	Activities	Target	Actor	Time frame
1	Run mandatory PRO	- Collect fees - Run registration system - Run waste management practices by using fees - Run controls - Report regularly - Raise awareness	Fulfil requirements of legal framework	Mandatory PRO	Long term (after EPR framework is in place)
2	Optimise mandatory PRO	Use modulated fees to give financial incentives to strengthen recycling	Fulfil requirements of legal framework, optimising recycling amounts	Mandatory PRO	Long term (after EPR framework is in place)
3	Optimise mandatory PRO	Raise the demand for recyclates by giving incentives (financial and/or quota/ amount)	Fulfil requirements of legal framework, optimising recycling amounts	Mandatory PRO	Long term (after EPR framework is in place)
4	Optimise mandatory PRO	Harmonise and formalise collection schemes for Kenya	Fulfil requirements of legal framework, optimising collection amounts	Mandatory PRO	Long term (after EPR framework is in place)
5	Optimise mandatory PRO	Optimise internal control mechanism Formalise informal packaging user and waste operators	Close financial and organisational gabs	Mandatory PRO	Long term (after EPR framework is in place)

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8.1 Annex 1: Background to Plastics

The term 'plastics' describes a huge group of polymers. The main distinction can be made between two groups: the thermoplastics comprising all plastics which will melt when heated and harden when cooled down in a reversible manner. Polymers of this group are for instance, polyethylene (PET), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), and polyethylene terephthalate (PET). On the other hand, there are the thermosets – a group which entails all plastics that will change their chemical structures when heated leading to the creation of a three-dimensional network. This change is irreversible meaning that these plastics cannot be re-melted once they have hardened. Examples for thermoset polymers are polyurethane, silicone and epoxy resins [PlasticsEurope, 2018].

Through a process called polymerisation the monomers are chained together forming the polymers, which is why polymers are usually very heavy molecules as there are composed of thousands of monomers. Each monomer combination, the chemical binding of different elements and compounds to the polymer chain, the inclusion of additives, and the use of crystallizability yield plastic fractions with different properties. The resulting plastics can be melted to form many different plastic products allowing for this vast range of application as aforementioned [American Chemical Council, n.y.].

The production of plastics is mainly concentrated in Asia, which accounted for more than 50 % of the global plastics production in 2017 – Middle East and Africa only accounted for 7.1 % (see Figure 28; PlasticsEurope 2018). This is also reflected in Kenya's import of plastics material in comparison to the domestic production, in which the import strongly dominated [Ipsos, 2019].

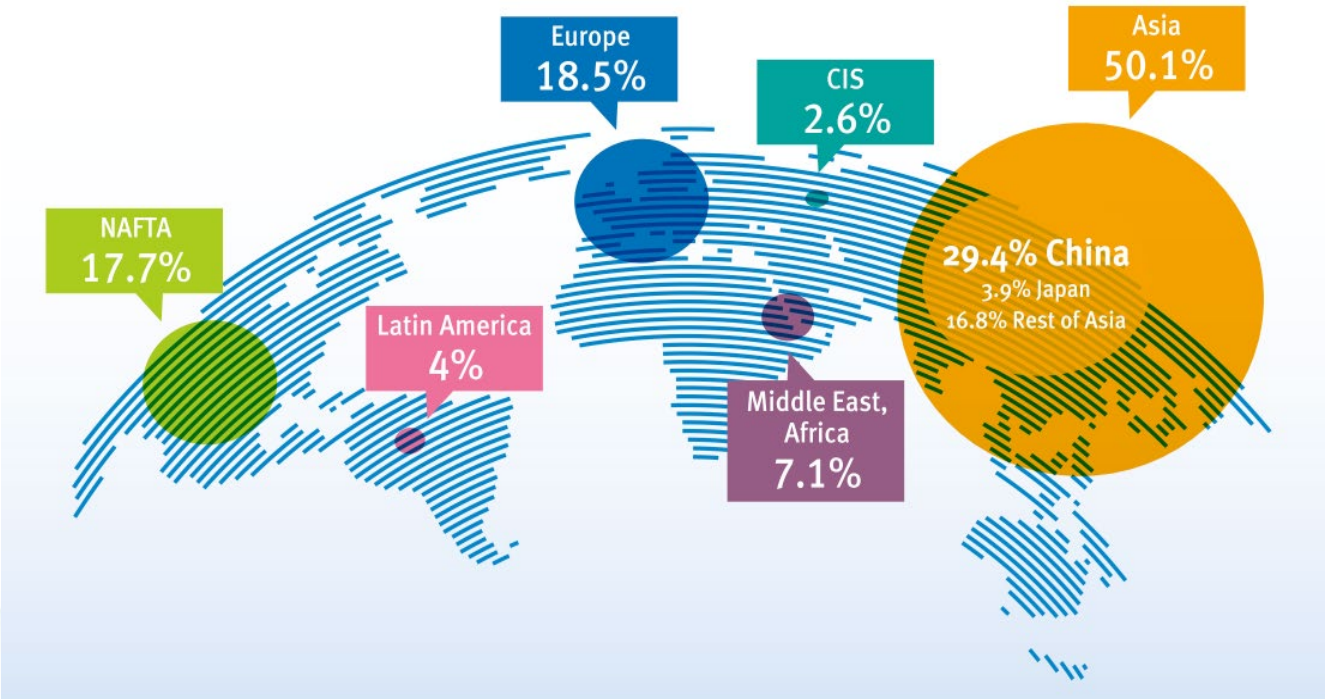


Figure 28: Distribution of the global plastics production, 2017 [PlasticsEurope, 2018]

However, plastics are not necessarily consumed where they are produced. While Asia is the hub for plastics manufacturing globally, the consumption ranges between 0 to 0.2 kg per capita per day while the highest plastics consumption takes place in Germany (0.48 kg per capita per day), Guyana (0.59 kg per capita per day) and Kuwait (0.69 kg per capita per day).

On a global scale, the produced plastics quantities and the generated waste vary significantly per sector as shown in the research of Geyer at l. [2017]. A visualisation of this table can be found in chapter 2.1, Figure 3 and Figure 4.

Table 12: Quantities of produced primary plastics and generated waste acc. to sector, 2015 [Geyer et al., 2017]

	Produced quantities in 2015 [Mt]	Waste quantities in 2015 [Mt]
Packaging	146	141
Building and construction	65	13
Other sectors	62	43
Textiles	47	38
Consumer & industrial products	42	37
Transportation	27	17
Electrical/electronic	18	13

8.2 Annex 2: The polymer types

Each industrial sector uses several polymer types. In the following, the most important polymer types are presented following the international seven plastic codes.

PET is a thermoplastic polymer, which originates from the group of polyesters. It is derived from the esterification of ethylene glycol with terephthalic acid or dimethyl terephthalate and a subsequent condensation process. Through a moulding process, the eventual PET product is then created. PET is a semi-crystalline plastic resin, which stands out through properties such as great tensile strength and chemical resistance as well as its light weight, elasticity, and stability over a wide range of temperatures (-60° to 220 °C) [Robertson, 2014]. Products made of PET were introduced on the markets as early as in the 1950s, however, as fibre for textiles. The global production of PET started to increase dramatically in the 1970s as it's suitability for applications such as food packaging had been discovered. Today, PET is used as packaging material for foods and beverages (particularly drinking water bottles), electronic components and as fibres in clothes [Plastikatlas, 2019]. The internationally assigned number is 1.

HDPE (high density polyethylene) is polymer made from PE, which is derived from the gas ethane, which is split into ethylene (and hydrogen) when heated. Through a subsequent low pressure polymerisation reaction, the polymer is formed. Moreover, polyethylene is also the basis for LPDE as well as PET through the creation of ethylene glycol [Posch, 2011]. Due to its lower degree of branching, HDPE processes a greater tensile strength, stiffness and chemical resistance in comparison to LDPE. Thus, HDPE is an ideal material for structural applications and rigid packaging such as bottles for milk and household chemicals. Other common applications are heavy duty items like pellets, crates and intermediate bulk containers as well as numerous medical and pharmaceutical applications [Emblem, 2012; Sastri, 2010]. The internationally assigned number is 2.

PVC was one of the earliest plastics discovered and until now is still one of the most widely used polymers globally. It is created from vinyl gas, which is derived from salt (57 %) and oil or gas (43 %). The vinyl chloride is polymerised through free radicals in suspension, bulk, emulsion or solution methods [Sastri, 2010]. There are two forms of PVC: rigid and flexible. PVC is generally very durable, light, strong, fire resistant, has excellent insulating properties and a low permeability. Through the combination with additives, applications of PVC can be found in all kinds of sectors. For instance, it is commonly used for building products (such as window frames, floor and wall covering, and linings for tunnels), coatings (such as rainwear or corrugated metal sheets), pipes, automotive applications, as well as medical products (including blood bags, surgical gloves, and transfusion tubes) [PlasticsEurope, n.y.]. The internationally assigned number is 3.

LDPE (low density polyethylene) is a polymer derived from PE as aforementioned and is generated in a similar but high pressure process like HDPE resulting in a product with a significantly higher degree in branching. Thus, LDPE as a material is more flexible and has a higher clarity than HDPE yet has a good breakage and puncture resistance. It softens around 100 °C, which makes it unsuitable for cock-in applications, but economically highly attractive to process. Thus, LDPE is widely used for packaging applications such as foils, trays, plastic bags for food and non-food purposes and as a protective film on other materials like paper, textiles and other plastics [Bayer et al., 2017; Sastri, 2010]. The internationally assigned number is 4.

PP is the polymer, which is generated through the catalytic polymerisation reaction of propylene gas into long-chained polymers of propene. There are two processing methods:

i) low pressure precipitation polymerisation, and
ii) gas phase polymerisation, which is the more common one.

As a subsequent step, the powder is processed into granulate. PP is currently the fast growing polymer globally. This is due to its ability to replace both conventional materials, like glass or wood, and other thermoplastic polymers at lower costs. PP has an excellent strength, low surface energy, low gas and liquid permeability and is relatively easy to process. It resembles HDPE in many regards. However, due to its molecular structure, it exhibits a higher stiffness and resistance to creep as well as high temperature capabilities. Thus, PP is used for a wide range of applications. It is used in films and multilayer applications such as consumer packaging, medical packaging, labels, stickers, personal hygiene and construction films. Moreover, it is used to form fibres, which represents the single largest use. These fibres are used for instance in carpeting, ropes, and automobile interior [Massey, 2007; Sastri, 2010]. The internationally assigned number is 5.

PS consists of a monomer styrene, which is a liquid petrochemical. PS is generally clear, hard and brittle and available in two forms: rigid PS and foamed PS. It has an excellent transparency, high tensile strength, but poor barrier properties in regards to moisture vapour and gases, which is why PS is a suitable material for 'breathable' films. Typical applications of PS are packaging, take-away food cartons, household applications, consumer electronics products, building and construction and medical applications [Görtz, 2001; Sastri, 2010]. The internationally assigned number is 6.

Number 7 is given for the group 'others' and comprises all other plastics, which are not part of the previous groups as for instance nylon, polycarbonates or mixed plastic, which is a material consisting of various polymer types. Differentiating according to these seven polymer groups, the global primary production and waste generation per polymer in 2015 is as follows (Table 13):

Table 13: Quantities of produced plastics and generated waste acc. to polymer, 2015 [Geyer et al., 2017]

	Produced quantities in 2015 [Mt]	Waste quantities in 2015 [Mt]	Percentage of waste quantities in regards to production
PET	33	32	97 %
HDPE	52	40	77 %
PVC	38	15	39 %
LDPE	64	57	89 %
PP	68	55	81 %
PS	25	17	68 %
Others	127	86	68 %

The table above shows that the plastics fraction which are mainly used for packaging applications have a significantly shorter in-use phase than those which are also used for applications in sectors such as building and construction, as for instance seen in PET and LDPE in comparison to PVC.

8.3 Annex 3: Recycling the different polymer types

Recycling plastic polymers is highly dependent on the purity of the waste polymer fractions meaning the presence of contaminants from other waste materials as well as other polymer types as many plastic polymers are not compatible to create recyclates. Another important factor for recycling is the distinction between thermoplastics and thermoset as **only thermoplastics can be mechanically recycled** due to their ability to be re-melted (see chapter 2.2, [Hopewell et al., 2009]. The typical steps in mechanical recycling are cleaning (e.g. the removal of labels), grinding, washing and re-extrusion, in which the material is melted and formed into pellets, granules or fibres. Moreover, there are often filtration steps in the recycling process to separate the polymers from other, contaminating polymers [Plastic Recyclers Europe, n.y.].

PET is a polymer, which can be well mechanically recycled: the simplest and most cost-effective recycling process is the re-extrusion in which the PET waste recycled into fibres or granules and pellets. This recyclate is used for fibres in the nonwoven and textiles industry as well as PET bottles and other PET packaging applications. In fact, PET is the only polymer yielding recyclates which can be reused for food-grade applications – although this require specific processes to yield very high-quality recyclates. Feedstock recycling of PET waste is also possible albeit being significant more expensive due to the energy-intensive process of de-polymerising by hydrolysis, methanolysis or glycolysis [Park & Kim, 2014].

Just as PET, **HPDE**, **LDPE**, and **PP** are polymers which can be well mechanically. The HDPE recyclate can be used to manufacture several typical HDPE applications, such as pipes, films and sheets, ropes, toys and even packaging applications such as bottles (although not for food-grade packaging) [Garrian et al., 2007]. The LDPE recyclate is used to produce piping, trash bags, sheeting and films for building and agricultural applications, composite lumber, and other products [Plastic Recyclers Europe, n.y.] while PP recyclates are used for manufacturing for instance battery cables, rakes and bins, bottle caps or auto case batteries. HDPE, LDPE and PP can also be chemically recycled through a thermal pyrolysis at temperatures >700 °C. However, just like the chemical recycling of PET, the process is consumes great amounts of energy [Achialias et al., 2007].

Also **PVC** is a polymer, which can be both mechanically and chemically recycled. As PVC is widely used in the building and construction industry, a great share of the PVC waste is industrial waste and not household waste, which is why the PVC waste is relatively pure and less contaminated with other polymers. Moreover, it is critical to recycle PVC separate from other polymers as the high chlorine content in raw PVC and high levels of hazardous additives added to the polymer to achieve the desired material quality cause a deterioration of the recyclates of other polymers. In the mechanical recycling process, PVC is recycled in a comparable fashion to the other polymers. When different kinds of PVC waste are mechanically, it is difficult to predict the resulting product's leading to problems as most PVC products require a specific PVC content. Thus, material recycling is more suitable for post-industrial waste than for post-consumer waste. For the chemical recycling, pyrolysis, hydrolysis and heating are used to convert the waste into its chemical component. The resulting products like sodium chloride, calcium chloride, and hydrocarbon products are used to produce new PVC, as feed for other manufacturing processes or as fuel for energy recovery. The advantage is that it is able to treat mixed or unsorted PVC waste. However, chemical recycling is associated to very high costs [Rubio, 2019].

PS – being a thermoplastic – is also recyclable: As many PS products are so-called expanded polystyrene (EPS) foams, a critical step in the mechanical recycling is the compacting, densification or dissolving as EPS foam contains a significant share of air. After this step, the EPS is filtered to remove impurities and shredded (depending on the previous step) and can be used for non-food packaging and products. Another bottleneck is that at present, it is more economical to produce new EPS foam products than to recycle it [Rubio, 2018]. PS is currently not recycled in Kenya [Eunomia, 2018].

As aforementioned, there is a great difference in regards to recycling thermoplastics and thermosets. As the group 'others' is an umbrella for all other polymers, as well as mixed plastics, meaning that no general statement regarding the recycling can be made which is applicable for all plastic in this group.

8.4 Annex 4: Recyclate usage

The 'European Plastic Converters' analysed the usage of recyclates across sectors and polymer types [EuPC, 2017]. Please note that the percentage numbers represent the number of plastic producers in this field using recyclates (Figure 29) as well as the number of plastic converters using a certain polymer type (Figure 30).

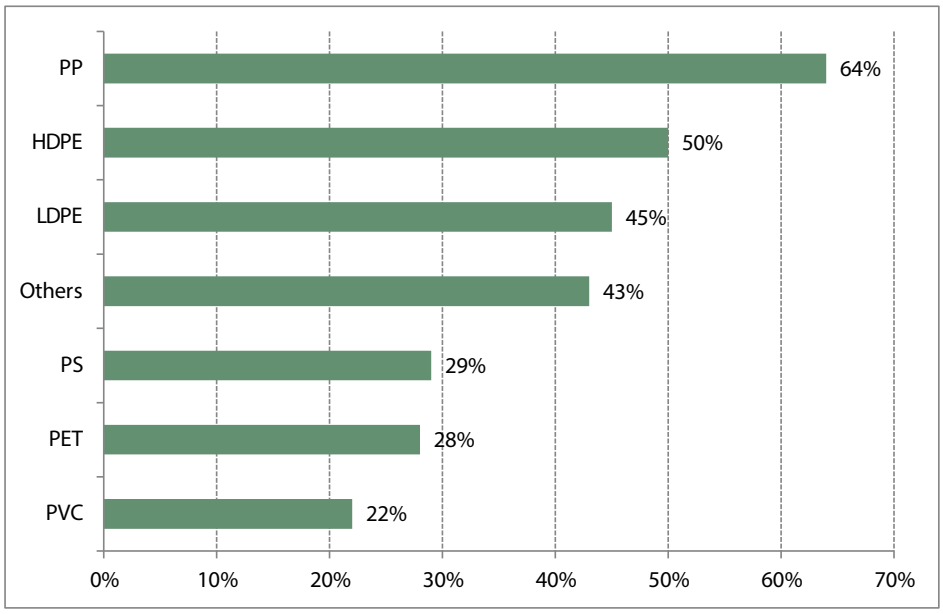


Figure 29: Recyclate use according to polymer fraction [based on EuCP, 2017]

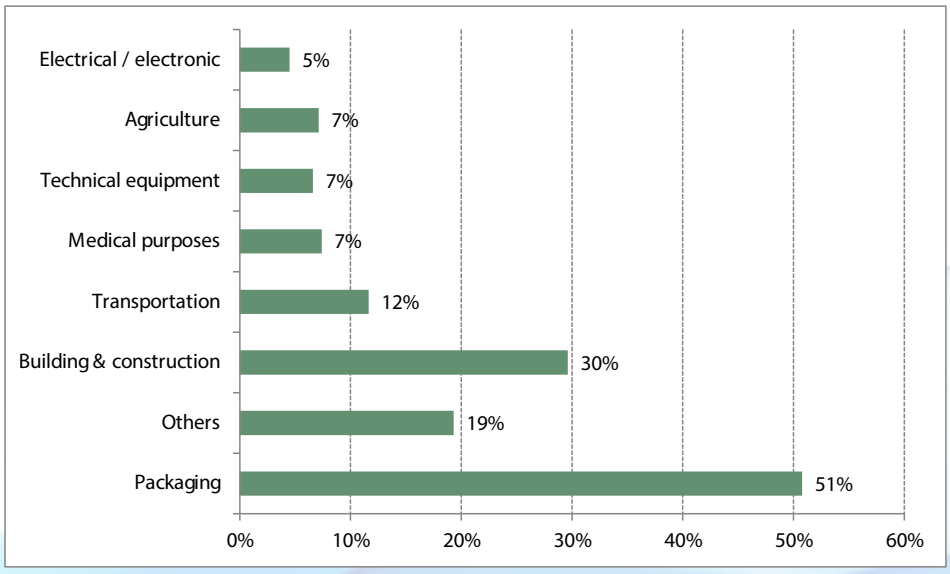


Figure 30: Recyclate use according sectors [based on EuCP, 2017]

Additionally to that, a German study carried out by the Trade Association Germany (*Handelsverband Deutchland HDE e.V.)* in 2018 examines the usage of recyclates, in particular what and how many obstructions come along with the usage of different types of recyclates stemming from different types of plastic packaging available in Germany. The study [GVM, 2019] identifies obstructions in five dimensions: availability, function, law, costs and ecology.

To identify the overall results of the recyclates, the study assembled a chart from 0 to 10, 0 meaning that there are no obstructions to the usage of recyclates and 10 meaning that the usage of recyclates is impossible. The scores were summarised in five fields: 0-<2 equal no or very little obstructions, 2-<4 equal little obstructions, 4-<7 equal moderate obstructions, 7-<9 mean large obstructions, 9-10 mean very large obstructions [GVM, 2019].

The results of the study show that packaging segments with the fewest obstructions were non-food segments such as boxes, palettes, plant pots, non-food cans and barrels, transportation foils, labels and carrier bags. The packaging segments which provided the largest obstructions were those used in connection with perishables, such as foam plastics used for food, compound foils, plastic bags, containers and other cups. In general, the largest obstructions are related to the availability of high-quality recyclates, the look-and-feel of the recyclates in terms of odour or missing transparency, and the insufficient physical and mechanical aspects of the majority of recyclates currently available [GVM, 2019].

In Germany, approximately 3.2 million tons of plastic packaging are used, of which merely 10 % provide none or little obstructions for the usage of recyclates. The rest of the market provides an equal share of moderate obstructions (~45 %) and of large to very large obstructions (~45 %) [GVM, 2019].

The study states that plastic recyclates will always provide worse technical characteristics than comparable virgin materials. Requirements such as durability are significant obstructions for plastic recyclates and could, if feasible, only be resolved by mixing recyclates with primary materials. In the long run, however, mixing recyclates with new materials will inevitably have a negative impact on the quality of the material life cycle [GVM, 2019].

Political regulations or stakeholder commitments for the usage of recyclates would increase the demand for recyclates and set directions for the market development. At the same time, however, certain types of obstructions would be intensified through such a procedure. Due to the rising demand and unchanged availability of recyclates, the rather favourable material costs will immediately become more expensive. Moreover, without introducing quality standards, the quality of the material life cycle would diminish [GVM, 2019].

Sustainable improvements for the usage of recyclates would be the introduction of a mandatory quality standard, the quickening and de-bureaucratisation of the approval of recyclates being in contact with edibles and the increase of consumer acceptance of recyclates and the resulting consequences. For example, packaging does not need to be transparent [GVM, 2019].

As mentioned above, binding regulations and stakeholder commitments could enforce a significant development on the market of recyclates. Mandatory quality standards should ensure that recyclates meet the requirements so that they may be used on par with new material. Correct labelling and certification is essential to gain trust of manufacturers and consumers to use recyclates for their packaging and buy products packed in recycled materials. In that sense, it would be recommendable to establish the required recycling infrastructure prior to the introduction of such regulations. As compound materials are rarely recycled, ideally the packaging should be made of mono-material.

8.5 Annex 5: The circular economy concept in detail

The circular economy offers a more efficient resource use, which has economic, environmental, and social benefits. Economic benefits are the result of the decreased resource dependency on raw materials and thus less import dependency as well as the creation of employment possibilities. Moreover, less resource extraction and disposal of waste also offers significant ecological benefits, since the environmental threats connected to extraction and disposal will be reduced if the cause is removed. Last but not least, this offers also social benefits as the threat for human health driven by environmental impacts of extraction and disposal is reduced and the need to reintroduce resources into the economic system instead of disposing them offers new employment possibilities [Stahel, 2014; Wilts, 2016].

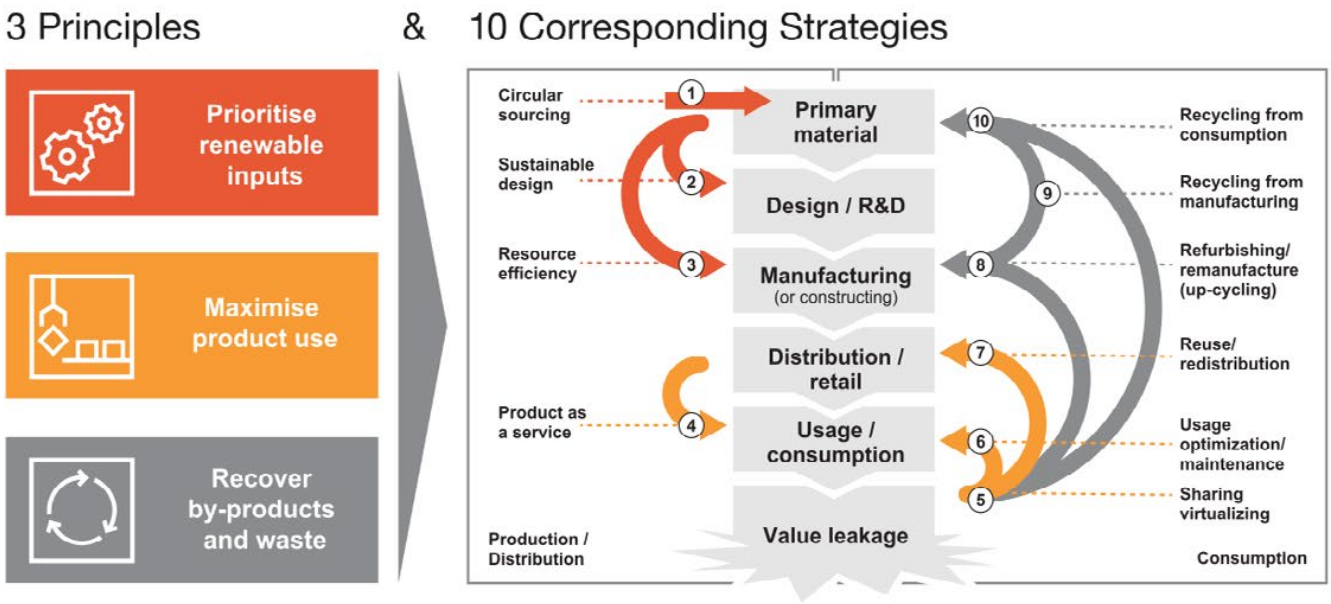
The circular economy is based on three overarching principles: reduce, reuse, and recycle [Ghisellini et al., 2015; Wilts, 2016]. As the name implies, the reduction principle pursues the maximum reduction of raw material and energy demand, which are needed for production as well as waste that is generated during production and/or consumption. This can be achieved by improving both the production and consumption processes, e.g. by developing more efficient technology, downsizing the packaging material or changing consumers' demand [Feng & Yan, 2007; Su et al., 2013].

The reuse principle describes that products or components of products, that are not waste, are reused again or – if they have turned into waste – are prepared for reuse [Ghisellini et al., 2015]. This offers especially environmental benefits as it decreases the resource and energy demand since the product is not newly manufactured [Castellani et al., 2015]. The last principle, the recycle principle, refers to any process, in which waste is recovered through reprocessing the material or its chemical constituents thereby making it available for new manufacturing processes [Ghisellini et al., 2015, Hopewell et al., 2009].

Shifting to a circular economy as a response to the current plastic situation would focus on closing the loop by reducing the overall amount of plastics used where possible, e.g. for instance through redesigning plastic products, substitution with other materials or banning certain products where more sustainable alternative materials exist, and increasing the recycling and preparing for reuse of the generated plastic waste to reduce the amount of plastic waste that is disposed and to prevent littering and improper waste management practices.

A circular economy has important implications for all steps of the value chain and the respective measures cover a broader field than just waste management measures and are operationalised at different scales – ideally done in a complementing fashion (Figure 6). However, this is usually not the case and most initiatives, despite being often promising, remain fragmented and measures across scales are often not well aligned [WEF, 2016]. To overcome this, a good coordination and collaboration between the actors of the various circular economy measures is vital. An important prerequisite for that is to align various measures is acknowledging the importance of actors outside the waste management and eventually broadening of the circle of the involved actors. Particularly actors from the industry are important to include as e.g. their product design strongly influences if a waste item can be reused or at least recycled [Silva et al., 2017; Wilts, 2016]. Moreover, a stronger consideration of the consumers' influence on circular economy measures is also important as they ultimately determine if they buy a product, which can be reused or recycled, or not, as well as if and how well waste is separated, which also plays a critical role if reusing or recycling is even possible [Wilts, 2016]. Thus, a well-executed circular economy benefits from including and cooperating with multiple actors from all sectors.

The following Figure 31 illustrates the three main principles and ten corresponding strategies towards circular economy.



- Circularity can be centred around three overarching principles, which define ten corresponding strategies.
- The diagram illustrates the continuous flow of resources in both the production/ distribution phase and the consumption phase.
- Circularity in the production/ distribution phase is anchored in four strategies (1-4) that aim to maximise the use of renewables and minimise value leakage across the value chain.
- Circularity in consumption has six strategies (5-10) that reduce value leakage by circulating products and materials at their highest utility through sharing, reuse, repair, remanufacturing, and recycling.
- The end-of life of a product represents value leakage as important by-products are not collected for productive use. Instead of leaking value by discarding products and materials after use, the circular economy stops this value leakage in order to yield more value.

Source: PwC analysis

Figure 31: Three principles and ten corresponding strategies towards circular economy [PWC, 2019]

8.6 Annex 6: Global trends

To push circular economy also on a global scale, there are several global commitments driven by both governments as well as private sector initiatives to transit to a waste-free circular plastics economy, both will be examined in this chapter. In particular, emphasis is put on the G7 Oceans Charter and the Sustainable Development Goals (SDGs) as well as 'The New Plastics Economy' published by the Ellen MacArthur Foundation (EMF).

Government driven initiatives – G7 Ocean Plastic Charter

Marine littering poses a serious threat to the environment worldwide. Based on the urging need to address this issue through a global commitment, five of the G7 countries adopted the Ocean Plastics Charter on June 9, 2018 to demonstrate their commitment to stop the growing marine littering problem by taking concrete actions to address and eventually solve the issue (Figure 32). Canada, France, Germany, Italy and the UK thereby committed to a more sustainable approach in their usage of plastics [Government of Canada, 2018].

Figure 32: G7 Ocean Plastic Charter

As envisioned, the Ocean Plastics Charter brings together partners such as local governments, businesses and civil rights movements to take action and move toward a more responsible, sustainable use of plastics. To put this into practice, the Charter frames five specific resource-efficient approaches in the management of plastics:

1) **Sustainable design, production and after-use markets** to create 100 % reusable, recyclable of recoverable plastics by 2030, reduce single-use plastics (SUP), creating secondary plastics markets and alternatives to plastics through green public procurement, policy measures and international incentives, and – together with the industry – reduce microbeads in cosmetics and personal care products
2) **Collection, management and other systems and infrastructure** to significantly increase recycling rates through collective actions with the industry and local governments, increase a proper plastic waste management to reduce leakages, shift to a whole supply chain approach towards greater responsibility, significantly increase public-private funding and capacity development for waste management particularly in hot spot areas including small islands and remote communities
3) **Sustainable lifestyles and education** to support industry lead initiates and knowledge exchange through existing alliances and platforms, strengthening preventive measures for marine litter and empower consumer choices through labelling and promote sustainable consumption particularly through giving woman and the youth a leadership role in this regard
4) **Research, innovation and new technologies** to promote research and development through sustainable technologies, design and production methods by the private sectors and innovators for;

- reducing the plastic leakages at all steps of the value chain,
- removing plastics and micro plastics from the marine habitat, and
- assessing the impact on human health, analyse the current plastic consumption by major sector use, harmonise the G7 monitoring methods

5) **Coastal and shoreline action** to raise public awareness through campaigns, collect data and target investments to remove debris from coasts and shorelines, accelerate the implementation of already existing action plans and programmes as for instance the 2015 G7 Leaders' Action Plan to Combat Marine Litter through the Regional Seas Programs [Government of Canada, 2018].

By now, 21 governments, including Kenya, and 63 business and organisations, like KAM [Government of Canada, 2019] joined the G7 Ocean Plastics Charter.

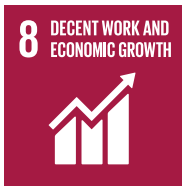
Additionally in June 2019, the G20 member states declared during their meeting in Japan, to combat marine litter and committed to develop a comprehensive approach preventing and reducing plastic litter discharge into the marine habitat. Moreover, they announced to share their best practices with other nations. However, all measures are on a voluntary basis [Zeit, 2019].

Government driven initiatives – Sustainable Development Goals

Described by the UN as a 'blueprint to achieve a better and more sustainable future for all', the Sustainable Development Goals (SDGs) are 17 interconnected goals to address global challenges and improve global living standards by 2030 [UN, n.y.]. To work towards these identified goals, the concept of a circular economy has been identified as a central element in regards to SDG 7 on energy, SDG 8 on economic growth, SDG 11 on sustainable cities, SDG 12 on sustainable consumption and production, SDG 13 on climate change, SDG 14 on oceans, and SDG 15 on life on land. In particular, this means for the respective SDGs (Figure 33):

Figure 33: The 17 SDGs of the UN

Circular Economy and SDG 7 (Affordable and Clean Energy): The current systems of energy production depend on non-renewable resources such as coal, oil and natural gas. In 2018, the global electricity demand rose by 4 %, which was met to a significant share with energy generated from coal and gas-fired power plants increased significantly which in its turn increased CO2 emissions form the sector by 2.5 % [IEA, 2018]. Transforming to a circular economy means shifting the focus on enhancing and increasing the efficiency of the current renewable power production as the main source of energy, instead of a subsidiary one as well as designing efficient systems to store and distribute energy to satisfy the demand with as less waste of energy as possible.



Circular Economy and SDG 8 (Economic Growth): As mentioned, the linear economy, which is currently the dominant economic system, is built on the principle of take-make-dispose which grants only limited sustainability since the resource availability is limited and most resources are lost after becoming waste. Within a circular economy, this is changed as reflected in the principles of reduce, reuse, and recycle. The circular economy creates a new market for secondary materials and end-of-life applications, which will create jobs and opens the door to more specialised fields of study and development adding to the growth of the economy in turn.

Circular Economy and SDG 11 (Sustainable Cities): Industrialized growth increases the urban population and density as well as the consumption. The resulting effects of urbanization deeply influence the development of cities around the world. According to UN estimates, the urbanized population increased from 14 % to 54 % between 1900 and 2015 and is predicted to rise to 66 % by 2050, which will put tremendous pressure on cities and their management. The situation also calls for better ways on how to address waste management and minimise the negative effects related to an improper waste management, thus, highlighting the need for a shift to Circular Economy [WEF, 2018]. This approach will change cities by improving the living qualities and creating more jobs (see previous SDG).

Circular Economy and SDG 12 (sustainable consumption and production): As resources are limited, the current economy will face an inevitable resources scarcity that threatens the industrial sector and all related sectors. Circular economy provides a solution to these issues by using secondary materials as resource and less virgin material through the approach of recycling and reusing. Moreover, a circular economy also focuses on enhancing resource management along the value chain, e.g. through design for recycling, to maintain resources for longer periods and to avoid waste in production, supply, use, and disposal - all of which grant a more sustainable consumption and production [Ministerial Conference Page, 2019].

Circular Economy and SDG 13 (Climate Change): Climate Change is a result of the increase in earth's temperature due to the greenhouse gas emissions. 62 % of global greenhouse gas emissions – excluding those from land use and forestry – are released during the extraction, processing and manufacturing of goods to serve society's needs [UN, 2019]. Circular economy through its three principles of reduce, reuse, and recycle, represents a crucial part of the solution to cut down the effects of climate change and global warming by reducing greenhouse emissions through decreasing the need to constantly extract and produce virgin materials, and eliminating waste form the natural environment.

Circular Economy and SDG 14 (Life below Water): The UN estimates that 40 % of the oceans are significantly impacted by human activities, including pollution, overfishing, and loss of coastal habitats. According to the UNESCO, over 220 million tons of plastics are produced each year, but inappropriate disposal of plastics is often not addressed as huge quantities of plastics and micro-plastics end up in seas and oceans threatening the marine ecosystems [UNESCO, n.y.]. Circular economy is a solution to this problem as leakages would be stopped during the steps of the value chain but also particularly leakages of waste would be dramatically cut down as waste would be recycled and not lost to the environment.

Circular Economy and SDG 15 (Life on Land): According to UN, around 1.6 billion people depend on forests for their livelihoods, 2.6 billion people depend directly on agriculture for a living, [UN, 2017] and until now, there are around 7.7 billion humans living in 2019. The current linear economy and waste disposal are endangering lives of species living on land by accumulating waste (especially plastic and micro-plastic) in land and soil as for example 'chlorinated plastic can release harmful chemicals into the surrounding soil, which can then seep into groundwater or other surrounding water sources, and also the ecosystem. This can cause a range of potentially harmful effects on the species that drink the water' [UNEP, n.y.]. Circular economy provides a solution to this by keeping more resources and materials for as long as possible in use. This can be achieved in a number of different ways, including increased product durability, reuse and recycling.

Private driven initiatives – Ellen MacArthur Foundation (EMF)

In 2010, the EMF was launched as a charity with the mission to accelerate the transition to a circular economy on a global scale. One of their key topics is the so-called 'The New Plastics Economy', which envisions a circular economy in which plastics never becomes waste but remains a resource. To achieve its vision, the New Plastic Economy frames six key points through which such a circular economy could become possible:

1) Elimination of problematic or unnecessary plastic packaging through redesign, innovation, and new delivery models is a priority.
2) Reuse models are applied where relevant, reducing the need for single-use packaging.
3) All plastic packaging is 100 % reusable, recyclable, or compostable.
4) All plastic packaging is reused, recycled, or composted in practice.
5) The use of plastic is fully decoupled from the consumption of finite resources.
6) All plastic packaging is free of hazardous chemicals, and the health, safety, and rights of all people involved are respected [EMF, n.y.].

The first report 'The New Plastics Economy – Rethinking the future of plastics' was published in January 2016. In light of the question of how to initiate the system effectiveness of the global plastics economy with focus on the global plastics packaging value chain and material flow- The first report proposes to create an alternative mind-set by approaching plastics as an integral part of an effective global material flow, which is aligned with the circular economy principles. As key findings, the report highlights that;

i) the predominant share of 95 % of plastics is only used once, which equals a resource loss of USD 80-120 billion annually, and
ii) plastic packaging generates severe, negative environmental impacts. This impact is coined by the now famous forecast that in a business-as-usual scenario 'there may be more plastic than fish in the ocean, by weight, by 2050' (EMF, 2016, p. 29).

As a conclusion, the report urges to create an effective after-use economy, drastically reduce the leakages into the environment and decouple plastics from fossil fuels [EMF, 2016].

Following up in this report, 'The New Plastics Economy: Catalysing action' was published in 2017 mapping a global action plan to transition towards 70 % reuse and recycling of plastic packaging complemented with a redesign and innovation for the remaining 30 %. Thereby, this report delivered a global transition strategy, which is captured through five mutually reinforcing building blocks for;

i) cross value chain cooperation ('Dialogue Mechanism'),
ii) cross value chain developments for a design shift enhancing the recycling economics and material health ('Global Plastic Protocol'),
iii) two innovation challenges for the proposed fundamental redesign ('Innovation Moonshot'),
iv) assessing the socio-economic impact on the marine habitat ('Evidence Base') and
v) broad stakeholder exchange to accelerate the system shift ('Stakeholder Engagement') [EMF, 2017b].

In 2018, the EMF launched the 'Global Commitment' in which more than 400 stakeholders including consumer good companies, packaging producers and packaging designers which collectively are responsible for 20 % of the produced plastic packaging worldwide committed to change how plastics are produced, used and reused. In the latest update in June 2019, the report highlights the commitment of consumer good companies and retailers to increase the recycled content from 2 % (current global average) to 25 % in 2025, increasing piloting refill and reuse scheme in 50 retailer and brands and the publicly reporting the annual volumes of plastic packaging production and use, including major consumer packaged goods companies and retailers like Nestlé, The Coca-Cola Company, Unilever, Carrefour, Colgate Palmolive, Danone, L'Oréal, and Mars [EMF, 2019].

Other private sector driven initiatives

In January 2019, 27 companies from all steps of the plastics value chain initiated The Alliance to End Plastic Waste as a private-sector initiative to push actions on reducing the plastic litter in the aquatic environment by combining their expertise, resourced and outreach to create a global vision and a respective strategy. In particular, the alliance targets;

i) the infrastructure development for waste collection and proper waste management to increase recycling,
ii) innovation for waste minimising technology, better plastics recycling and creation of post-use applications,
iii) education and engagement of all stakeholders including governments from all levels, businesses and communities, and
iv) clean-ups of already polluted habitats. In July 2019, the number of committed business has risen to 39 [The Alliance to end Plastic Waste, 2019].

Moreover, there are also several private sector initiatives founded in several middle-income countries to foster circular economy measures in their respective countries. Examples are for instance:

- **PARMS:** The Philippine Alliance for Recycling and Material Sustainability; member include Coca-Cola Philippines, Nestlé Philippines, Pepsi-Cola Products Philippines, Procter & Gamble Philippines and Unilever Philippines [PARMS, n.y.].
- **PRAISE:** The packaging and Recycling Alliance for Indonesia Sustainable Environment; members include Nestlé Indonesia, Coca-Cola Indonesia, Tetra Pak Indonesia, Unilever Indonesia, Titra Investama, Indofood Sukses Makmur [1PRAISE, n.y.].
- **GRIPE:** The Ghana Recycling Imitative by private Enterprises; members include Dow Chemical West Africa, Nestlé Ghana, Coca-Cola Ghana, Unilever Ghana, Voltic, Fan Milk Ghana, Guinness Ghana Breweries, PZ Cussons Ghana [GRIPE, n.y.].
- **TIMPSE:** Thailand Institute of Packaging and Recycling Management for a Sustainable Environment; members include Nestlé Thailand, Unilever Thailand, Coca-Cola Thailand, Pepsi-Cola Thailand, Tetra Pak Thailand [TIMPSE, n.y.]

Nevertheless, it needs to be acknowledged that the successes of these initiatives are limited as the companies, who are working voluntarily on this issue, are competing with those companies who are not participating in such an initiative in the respective country.

8.7 Annex 7: Questionnaire for online survey

AHK Delegation der Deutschen Wirtschaft in Kenia
Delegation of German Industry and Commerce in Kenya

cyclos

Questionnaire for online survey

1. Plastic Value Chain

Please tick in which part of the value chain your company activity takes place. If you are active on several parts, please tick all of them and indicate clearly what information below relates to which activity.

- Importer of raw materials/ virgin or recycled plastics
- Manufacturing/ processing of plastics
- Plastic used for packaging of locally manufactured or imported goods
- Distributor/ Retailer of goods packed in plastics
- Consumer of goods packed in plastics
- Collection/ Segregation of plastics
- Recycling of secondary plastics
- Other, please specify

2. Briefly describe your company's activity, indicating precisely your plastic usage.

3. Which of the following plastic fractions are you using?
- LDPE
- HDPE
- PP
- PET
- PVC
- PS
- Others

Can you specify on the respective volumes you purchase e.g. per month or per year?

4. Are there challenges faced by industry at county and national level in the implementation of a sustainable waste management practices? Can you briefly describe, if applicable?

5. Has your company put in place a take back scheme for your packaging products? If so, please give a brief description.

8.8 Annex 8: Circular Economy and The Big4 Agenda

Circular economy represents also a tool which can contribute to achieving the Big4 Agenda goal of manufacturing expansion in the blue economy, agro-processing, leather and textile industries:

Circular economy and blue economy:
The Blue Economy encourages a better stewardship of the ocean's or 'blue' resources, which includes a significant reduction of environmental risks for and ecological scarcities of the marine resources [The Commonwealth, n.y.]. Based on a circular economy approach, recycling of plastic waste would contribute to an improved blue economy as plastic litter is a serious threat for the marine habitat.

Circular economy and agro-processing industry:
Food-processing is a sector of the agro-processing industry that includes the methods and techniques used to transform raw ingredients into food for human consumption. The relationship between the plastic and food sector is complicated: More than 50 % of food waste takes place in households while nearly 20 % is wasted during processing. Plastic packaging contributes in preserving food by preventing damage during transport, and extending shelf life, which help reducing food waste. That makes it hard to eliminate plastic from the food industry. At the same time, improper disposal of plastic packaging is the leading source for plastic litter in the environment [Dora & Iacovidou, 2019]. Thus, redesigning plastic packaging that it is easy to recycle and reuse (if possible), reusing packaging where possible and a comprehensive collection system and following recycling - or other environmentally sound treatment method if packaging waste cannot be recycled - as envisioned in a circular economy, is important.

8.9 Annex 9: Alternatives to plastics

Kenya has currently no comprehensive waste collection and treatment infrastructure for waste in general and plastics in particular. In light of the prevailing waste management conditions (predominantly landfill, low recycling structure for glass, plastics and paper, no relevant reusable systems), the use of resources for instance in the form of packaging should be reduced as much as possible in order to minimize resource losses and unordered deposits with the associated ecological consequences. From a resource conservation point of view of, the development of an orderly and comprehensive recycling structure is the preferred alternative. A strategy in dealing with plastics and plastic waste is developed in the Action Plan. This must be taken into account in the following alternatives to plastics.

The results for three different material comparisons are based on the insights of the Kenyan waste management situation (see chapter 0). The following comparisons have been made:

i) water bottles (which also apply for cooking oil and yoghurt cups, see Table 21),
ii) grocery carrier bags (see Table 22), and
iii) construction pipes (see Table 26).

Plastics are utilised in many areas in which other materials are used to fulfil the same purpose. Firstly, the raw materials utilized in the further processing will be compared in regards to the emissions which result in their production as well as other environmental aspects, if available. Therefore, this Table 14 identifies the Global Warming Potential (GWP). The GWP is a substance's / material's potential contribution to the so-called greenhouse effect. This contribution is portrayed as an equivalent in relation to the GWP of carbon dioxide (CO_2). For evaluation the figures GWP100 are utilised, which identify the contribution of each particular substance or material averaged for a time span of one hundred years. The lower the figure of the CO_2 equivalent, the lower is the potential impact on global warming and the relating environmental effects. [BMVBS, 2013]

Table 14: Global Warming Potential for different raw materials

Category	GWP_{100} [kg CO_2 equi.] per kg	Database
Plastics		
ABS	3.76	Bath Uni via [Carbon Footprint Ltd, ny]
ABS	3.10	[PlasticsEurope, 2019]
(Expanded) Polystyrene (EPS)	3.29	Bath Uni via [Carbon Footprint Ltd, ny]
(Expanded) Polystyrene (EPS)	2.37	[PlasticsEurope, 2019]
Polystyrene (PS)	2.25	[PlasticsEurope, 2019]
HDPE	1.93	Bath Uni via [Carbon Footprint Ltd, ny]
HDPE	1.80	[PlasticsEurope, 2014]
Recycled HDPE	0.93	[Liebich, 2016]
LDPE	2.08	Bath Uni via [Carbon Footprint Ltd, ny]
LDPE	1.87	[PlasticsEurope-A, 2014]
Recycled LDPE	1.41	[Liebich, 2016]
Polypropylene	1.63	[PlasticsEurope, 2019]
PP, Injection Moulding	4.49	Bath Uni via [Carbon Footprint Ltd, ny]
PP, Orientated Film	3.43	Bath Uni via [Carbon Footprint Ltd, ny]
PP	1.63	[PlasticsEurope-B, 2014]
Recycled PP	0.95	[Liebich, 2016]
Polycarbonate	7.62	Bath Uni via [Carbon Footprint Ltd, ny]
PVC	3.10	Bath Uni via [Carbon Footprint Ltd, ny]
PET	5.56	Bath Uni via [Carbon Footprint Ltd, ny]
Glass		
Primary Glass	0.91	Bath Uni via [Carbon Footprint Ltd, ny]
Secondary Glass	0.59	Bath Uni via [Carbon Footprint Ltd, ny]
Aluminium		
Aluminium Cast products (primary)	13.10	Bath Uni via [Carbon Footprint Ltd, ny]
Aluminium Cast products (secondary)	1.45	Bath Uni via [Carbon Footprint Ltd, ny]
Aluminium Cast products (typical)	9.22	Bath Uni via [Carbon Footprint Ltd, ny]
Aluminium Extruded (primary)	12.50	Bath Uni via [Carbon Footprint Ltd, ny]
Aluminium Extruded (secondary)	2.12	Bath Uni via [Carbon Footprint Ltd, ny]
Aluminium Extruded (typical)	9.08	Bath Uni via [Carbon Footprint Ltd, ny]
Aluminium Rolled (primary)	12.80	Bath Uni via [Carbon Footprint Ltd, ny]
Aluminium Rolled (secondary)	1.79	Bath Uni via [Carbon Footprint Ltd, ny]
Aluminium Rolled (typical)	9.18	Bath Uni via [Carbon Footprint Ltd, ny]
Steel		
Steel Bar & rod - Primary (100% hypothetical virgin)	2.77	Bath Uni via [Carbon Footprint Ltd, ny]
Steel Bar & rod - Secondary	0.45	Bath Uni via [Carbon Footprint Ltd, ny]
Steel General Steel - World Typical - World 39% Recy.	1.95	Bath Uni via [Carbon Footprint Ltd, ny]
Steel Coil – Galvanised (100% hypothetical virgin)	3.01	Bath Uni via [Carbon Footprint Ltd, ny]
Steel Coil – Galvanised (typical 35.5 % Recy.)	2.12	Bath Uni via [Carbon Footprint Ltd, ny]
Paper		
Paper (primary)	0.96	[Raschke, 2016]
Paper (primary)	1.28	[Ifeu, 2018]
Recycled Paper	0.68	[Raschke, 2016]
Recycled Paper	1.14	[Ifeu, 2018]
Concrete		
General Concrete	0.11	Bath Uni via [Carbon Footprint Ltd, ny]
Concrete – depending on composition	from 0.10 till 0.15	Bath Uni via [Carbon Footprint Ltd, ny]
Concrete (Precast Mix 1)	0.214	[Marceau et al., 2007]
Reinforced Concrete	0.204	[Struble, Godfrey, 2004]

Information: These figures serve the purpose of orientation and classification of each particular material and result from surveys which do not explicitly consider the Kenyan frame conditions. Among other things, this applies to the basic processing technique, utilised electricity mix. However, these base figures in relation to each other portray the contribution to the greenhouse effect, such as aluminium which has a relatively high contribution compared to plastics or paper.

Table 14 clarifies, that the GWP of;

- Glass ranges within the scope of approximately 1 kg CO2-equiv. per kg,
- Paper ranges between approximately 1 to 1.3 kg CO2-equiv. per kg,
- Plastics range from approximately 1.7 to 3.4 kg CO2-equiv. per kg (depending on the type of plastic),
- Steel ranges from approximately 2 kg CO2-equiv. per kg (depending on the portion of recycled material) to approximately 2.7 kg CO2-equiv. per kg (for primary material),
- Aluminium ranges of the scope of about 9 (depending on the portion of recycled material) to > 12 kg CO2-equiv. per kg (for primary material).

It also becomes evident that the usage of recycled or secondary materials relates to a relatively low GWP in regards to each particular type of material. Furthermore, through a comparison on the item-base (e.g. bottles, pipes) one many take into consideration that the GWP is largely related to the specific weight of the materials, the usage of materials (e.g. plastics vs. glass), as well as the user behaviour (single-use vs. multiple use) and the aligned waste management or recycling opportunities.

Bottles (for water): PET-bottles substituted by glass, aluminium can or liquid packaging board

Beverages like water are generally sold in different types of packaging, amongst them PET bottles, glass bottles, aluminium cans and drink cartons. Especially usage, as well as the transport is significant when making an environmental performance evaluation.

The manufacture of glass bottles and aluminium cans is energy-intensive, which means that the environmental performance evaluation only results positively, if these products are used multiple times (e.g. within the frame of a circular system) and are not transported over long distances. This and other frame conditions need to be considered when making an environmental performance evaluation on item level.

Information: Due to the greatly differing frame conditions, in which the following data and results were investigated, it is important to illustrate the functional mechanisms which occur in the production and usage, as well as in the disposal, as they do not exist in Kenya in such an adequate form. Thus, the mentioned examinations will provide insights which may apply to Kenya in a similar manner, so that resulting advantages and disadvantages could be distinguished.

This kind of comparison was intensely examined in Germany conducting the research 'Ökobilanz für Getränkeverpackungen II / Phase 2' [Schonert et al., 2002]. Detzel et al, [2016] validated and updated these results. During this examination different scenarios were created, according to the ISO 14040 environmental performance evaluations. These also include analysis in relation to transportation and existing waste infrastructure. Specifically, PET bottles (single use incl. recycling) and glass bottles (single-use and multiple use incl. recycling) with a filling volume of 1 l were compared. The following Table 15 portrays the results in a simplified way per category qualitatively next to each other, acc. to which reusable water bottles are preferred in comparison with one-way PET bottles and one-way glass bottles.

Table 15: Ranking of different water bottles related to selected environmental criteria [Schonert et al., 2002]

Criteria	Glass multiple use	Glass single-use	PET single-use
Aquatic eutrophication	1	3	2
Terrestrial eutrophication	1	3	2
Depletion of resources	1	3	2
GWP kg CO_2 per 1 l	1	3	2
Acidification	1	3	2

A further examination compared PET single-use systems to PET multiple use systems. According to Schonert et al. [2002] the environmental impacts as shown above from single-use were halved through adjustment to a multiple use system, however, slightly exceeds the impacts of reusable glass bottles.

Glass multiple use bottles provide a better environmental performance compared to aluminium cans and steel cans for a filling volume of 0.5 l (see Table 16) meant for immediate consumption.

Table 16: Ranking of different beverage packaging for immediate consumption related to selected environmental criteria [Schonert et al., 2002]

Criteria	Glass multiple use	Aluminium can single-use	Steel can
Aquatic eutrophication	1	2	3
Terrestrial eutrophication	2	1	3
Depletion of resources	1	2	3
GWP kg CO_2 per 1 l	1	2	3
Acidification	1	2	3

Similar examinations have been done in Austria with the research 'Ökobilanz von Getränkeverpackungen in Österreich Sachstand 2010' [Kauertz et al., 2011]. A comparison is possible on a manufacturing basis of the different arrangements without the influences of the following chain mechanisms, because the proportions of the different functional mechanisms were classified in categories (such as hollow-glass production, PET production). Thus, the GWP of the production of a 1 l glass bottle (water, multiple use), including labels and caps is approximately 22 kg CO2-equiv per 1 l and the GWP of a 1.5 l PET bottle (water, multiple use), including labels and caps is approximately 39 kg CO2-equiv per 1 l.

Acidification and fossil resources depletion resulting of the glass bottle production are half as much as they are for the PET bottle production. If the distribution afterwards is taken into consideration, the effects align. The following Table 17 identifies which categories have negative effects.

Table 17: Phase depending negative effects for different beverage packaging relating to selected environmental criteria [Kauertz et al., 2011]

Criteria	Glass multiple use	PET single-use
Global Warming Potential (GWP)	Distribution Filling Hollow-glass production	PET production Distribution Disposal
Fossil resources depletion	Distribution Production of labels and caps Filling	PET production Distribution Production of packaging for sale and transport
Acidification	Distribution	PET production Distribution

On closer examination, these two sectors of the functional mechanisms responsible for more than 50 % of the system load. The biggest influential factor for the results of the PET single-use systems are the contributions from the sector PET production.

These studies are widely confirmed by the study 'Studie Life Cycle Assessment of PET (Polyethylene Terephthalate) bottles and other packaging alternatives' [Schmidt et al., 2000]. During the comparison of the global warming potentials, in which credits from the following chain mechanisms for the recycling etc. are neglected, it is stated that single-use PET bottles 1 l with 123 to 160 kg CO2-equiv per 1,000 l beverages provide a relatively higher GWP than returnable light glass bottles (70.1 kg CO2-equiv), or returnable PET bottles (59.5 kg CO2-equiv). So far the credits for the secondary materials are taken into account as a 'net calculation, the contributions reduce for all examined materials, especially for PET bottles, which continue to provide the comparatively largest contribution (98.2 to 120 kg CO2-equiv per 1,000 l).

The goal of this examination 'The Global Warming Potential analysis of beverage: Which is the best option?' Paqualino et al., [n.y.] was to evaluate the contribution of packaging to the environmental profile of a product's life cycle (beverage production, transport, packaging production and final disposal). The disposal methods considered are landfilling, incineration and recycling, and the packaging types are aseptic carton, glass, HDPE, aluminium can and PET, and their sizes are from 200 ml to 8 l. Recycling was found to be the most environmentally friendly disposal option for all the packaging alternatives compared, and landfilling was considered the second best option. The packaging options with the lowest environmental impacts were aseptic carton and plastic packaging (for sizes greater than 1 l). The influence of beverage production on the life cycle varies according to the type of beverage. Global Warming Potential has been considered as the environmental indicator in this study (incl. Caps and lids). The following arrangements were examined, which parallel a filling volume of 1l.

- Liquid packaging board (aseptic carton), size 0.2 l (50 g/l) till 1.5 l (35.2 g/l)
- Aluminium can, size 0.33 l (67.9 g/l) till 0.5 l (34.7 g/l)
- Glass brown, size 0.33 l (722.7 g/l) till 1.0 l (468.8 g/l)
- Glass white, size 0.33 l (722.7 g/l) till 1.0 l (492.2 g/l)
- HDPE, size 0.2 l (91.1 g/l) till 1.5 l (32.7 g/l)
- PET, size 0.33 l (42.4 g/l) over 1.5 (19.3 g/l) till 8.0 l (17.5 g/l)

Also according to other studies (i.a. [Schmidt et al. 2000], the specific weight per 1 l filling volume is corresponding to the following list (Table 18).

Table 18: Masses of different packaging types

Packaging type	Mass per 1 l
PET (one way)	Approx. 33 to 46 g
Beverage carton	Approx. 35 g (highly depending on size)
Alumnium can	Approx. 35 to 68 g (depending on size)
PET (returnable)	Approx. 71 g
Glass (light)	Approx. 470 to 490 g
Glass (heavy)	> 700 g

Contrary to the mentioned studies, this analysis focuses on the effects of the subsequent disposal methods (landfill, incineration and recycling):

- Landfill: includes the dump infrastructure, the use of land, the effect of landfilled waste, and the emissions to the soil, air and groundwater released by waste disposed of in landfills.
- Incineration: covers the incineration plant infrastructure, the incineration process, the electricity generated and the disposal of residual ashes (to landfill). Electrical energy recovery was considered as an avoided environmental load.
- Recycling: takes into account the recycling plant infrastructure, the sorting and recycling processes, the products obtained and the wastes generated. The products obtained from the recycling process are considered to displace virgin raw materials and are thus an avoided load.

The first result is that larger packages always have a lower environmental impact than smaller packages, and optimal packaging sizes guarantee minimum product losses and maximum ease of use for consumers. As shown in Table 19 , beverage cartons and plastic packaging (for sizes greater than 1 l) present the lowest GWP for the three disposal methods. Except for glass, the GWP figures of an existing recycling are within a comparable range. However, the GWP of disposal of aluminium in a landfill was significantly lower [Paqualino et al., ny].

Table 19: GWP of different packaging types relating to different disposal scenarios [Paqualino et al., ny]

Type	beverage	Landfill	Incineration	Recycling
Beverage carton (1.5 l to 200 ml)	Juice	0.057 to 0.091	0.069 to 0.113	0.048 to 0.074
Glass white (1 l to 330 ml)	Juice/water	0.557 to 0.727	0.729 to 0.975	0.352 to 0.513
PET (8 l to 330 ml)	Water	0.079 to 0.224	0.130 to 0.311	0.036 to 0.101
Aluminium can (500 ml to 330 ml)	Beer, also applicable for water	0.439 to 0.859	0.458 to 0.895	0.039 to 0.077

For India, a comparable LCA for glass and PET bottles was conducted [Stichling, Singh, 2012]. Based on the chosen reference scenarios for glass bottles (focus on 100 %), following functional mechanism categories were compared (Table 20).

Table 20: Comparison of PET-bottles with glass-bottles according to [Stichling, Singh, 2012]

Criteria	PET-bottle compared with glass-bottle (same functional unit)
Acidification Potential [kg SO2-equiv.]	Lower (60 %)
Eutrophication Potential [kg PO4-equiv.]	Lower (69 %)
GWP100 [kg CO2-equiv.]	Lower (57 %)
Human Toxicity [kg DCP-equiv.]	Higher (123 %)
Photochem. Ozone Creation Potential [kg Ethene-equiv.]	Higher (136 %)
Terrestic Ecotoxicity Potential [kg DCB-equiv.]	Higher (246 %)
Primary energy demand from ren. And non ren resources [MJ]	Lower (74 %)

The study 'Comparative Life Cycle Assessment of Tetra Pak® carton packages and alternative packaging systems for liquid food on the Nordic market' comissioned by Tetra Pak International SA liquid packaging board was comapred with competitive liquid food packaging made of PET and HDPE for the Swedish, Finnish, Danish, and Norwegian market. A considerable role for these generally low environmental impacts of beverage cartons plays the renewability of their paperboard components and a high use of renewable energies. They benefit from the use of renewable materials and energies in the production processes. Especially the use of paperboard as the main component leads to low impacts compared to the use of plastics or glass for bottles [Markwardt et al., 2017].

In general the examined beverage carton systems analysed for these markets show lower burdens in all of the impact categories than their competing systems. These impact categories are

- Climate change,
- Acidification,
- Photo-Oxidant Formation,
- Ozone Depletion Potential,
- Terrestrial Eutrophication,
- Aquatic Eutrophication,
- Particulate Matter,
- Total Primary Energy,
- Non-renewable Primary Energy,
- Use of Nature,
- Water use (related to water input).

An exception to this occurs in some categories if the carton contains a high share of bio-based PE.
The use of bio-based polyethylene, though does not deliver such an unambiguous benefit. While the utilisation of bio-based PE instead of fossil-based material leads to lower results in 'Climate Change' the emissions from the production of this bio-polyethylene, including its agricultural background system, increase the environmental impacts in all the other impact categories regarded.

A comparsion of the different material solutions is shown in Table 21.

Table 21: Comparison of different materials for bottles for water

	Comparison: Bottles for water			
GWP	+ Relatively low GWP, if returnable, relatively higher than glass bottles	0 Light glass bottles have smaller GWP than single-use PET, but larger than reusable PET	- Highest GWP, compared to PET, glass and tetra pack	0 Relatively low GWP, nearly on par with light glass bottles, depending on whether they are reusable
Water footprint	+ smallest water foot print, as PET is made from fossil resources	- A lot of water is needed in the manufacture of glass, more than for manufacture of PET	- A lot of water is needed in the manufacture of aluminium, more than for PET	-- A lot of water is needed to produce the cardboard, which is then coated to hold liquids
Use of renewable resources	- The resource for PET is fossil based; a finite resource, can possibly changed into bio based plastics such as corn starch, may result in competition over cultivable land and higher water demand	+ In large portions, glass is made of sand; which is available in abundance	+ One of the most abundantly available elements on Earth; however, may also be found in many other minerals; yet it still is a finite source	0 In large portions made from cardboard and thus paper fibres, which are manufactures from cutting down trees
Use of secondary material	0 Although PET bottles are recyclable, the PET bottles oftentimes are not being turned into new PET bottles, but the plastic fibres are processed for a different purpose	+ Today, glass manufacture uses a lot of waste glass to mix with during the manufacture of new glass items; it is a mixed of old and new glass	0 If the aluminium can is made up of different materials, such as compounds, the aluminium waste may be recycled for a different purpose (down cycling)	0 It is difficult to tell how much recycled material is used for new liquid packaging boards, as they are no labels yet indicating it
Health aspects	0 May be used multiple times, but needs to be washed before reuse, as bacteria can infest the bottle	+ Easier to clean for reuse, no health hazards known	0 The top should be wiped before cleaning, to avoid germs leaching into the water when pouring out	+ Manufactured and filled at high temperature, no information on germ infestation
Safety aspects: handling, usage	+ Do not break easily, light weight	- Breakable, also drinking straight from the bottle may cause harm if top is damaged or if glass knocks against teeth; heavy weight may be difficult for disabled or elderly people to handle	+ Does not break easily, may create dents, light weight, needs small storage space	+ Does not break easily, lighter weight, compared to glass

Economics (world-wide)	0 Production requires least amount of resources, is made from fossil resources	-- Production process is longer, requires more resources, also transportation is more energy intensive as they are heaviest in comparison with PET, aluminium and liquid packaging boards, this also counts for collection	- Production process is longer, requires more resources, also transportation is more energy intensive as they are heavier, this also counts for collection	- Production process is longer, requires more resources, also transportation is more energy intensive as they are heavier, also counts for collection
Economics (price)	+ Usually cheaper than glass, aluminium cans and tetra packs, especially considering filling volume, PET has biggest filling volume	- Most expensive, but filling volume across many ranges	0 Less expensive than glass, more expensive than tetra packs and PET, considering the filling volume	0 More expensive than PET and cans, but less than glass
Consumer aspects	0 Light weight, thus easy to transport and carry around, more difficult to clean	+ Heavy weight, thus may be more difficult to transport, may look aesthetically pleasing, easier to clean	0 Single-use, refilling does not work, small units, small filling volume, may be an alternative for travelling as they do not need much space	+ Can be disposed of in the plastic waste; recyclable, single-use, heavier weight than PET, but lighter than glass
Waste management	0 Returnable PET bottle system not available everywhere yet, adequate waste management infrastructure needs to be established	0 Returnable glass bottle system not available everywhere yet; adequate waste management infrastructure needs to be established	0 Returnable aluminium can system not available everywhere yet; adequate waste management infrastructure needs to be established	-- Tetra pack technically recyclable, but only in specific paper mills which are not available everywhere, therefore disposal in waste-paper should be avoided as regular paper mills cannot process liquid packaging boards; adequate waste management infrastructure needs to be established

The same principles apply to the comparison for cooking oil (HDPE vs. metal and glass) and yoghurt cups (PP vs. liquid packaging board and glass).

Carrier bags: LDPE vs. paper, cotton and non-woven PP

As mentioned (see chapter 3), the Kenyan government passed a ban prohibiting on the use, manufacture and importation of all plastic bags for commercial and household packaging, which includes PE carrier bags and PE flat bags, to reduce the amount of littered plastic bags as well as the associated negative externalities of littered plastics in the environment. However, many concerns have been voiced after that questioning if the alternatives provide are indeed better from an environmental perspective.

The Danish Ministry of Environment and Food published the 'Life Cycle Assessment of grocery carrier bags' in 2018 [Bisinella, 2018] researching the life cycles and environmental impacts of different types of carrier bags, as well as how many times they needed to be reused to break even with the environmental impact of an average LDPE plastics grocery shopping bag.

The study examined the following types of carrier bags available in stores in Denmark:

- LDPE, four types: average, soft handle, rigid handle, recycled
- PP, two types: non-woven, woven
- Recycled PET
- Polyester (of virgin PET polymers)
- Starch-complexed biopolymer
- Paper, two types: unbleached, bleached
- Cotton, two types: organic, conventional
- Composite (jute, PP, cotton)

A Life Cycle Assessment (LCA) takes into account the potential environmental impacts related to the resources which are necessary to produce, use and dispose of the product. The LCA also examines the potential emissions that may occur during the disposal. To assess the carrier bags and their environmental impact, the different materials as shown above were compared to the characteristics of an average LDPE carrier bag which is available in Danish supermarkets.

End-of-Life scenarios for carrier bags

The study examines three main end-of-life (EOL) scenarios for the different types of carrier bags. EOL1 would be incineration of the carrier bag. After serving its primary function (carrying groceries from supermarkets to another destination) the bag is disposed of, collected and incinerated. The electricity and heat produced during incineration allows for avoiding the production of electricity and heat from another source.

The second EOL is recycling of the material. After disposal with separately collected material of the same type, the collected waste is sent to material recycling. The recycled secondary material allows for avoiding production of the same amount of material from primary sources. The residues of the recycling process are incinerated which results in the production of electricity and heat, which allows for avoiding the production of heat and electricity from other resources.

The third EOL is the reuse as waste bin bag. After serving its primary function, the carrier bag is reused for another function, which is collecting residual waste. This practice allows avoiding the production and disposal of a traditional waste bin bag. The electricity and heat produced during incineration process allows for avoiding production of the same amount of electricity and heat from other resources.

Factors not included in the study

This Life Cycle Assessment does not consider behavioural changes or consequences of introducing further economic measures. Also economic consequences for retailers and carrier products are not taken into consideration. Moreover, this report does not include the effects of environmental littering. Neither does it include construction and decommissioning of capital goods such as infrastructure and machinery, nor does it analyse the existing capacities or new capacities requirements.

Environmental indicators examined in this study

In determining the carrier bag with the smallest environmental impact, the study examined the life cycle of the different types in relation to recommended environmental indicators as stated by the European Commission. These indicators were:

- Climate change
- Ozone depletion
- Human toxicity, cancer effects
- Human toxicity, non-cancer effects
- Photochemical ozone formation
- Ionizing radiation
- Particulate matter
- Terrestrial acidification
- Terrestrial eutrophication
- Freshwater eutrophication
- Marine eutrophication
- Ecosystem toxicity
- Resource depletion, fossil
- Resource depletion, abiotic
- Water resource depletion

In the study, the different types of carrier bags were examined in relation to the environmental indicators as shown before. The indicator climate change was also viewed separately for the different types of carrier bags. This indicator includes factors such as global air temperature change or concentrations of CO2 in the atmosphere.

Results of Life Cycle Impact Assessment

In almost all categories, grocery bags made of LDPE provided the lowest environmental impact out of the materials examined. Overall, light carrier bags such as LDPE, paper and biopolymer were the carrier bag alternatives which provided the lowest environmental impact. Heaver multiple-use carrier bags such as composite and cotton bags obtain the highest environmental impacts across all impact categories. Therefore, it is useful to determine how many times a type of bag needs to be reused to lower the environmental impacts related to their production to values comparable to lighter carrier bags. Thus, the study also calculated how many times different types of carrier bags would have to be reused to provide the same environmental performance as the LDPE carrier bag:

- All environmental indicators considered, a recycled LDPE bag would have to be reused twice, before being used as a waste bin bag and then disposed of.
- Non-woven PP bags should be reused 52 times, before being recycled.
- Woven PP bags need to be reused 45 times, and then recycled, to break even with LDPE bags.
- Bags made from recycled PET would need to be reused 84 times to have the same environmental impact as LDPE bags, before they are being recycled.
- Polyester PET needs to be reused 35 times and then recycled.
- Considering all indicators, bags made from biopolymers need to be reused 42 times, before they are either used as a waste bin bag or incinerated.
- Unbleached paper bags should be reused 43 times before they are either used as waste bin bags or are incinerated.
- Bleached paper also needs to be reused 43 times, until it is either used as a waste bin bag or incinerated.
- Organic cotton should be reused 20,000 times before it is either used as a waste bin bag or incinerated to break even with LDPE bags.
- Conventional cotton needs to be reused 7,100 times, before it is used as a waste bin bag or incinerated.
- Composite bags should be reused 870 times before they are used as waste bin bags or are incinerated.

The comparable study 'Life cycle assessment of supermarket carrier bags: a review of the bags available in 2006' commissioned by the UK Environment Agency and published in 2006 [Edwards, Frey, 2011], comes to overall similar conclusions as the 2018 Danish report.

In the Life Cycle Assessment, grocery carrier bags available in UK supermarkets were examined. However, contrary to the 2018 study, the UK Environment Agency then used conventional HDPE bags as reference, as they were the average bags being handed out for free in grocery stores at the time. One of the goals of this study was to determine a life cycle inventory of environmental impacts associated with the production, usage and disposal of lightweight carrier bags. Another goal was to compare the environmental impacts arising from lightweight plastic carriers to those caused by alternatives. In this study, however, several factors were not taken into consideration. These include the consequences of carrier bag taxes, the effects of littering, the ability to and willingness of consumers to change their behaviour, any adverse impacts of degradable polymers in the recycling stream and potential economic impacts on the UK industry.

Environmental impact indicators as used in the research

To determine the environmental impact of the different types of carrier bags, the study formulated a total of nine environmental indicators:

- Global warming potential
- Abiotic depletion
- Acidification
- Eutrophication
- Human toxicity
- Fresh water and aquatic ecotoxicity
- Marine aquatic ecotoxicity
- Terrestrial ecotoxicity
- Photochemical oxidation

The indicators as shown above are largely comparable to the set of environmental indicators which the Danish study used in their 2018 life cycle assessment report.

Results of life cycle assessment

The study concluded that conventional HDPE bags provided the lowest environmental impact of lightweight bags in eight out of nine environmental impact categories.

- LDPE bags need to be reused five times in order to reduce their environmental impact below that of the conventional HDPE bag.
- A paper bag would need to be reused four times to reduce its global warming potential to below that of a conventional HDPE bag. However, many reuses are unlikely due to its low durability.
- Cotton bags provided a greater environmental impact than conventional HDPE bags in seven out of nince categories. 173 reuses are required to reduce the environmental impact below of that of a conventional HDPE bag with average secondary reuse impact.

Overall, when compared to a conventional HDPE bag which is disposed of and is not used to serve a secondary use as, e.g. a waste bin liner, then a paper bag needs to be reused 3 times, an LDPE bag should be reused four times, a non-woven PP bag should be reused 11 times and a cotton bag needs to be reused 131 times, to reduce their environmental impact to that of a conventional HDPE bag.

Both studies that were used as a reference concluded that grocery shopping bags out of LDPE and HDPE respectively provided overall lower environmental impacts than paper, cotton und non-woven PP bags. That being said it is important to consider that factors such as environmental littering were not taken into consideration during both life cycle assessments as both studies analysed the different materials for carrier bags from a superordinate angle. A comparsion of the different material solutions is shown in Table 22.

Table 22: Comparison of different materials for carrier bags

	Comparison: Grocery carrier bags			
	LDPE	**Paper**	**Cotton**	**Non-Woven PP**
GWP	+ Overall best climate change performance	- More impact than LDPE and non-woven PP, due to trees being cut down, heavier weight	- More impact than LDPE, paper and non-woven PP due to longer production process of cotton fibres, heavier weight	0 More impact than LDPE but better than cotton and paper
Water footprint	+ Overall smallest water footprint, resource for conventional plastic is fossil-based	- Bigger water footprint than LDPE, much water is needed in production of paper fibres	-- Bigger water footprint than LDPE and paper, much water is needed to produce cotton yarn and fertilizer production	0 More water is used than for LPDE bags, but less than for paper and cotton bags
Use of renewable resources	- Resource for conventional plastic is fossil-based, a finite resource, can possibly changed into bio based Plastics such as corn starch, may result in competition over cultivable land and higher water demand	0 Made out of renewable resources but trees need to be cut down to gain paper fibres, results in deforestation; usage of fertilizers result in terrestrial and freshwater eutrophication, high water demand	0 Made of renewable resources but deforestation due to growing demand for cotton fibres and therefore cotton plants; usage of fertilizers results in terrestrial and freshwater eutrophication, plants need a large amount of water to grow	- Resource for conventional plastic is fossil-based, a finite resource, can possibly changed into bio based Plastics such as corn starch, may result in competition over cultivable land and higher water demand
Use of secondary material	+ Highly eligible for use of secondary material, already done in many cases	+ Highly eligible for use of secondary material, already done in many cases	- Normally no use of secondary material	+ Highly eligible for use of secondary material, already done in many cases
Health aspects	- LDPE has slightly more human toxicity	0 On par with non-woven PP, provided the least human toxicity	-- Cotton provided the most human toxicity; may become habitat for bacteria, fungi and mould	0 On par with paper, provided the least human toxicity
Safety aspects: handling, usage	-- LDPE bags fly away easily, littering, potentially dangerous when ingested (wildlife), breeding spot for mosquitoes	0 Paper bags tear easily, especially when wet, difficult to clean, takes up more space than plastic	+ Not sanitary for handling edibles, but generally meant for multiple use, washable	+ Generally meant for multiple use, sturdy, durable

Economics (worldwide)	- to 0 Bags used worldwide, banned in some places, customer incentive in favour of multiple-use	0 Generally available for fee, not commonly used in supermarkets, yet some retailers (textile) give them out for free	- Usually available for purchase, but production requires a lot of resources related to manufacture of cotton fibres	0 In places with bans against single-use plastic bags, they are commonly used, usually available for purchase
Economics (price)	++ Price for LDPE is cheapest, retailers make profit when they sell bags for e.g. 20 ct	0 More expensive than LDPE bag but cheaper than cotton, less durable	- Most expensive bag compared to LDPE, non-woven PP and paper bag	+ Generally less expensive than cotton bag, but more expensive than LDPE and paper bags
Consumer aspects	- to 0 Meant for single to multiple use, flexible, lightweight	- Multiple-use is difficult because paper has low durability, especially when wet, recycling oftentimes easier	0 Meant for multiple use, doesn't tear easily, repairable, washable, not sanitary for edibles, (attractive design)	0 Meant for multiple use, sturdy, usually large capacity, some stores give discount when one shops with such a bag
Waste management	- Collection with other PE, plastics but hard to collect, flies away, danger of littering, pollution, recyclable	+ Can be collected with other papers, degradable in environment, recyclable	- Can be collected with waste textiles if existent, no proper recycling	N/A

Construction Pipes: Plastics vs. (galvanised) steel and concrete

Construction pipes are used in areas such as sewerage and drainage or water supply and waste water disposal. For the following examination it is assumed that the pipes, which are made of different kinds of materials, are equally suitable for the required utilisation, as they are subject to standard such as technical norms.

The table identifies the GWP100 of the different types of pipes in Table 23. According to this the different materials lie within a comparable range at a GWP value of 1.94 (steel) to 3.23 (PVC) per kilogram.

Table 23: Selected GWP100 for construction pipes

Category	GWP_{100} [kg CO_2 equi.] per kg	Database
HDPE Pipe	2.52	Bath Uni via [Carbon Footprint Ltd, n.y.]
PVC Pipe	3.23	Bath Uni via [Carbon Footprint Ltd, n.y.]
Steel Pipe - World Typical - World 39% Recy.	1.94	Bath Uni via [Carbon Footprint Ltd, n.y.]
Steel Pipe - Galvanised (typical 35.5 % Recy.)	> 2.12	Bath Uni via [Carbon Footprint Ltd, n.y.], data for steel coil plus contribution for pipe construction

Different surveys examined the environmental performance evaluation of different kinds of pipes. Due to the multitude of possible types of piping system, usually comparable applications are balanced. These are portrayed as follow: The survey 'Polypropylene Materials for Sewerage & Drainage Pipes with Reduced Energy and Carbon Footprints' Wassenaar [2016] compares the environmenteal impact in terms of GWP and non renewable energy demand (NRED) of innovatively produced PP pipes (based on high modulus propylene block copolymers [HM] and mineral modified propylene [MD]) with standard block copolymer [B] PP pipes, as well as concrete materials. The study has been conducted according to the international ISO 14020 and 14021 standards governing environmental claims, particularly their accuracy. The compliance of the LCA with these standards has been verified by an external independent auditor.

The functional unit is 1 m of installed plain wall pipe with a ring stiffness of >8 kN/m⁺. The base case considers a DN of 250 mm for plastic pipes and the closest equivalent concrete pipe size (DN 225 mm). The weight which results from the functional unit is pivotal for further examination:

- PP-MD (DN 250 mm): 8.0 kg per m
- PP-HM (DN 250 mm): 5.9 kg per m
- PP-B ((DN 250 mm): 6.6 kg per m
- Concrete (DN 225 mm): 97.6 kg per m

It is evident that the specific weight of concrete compared to PP (or plastics in general) for the same application is many times higher (12 to 16 times). If the diameter is bigger, this proportion decreases. For a diameter of 800 mm for plastic pipes and 750 mm for concrete pipes, the proportion ranges at seven to nine times [Wassenar 2016].

In comparision, the following results appear: Concrete pipes have a higher GWP due to the production of raw materials (nearly twice, see Figure 34). Generally, the raw materials production accounts for that, which is comparable to the raw material production of PP, as well as the related transformation. If transportation is taken into consideration, the GWP results in a higher figure for concrete pipes, predominantly due to the heavier specific weight.

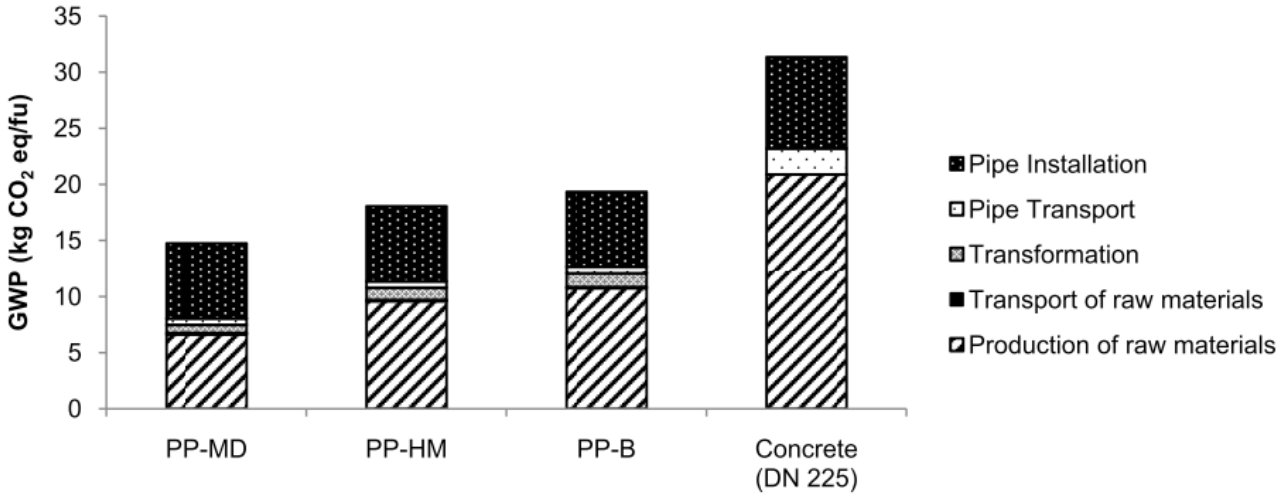


Figure 34: GWP for 1 m of installed plain wall sewerage and drainage pipe [Wassenaar, 2016]

Contrary to that, plastic pipes generally provide a higher NRED due to the fact that for plastic pipes the largest contributor to NRED is associated with the internal energy component of the raw material (see Figure 35).

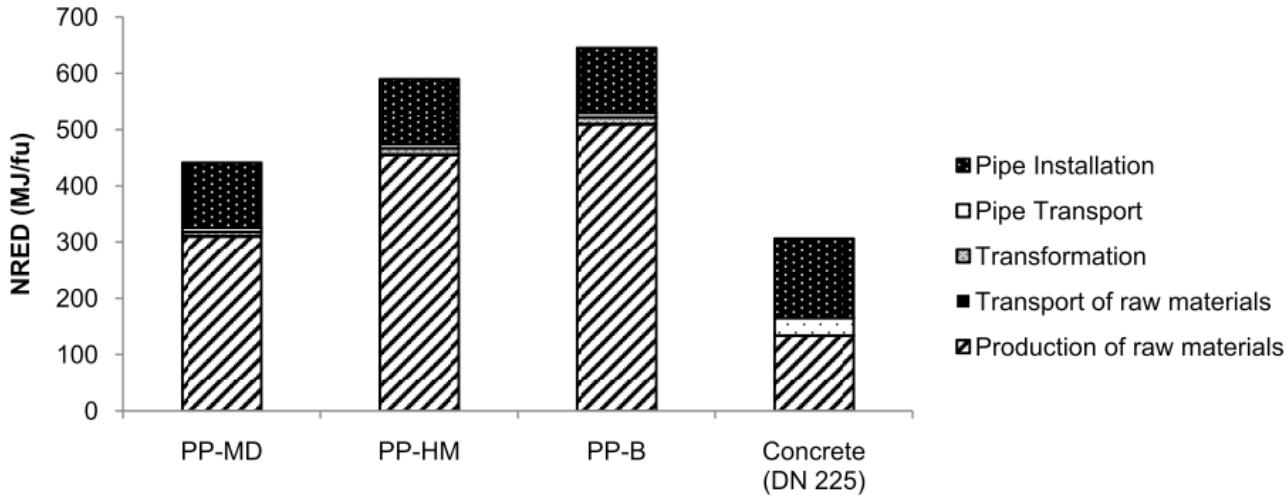


Figure 35: NRED for 1 m of installed plain wall sewerage and drainage pipe [Wassenaar, 2016]

The survey 'Life Cycle Analysis for Water and Wastewater Pipe Materials' [Du et al., 2013] examines the LCA damages of six commonly used pipe materials (PVC, ductile iron, cast iron, HDPE, concrete and inforced concrete). The function unit is a 12-inch pipe (30.5 cm) per km. Table 24 identifies the results of the GWP according to different phases. The installation phase for iron is highest due to the joining technology, while the transportation phase is highest for concrete, due to its weight. Both of these phases are nearly irrelevant for the total GWP, because the highest GWP contributions result from the production.

Table 24: Phase-Dependent and Total GWP per km of 30.5 cm (12 in.) diameter pipes for different Materials [Du et al., 2013]

Pipe materials (12-in. pipe)	Total GWP (10⁴ kg CO_2/km)	Production phase (10⁴ kgCO_2/km)	Installation phase (10⁴ kgCO_2/km)	Transportation phase (10⁴ kg CO_2/km)
PVC	318	315	2.81	0.26
Ductile iron	472	468	3.28	0.88
Concrete	68.3	63.1	2.91	2.26
HDPE	218	215	2.81	0.17
Reinforced concrete	152	146	2.91	2.47
Cast iron	353	349	3.28	0.84

For the 12-inch diameter example, iron pipes contributed the greatest increment to GWP among the six kinds of pipe materials compared. Concrete pipe had the lowest GWP, despite the energy demand associated with cement production. This is contrary to survey of Wassenaar [2016], as mentioned above, although nearly similar basic data was used for the examination of concrete pipes (main reference Marceau et al. [2007]). Further, Du et al. [2013] identifes that PVC yields the greatest GWP per unit pipe legnth at diameters ⌖76.2 cm (30 inch). This seeming anomaly arises from the material-dependent schedule of pipe thicknesses, which increase dramatically for plastic water pipes of diameter greater than 61.0 cm (24 in.).

Appropriate to EPA [2000] the different types of pipe systems provide advantages and disadvantages (Table 25).

Table 25: General advantages and disadvantages of plastic, concrete and steel/iron pipes [EPA, 2000]

Category	Plastics	Concrete	Steel / iron
Advantages	• Very lightweight • Easy to install • Economical • Good corrosion resistance • Smooth surface reduces friction losses • Long pipe sections reduce infiltration potential • Flexible	• Good corrosion resistance • Widespread availability • High strength • Good load supporting capacity	• Good corrosion resistance when coated • High strength
Disadvantages	• Susceptible to chemical attack, particularly by solvents • Strength affected by sunlight unless UV protected • Requires special bedding	• Requires careful installation to avoid cracking • Heavy • Susceptible to attack by H_2S and acids when pipes are not coated	• Heavy

A cost comparison identifies that concrete pipes per meter are generally the cheapest, however they are only offered with larger diameters. Plastic pipes are usually cheaper than comparable stell/iron pipes [EPA, 2000; Rafferty, 1998].[2]

A comparsion of the different material solutions is shown inTable 26.

Table 26: Comparison of different materials for construction pipes

	Comparison: construction pipes		
	Plastics	Concrete	Steel / iron
GWP	+ Provide smallest GWP impact	- Provide highest impact compared to plastics and steel, also, but not only because of larger specific weight	0 Provide higher impact than plastics, but lower than concrete
Water footprint	+ Smallest water footprint compared to concrete and steel	- Largest Water footprint as it is used to manufacture concrete	0 Larger water footprint than plastic, but not as large as concrete

Use of renewable resources	- Resource for conventional plastic is fossil-based (a finite resource), can possibly changed into bio based plastics such as corn starch, may result in competition over cultivable land and higher water demand	- Manufacture requires a lot of energy, sand as resource is not abundantly available	- Manufacture requires a lot of energy; one bases of steel is iron ore, which is a finite resource
Use of secondary material	0 If made from mono-material: technically possible to recycle them, otherwise down cycling is possible	0 Generally recyclable if it is free of contaminants; concrete can be used in the manufacture of new concrete	++ Generally high recycling rates, secondary steel is commonly used in today's steel manufacture
Health aspects	0 Do not rust; drinking water from plastic pipes older than 1970s could potentially be harmful; solvents may attack pipe	0 Do not rust; acids and H2S may damage pipes if not coated	0 If galvanized, it does not rust; acidic and alkaline water damages them
Safety aspects: handling, usage	+ Light weight, corrosion resistance; good resistance against electric current; relatively easy to repair / replace; long pipe section reduces infiltration potential, strength affected by sunlight unless UV protected, requires special bedding	0 Heavy, weight corrosion resistance; high strength and long durability, heat resistance; supposedly last 35 to 50 years, difficult to repair	- Heavy weight; corrosion resistance when coated; high strength, supposedly last around ten years; can be joined easily, cutting, bending and threading is easy; higher risk for potential damage at joints at larger diameter
Economics (worldwide)	+ Easy to install; smooth surface reduces friction losses; flexible	+ Widespread availability; good load supporting capacity	+ Relatively easy to install, not as heavy as concrete
Economics (price)	+ Generally cheapest compared to steel and concrete	- Pipes generally offered at larger diameter	0 Cheaper than concrete, more expensive than plastic pipe
Consumer aspects	+ Economical, easier to transport and install	- Transportation is more difficult compared to steel and plastics because of larger weight	- Longevity may be needed to consider, as they may be threatened by corrosion
Waste management	0 Industrial waste oftentimes provides more mono-materials as household waste, therefore recycling is theoretically possible at larger scale, but adequate waste management infrastructure needs to be established	0 If free of contaminants such as wood or paper, concrete may be recycled to be used in the manufacture of new concrete; adequate waste management infrastructure needs to be established first	+ Steel can technically be recycled without any forms of material loss; however, adequate waste management infrastructure needs to be established

8.10 Annex 10: Global examples of education and awareness programmes

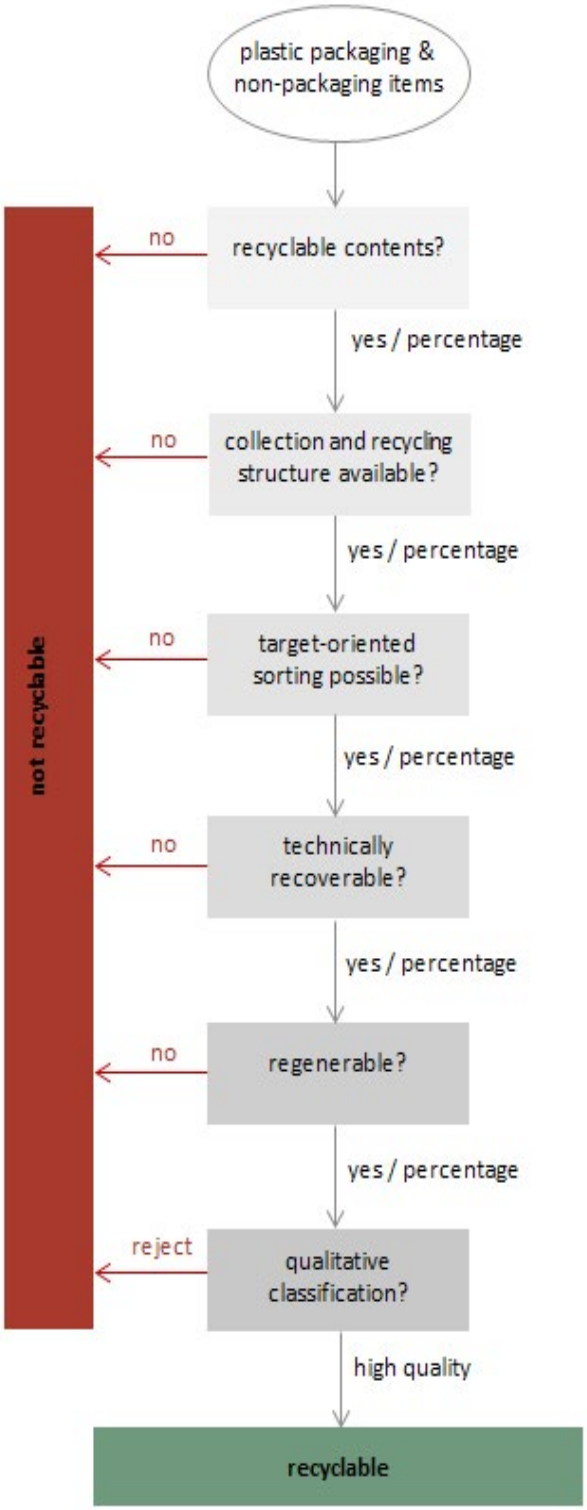
In California, the California Education and the Environment Initiative exists. The initiative is one of CalRecycle's (California's Department of Resources Recycling and Recovery) Office of Education and the Environment (OEE) programs that aim encourage environmental literacy among all California students from Kindergarten to 12th grade. The initiative provides curricula that combine the environment with the teaching of traditional academic subjects such as science, history, English language, and arts. Some of the topics discussed in the curricula are about earth and its resources, the history of the impact the human behaviour had on the environment, and the critical environmental issues the modern world faces [California Education and the Environment Initiative, n.y.].

One more example is the 2012 cooperation between the Paper Recycling Association of South Africa (RecyclePaperZA) and the Department of Education to incorporate recycling in the maths curriculum. The topic of recycling was integrated in the syllabus of grades R through seven. In partnership with E-CLASSROOM, a website that provides curriculum-based educational resources, the recycling-focused lessons are found in grade three, Life Skills content on the website. More content has also been developed to integrate recycling in Mathematics (data handling) and English for Grade one to six, using paper products as examples. Recycling as a curriculum topic ensures that learners grow up with an awareness of waste and the importance of recyclability [RecyclePaperZA, n.y].

Fostplus, Belgium (the Belgian PRO) launched multiple campaigns that target litter problem in Belgium. In 2016 with the support of the Fevia and Comeos sector organisations, Fostplus signed an agreement with the Flemish, Walloon and Brussels authorities to tackle the problem through campaigns and events. One example is the Grand Nettoyage de Printemps (Great Spring Clean) campaign in Wallonia in April 2016, where 40,000 participants cleared plots of land, streets and parks of litter. Another campaign was the Retail Clean-Up Days, November 2016. 1,100 shops in Flanders and Wallonia participated in the Retail Clean-Up Days. Each shop agreed to clean up the area within a 25 m radius of its premises. A surface area of 5.7 million m2 was cleaned up in total, the equivalent of more than 1,150 football fields. There are other campaigns launched by Fostplus that aim to raise awareness in communities about the correct way of sorting waste, and to stress the importance of sorting and its positive impact on the environment and future [Fostplus, n.y.].

Another example of is the Orange Bin Campaign in Israel: Recycling corporations collecting packaging waste from all of Israel launched the online campaign to raise public awareness about recycling and proper waste disposal. The campaign used YouTube as a platform to spread its message by creating a video that features young Israelis combining extreme sport with garbage collection to eliminate the negative idea about waste and recycling. The video went viral gaining around 900,000 views. And according to a statistic released in 2014 by the Israel Union for Environmental Defense and Migal, a Galilee research institute, over 300,000 Israeli households separate dry and wet waste, representing a 400 % increase in two years (Weißenbacher, 2016).

8.11 Annex 11: Flow chart for determining the recyclability



Notes


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Inner back cover

Kenya Association of Manufacturers
15 Mwanzi Road opp West Gate Mall, Westlands
P.O. Box 30225 - 00100 Nairobi, Kenya

E: info@kam.co.ke
M: +254 (0) 722201368, 734646004/5
T: +254 (020) 2324817
Twitter: @KAM_Kenya
Facebook: KenyaAssociationOfManufacturers

www.kam.co.ke