ECONOMIC CONSEQUENCES OF UNMANAGED PLASTICS AND ECONOMIC OPPORTUNITIES IN THE WESTERN INDIAN OCEAN:

Steps Toward Action Plans

UN environment programme

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WIOMSA
Coasts Ocean and People
WESTERN INDIAN OCEAN MARINE SCIENCE ASSOCIATION

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Compiled and prepared by: A J Ribbink; J M Wallace; D De Vos; J Osborne; C Steyn; S Pillay & N Vanmali (all from the African Marine Waste Network programme of the Sustainable Seas Trust); A Pretorius (Plastix 911); D Steyn (Plastics SA) & R Daniels (University of Cape Town)

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Designed by: Gordon Arara

Coordinated by: Jared Bosire, Arthur Tuda and Julius Francis

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ACRONYMS

ALDFG	Abandoned, Lost or otherwise Discarded Fishing Gear
AMWN	African Marine Waste Network
ASCLME	Agulhas and Somali Current Large Marine Ecosystems
BAU	Business as Usual
CSIR	Council for Scientific and Industrial Research
DRS	Deposit Refund Scheme
EPR	Extended Producer Responsibility
FAO	Food and Agricultural Organization of United Nations
GRP	Glass Reinforced Plastic
GDP	Gross Domestic Product
GHG	Green House Gas
IUCN	International Convention for the Conservation of Nature
MARPOL	International Convention for the Prevention of Pollution from Ships
MPP	Marine Plastic Pollution
MEDA	National Marine Ecosystem Diagnostic Analysis
MSW	Municipal Solid Waste
MRF	Material Recovery Facility
NGO	Non-Governmental Organization
PE-HD	Polyethylene High Density
POPs	Persistent Organic Pollutants
PRO	Producer Responsibility Organization
SUP	Single-Use Plastic
SDGs	Sustainable Development Goals
SST	Sustainable Seas Trust
UN	United Nations
UNEA	United Nations Environmental Assembly
UNEP	United Nations Environmental Programme
WIO	West Indian Ocean
WIOMSA	West Indian Ocean Marine Science Association
WWF	Worldwide Fund for Nature

SUMMARY AND KEY RECOMMENDATIONS

The global predictions are that on average the leakage of plastics into the seas will quadruple by 2040 unless dramatic steps are taken to curb production and mismanagement of plastics. The urgency is greater for the Nairobi Convention countries because their anticipated leakage of plastics will be 14% higher than the global average. Action is imperative. Action, however, must be guided by a knowledge of the circumstances that prevail in each of the ten countries, and the impacts of interventions should be measurable. This report is one of three to evaluate the state of knowledge in the five continental and five island states of the Western Indian Ocean. Its focus is on the economics of plastic management and mismanagement.

The steps of the plastics value chain through the life history of plastics, from production to end of life, were examined because they provide a stepwise manner to understand issues and to identify information gaps. The first scenario was to explore the costs of inaction on the economy, on humans, on the health of the environment, and on biodiversity. It was concluded that inaction is untenable.

Sequentially, through different scenarios, actions were introduced, beginning by adding formal waste management as the first action. In the next scenarios, economic recycling enterprises were progressively added as actions that provide economic incentives, which encourage informal participation in waste management. In each successive scenario, positive ramifications grew, with increased potential to provide jobs, alleviate poverty, improve human and environmental health, and different aspects of the economy, including fishing and tourism. These scenarios were hypothetical but based on existing principles related to the recycling opportunities and the circular economy.

While recycling is one way to deal with managing discarded plastics, another action is to reduce the quantity of plastics being produced, entering the market, and being discarded. To these ends the Extended Producer Responsibility and the Ellen MacArthur Pact Network were discussed, showing the benefits of each.

The primary results of the research are captured within the tables of Appendix 1, which were based on literature reviews and on interviews of informed persons in the region.

Principal discussion points and recommendations are given here.

- Municipalities/city councils play such pivotal roles that it is recommended that greater recognition of their essential services should be given and that increased financial support should be found to improve their capacity to better manage plastics.

- Management of plastic waste depends on measurements to set baselines, to plot trends, and to assess impacts of planned interventions, yet the WIO is data poor. It is apparent that in most countries, the data that are essential for evaluating current status and for planning are sparse, not available or difficult to find (South Africa is the exception). In particular, data collection is inconsistent, differing within and between countries. It is recommended as a high priority that a uniform, robust method for data collection, management and use is developed, starting with an inclusive, regional planning workshop.
- The disciplines encompassing plastics and all facets of their production and management are relatively new to the world. A consequence is that many of those in leadership positions in the plastics fields are self-trained. It is recommended that a coordinated drive to build capacity, upgrade education (including introducing it at school and university levels), and knowledge sharing should be planned and implemented.
- Every effort should be made to stimulate the growth and development of enterprises that use plastic waste to produce marketable products. These enterprises remove plastic waste from the environment. They provide incentives to the informal sectors, provide employment opportunities, contribute to poverty alleviation and benefit human health and the fisheries. It is recommended that governments should introduce enabling legislation to accelerate and support such initiatives.
- Sea-based sources of plastic waste appear to be significant within the Western Indian Ocean region but are poorly studied. It is recommended that capacity is built in this discipline and region-wide research is undertaken.
- It is recommended that regional collaboration, networking and information sharing should be promoted by the African Waste Network Maps, which is an interactive online platform developed for this purpose.

It is concluded that promising, positive progress is being made in every country and an encouraging momentum is developing, but there is a need to accelerate the processes, given the looming urgency to conquer global plastic pollution and the fact that no country is fully able to manage its plastic waste. The commitment of most countries to developing and implementing national action plans is encouraging.

Recently discarded plastics that were dumped on coastal dunes in KwaZulu-Natal by nearby residents. Wind and rain will carry these plastics into the Indian Ocean below if they are not collected. (Photo by: © Douw Steyn)

1 INTRODUCTION

1.1 Context of the study

This study includes all ten countries of the Nairobi Convention. Five are continental states: Kenya, Mozambique, Somali, South Africa, and Tanzania; and five are island states: Comoros, Madagascar, Mauritius, Reunion Island (France), and Seychelles (Figure 1). All ten countries benefit from the active coordination and leadership of the Western Indian Ocean Marine Science Association (WIOMSA), which was formed in 1993 to promote marine sciences and conserve the marine resources of the Western Indian Ocean (WIO). The Nairobi Convention and WIOMSA work closely in accord.

Figure 1. The ten Nairobi Convention countries of the Western Indian Ocean (WIO) showing the South Equatorial current, included here as it is purported to carry plastic litter from Southeast Asia and deposit it in the WIO countries, particularly the Seychelles (see below). On reaching Africa, the South Equatorial Current flows southwards as the Agulhas Current and northwards as the Somali Current. This map shows the general direction of the currents to depict how sea-borne plastic waste may be transported. The details and eddies of these currents that are known to oceanographers are not given here.

The burgeoning plastic litter challenge within the countries of the Nairobi Convention has been a concern of the United Nations Environment Programme (UNEP), Nairobi Convention, and WIOMSA for two decades, leading to the Western Indian Ocean Regional Action Plan on Marine Litter (UNEP 2018). The Nairobi Convention Secretariat and WIOMSA established a Group of Experts on Marine Litter and Microplastics in 2019 to grow collaboration among stakeholders, promote networking, and harmonize data collection.

A priority for the WIO Group of Experts is to undertake a regional assessment of the status of marine litter and microplastics. The assessment includes establishing the impact of litter on ecological and human health and economies. One of the challenges is to harness the inherent value in waste to build WIO economies and address poverty issues. Accordingly, the Nairobi Convention and WIOMSA commissioned three inter-related studies to assess:

(i) The status of marine litter and microplastics knowledge in the WIO region;

(ii) Their environmental, economic, and human health impacts; and

(iii) The effectiveness of measures undertaken to address the challenges and opportunities that could be harnessed for enhanced interventions.

1.2 Purpose and Scope

This paper is the second of the three interrelated studies focusing on environment, human health, and economics. More specifically, it aims to review and evaluate:

(i) The economic consequences of unmanaged plastics;

(ii) The economic incentives for each country to reduce the leakage of plastics into the environment through increased reuse and recycling (to establish a local recycling economy);

(iii) The cost of plastic pollution;

(iv) The cost of inaction; and

(v) The economic opportunities that can benefit communities as well as to identify economic incentives that will not only address poverty but will encourage a local secondary resources economy.

This study is undertaken in order to:

(i) Make recommendations on actions to be taken at national and regional levels to reduce the consumption of single-use plastics, to improve product design for recycling, to grow local recycling economies and to identify evidence gaps;

(ii) Make recommendations to promote collaboration and networking; and

(iii) Make recommendations to build capacity and promote understanding within the region.

1.3 Urgency and Need for Action

The problem with plastic starts long before it reaches the oceans, rivers, and beaches. It starts wherever people discard plastics, whether in their homes, offices, factories, retail stores, schools and universities, recreational areas, or elsewhere (Figure 2). From these sources it is washed or blown into waterways and rivers, on its way to the sea (Figures 3 and 4). .

Figure 2. Plastics are discarded and accumulate in towns where people work and where they live. (Photos by: © Douw Steyn & Annabe Pretorius)

Figure 3. Discarded plastics begin their journey to the sea, along waterways, rivers, and estuaries. Booms to catch plastic litter are used to reduce the leakage of plastics to the seas. (Photos by: © Annabe Pretorius)

Figure 4. Plastics flow from the rivers, into the sea, particularly after rains, and then some get washed onto the beaches, the remainder stays in the seas and may travel great distances in the oceans or sink. (Photos by: © Douw Steyn & Annabe Pretorius)

It is estimated that between 8 and 12 million tonnes of plastic enter the seas of the world annually (Jambeck *et al*., 2015, The Pew Charitable Trusts and SYSTEMIQ 2020). This may be more easily envisaged as between 250 and 380 kgs per second. Another way of drawing attention to the urgency is provided by The Pew Charitable Trusts and SYSTEMIQ (2020). They indicate that unless considerable action is taken to address plastic pollution, then on average, globally, 50 kg of plastic will enter the ocean for every metre of shoreline by 2040. These are estimates based on surrogate or inferred data from demographics, socio-economics, national economics, and so forth, because direct measurements leading to numerical data are not available for any country. The flow of plastics into the seas of the world is far too high, costly, and increasing rapidly (World Economic Forum 2016; Ellen MacArthur Foundation, 2020; The Pew Charitable

Trusts and SYSTEMIQ 2020; UNEP 2021). If the trend is not reversed, the costs to human and environmental health are predicted to be dire (The Pew Charitable Trusts and SYSTEMIQ 2020; UNEP 2021) and will represent heavy national, regional and global economic burdens (Ellen MacArthur Foundation 2021; The Pew Charitable Trusts and SYSTEMIQ 2020; UNEP 2021). Issues of plastic pollution are now rated among the greatest threats to humanity. UNEA has called for action to be taken at every level to combat the flow of plastics into the environment. Among the calls from the United Nations Environment Assembly (UNEA) and UNEP are for national and regional action plans. There is also a call for countries to commit to a Global Treaty, which is to be tabled at UNEA 5 (The Business Case for a UN Treaty on Plastic Pollution, 2021).

The precise contributions from the WIO countries and the rest of Africa to the global problem have not been quantified (Jambeck ***et al***., 2018) but could be considerable because the Africa Waste Management Outlook (UNEP 2018a) shows that, in many countries, unmanaged plastic waste has been accumulating since the 1960s. Currently, every country in Africa, including those of the WIO region, has unmanaged litter that has accumulated over decades in the terrestrial environment, principally in illegal dumps and in partially managed landfills (UNEP 2018a). Every day, in every country, newly discarded litter adds to the load that is already in the environment from where it leaks to the sea. Waste management endeavours of coastal cities are unable to keep pace with the growth of litter (UNEP 2018a), and the situation is worsening. If current global trends are not slowed or reversed, plastic waste generation will double by 2040 (The Pew Charitable Trusts and SYSTEMIQ 2020). Consequently, the amount of plastic waste accumulating on land, worldwide, will increase on average by 38% of its current load, with an estimated threefold increase of inflow to the seas. This increase would take the current 11 million metric tonnes per annum (about 350 kgs per second) to 29 million metric tons per year (about 920 kgs per second) by 2040 (The Pew Charitable Trusts and SYSTEMIQ 2020). This would result in a fourfold increase in the plastic stocks in the ocean (The Pew Charitable Trusts and SYSTEMIQ 2020). In WIO countries, however, a higher than average growth rate is expected because it is predicted that plastic pollution in middle to low-income countries will grow from 58% in 2016 to 71% by 2040 unless concerted, well-planned, multidisciplinary steps are taken to combat littering (The Pew Charitable Trusts and SYSTEMIQ 2020).

The underlying causes are that, in common with many other countries of Africa within the low to middle-income bracket, WIO countries are expected to experience rapid population growth, high levels of urbanization, an increasing proportion of affluent middle-class citizens, and accelerating economic-development (Jambeck *et al*., 2018, UNEP 2018, The Pew Charitable Trusts and SYSTEMIQ 2020). All these factors will contribute to rising per capita waste generation, including significant increases in plastic pollution (The Pew Charitable Trusts and SYSTEMIQ 2020). As WIO countries are currently unable to handle the present challenges of solid waste management (UNEP 2018), the capacity must be built up within every society, especially municipalities, to reduce further plastic pollution and to cope with the anticipated regional growth of plastics and other waste.

Clearly, a Business as Usual (BAU) approach which does not keep pace with the growing plastic challenge is unaffordable. National and regional action plans are required to promote a concerted, well-guided effort to decrease plastic pollution.

1.4 Economic Imperative and Circular Economy

Decision-makers in government, business and other leadership positions are more likely to respond to economic data and predictions, which they find more compelling than environmental issues. This is reason enough to seek to understand the value of the plastic industry and the potential value of plastic waste. However, within WIO countries, the opportunities to meet the challenge of poverty, and struggling local and national economies, make it imperative to evaluate and harness economic potential. The Ellen MacArthur Foundation emphasizes the imperatives of assuming an economic approach when advocating the principles of the circular economy and advancing the New Plastics Economy (World Economic Forum 2016; Ellen MacArthur Foundation 2020). These principles are sound and can be adapted to conditions within WIO countries.

1.5 The Multidisciplinary Challenges of Action Plans

One of the positive developments arising from the fourth session of the United Nations Environment Assembly (UNEA-4) of March 2019 is that countries are now tasked with developing national and regional action plans to manage plastic waste in a coordinated manner (Resolution UNEP/EA.4/L.10, UNEA). Such action plans are essential, but the development of effective, evidence-based plans depends upon nations having knowledge of and expertise in a wide range of plastic associated disciplines, and of the societies in which plastics are to be managed. The disciplines in which expertise is required range from the chemistry of plastics (including polymer chemistry) to a detailed understanding of every step of the plastics industry. Those who understand economics, socio-economics, the plastics economy (including the principles and practice of the circular economy), retailing, marketing, and consumer behaviour are core to planning. As all these disciplines must be appropriately placed within societies and communities, the planning teams developing Action Plans need to include the expertise of those who understand and can represent communities and others who can shape societal behaviour. Educators are required to develop and deliver appropriate educational programmes at many levels. Environmental experts should formulate actions necessary to protect ecosystem processes and the biodiversity in terrestrial, freshwater, estuarine, marine, and aerial environments. Scientists are required to accurately measure the impacts of remedial interventions and provide predictive models of likely scenarios in response to defined interventions in changing circumstances. Central players are those with expertise in waste management, engineering, recycling, repurposing, and upcycling. Many disciplines can be added to this list, but the point is that a multidisciplinary, coordinated approach is required. Collectively, these planners need to guide legal experts who work with policymakers to develop enabling legal environments that will facilitate the implementation of recommended actions within their own countries. Additionally, the problems of plastic pollution are experienced and shared across national boundaries, requiring regional collaboration in finding solutions.

2 METHODS

2.1 Literature Review

The literature review was extensive with the purpose of obtaining firm numerical data on the status of plastic pollution in each country and its management. The data were accumulated in tables under three headings:

- Waste management (with the focus on plastics);
- Sources and movement of plastics, including the role of import and export of plastics; and
- Plastics economies; the aim being to place monetary values on plastics and their management.

Researchers consulted hundreds of references, but only a few had the quantitative data required for this survey. Most gave descriptions of plastic pollution in general, and often the data provided referred to global statistics, occasionally providing African perspectives, but seldom on individual countries. Nevertheless, specific national data were found; the references for each country are provided with the tables in appendix 1.

Only those references providing 1) information and data used for this report and 2) those that gave guiding principles or reviews have been included in the bibliography.

The literature review was undertaken using keyword searches within SST's existing bibliography, but primarily extensive use was made of online search engines. The search was undertaken mainly in English, but some French and Portuguese papers, provided by colleagues in WIO countries, were translated using Google Translate. Formal peer-reviewed literature, reports, theses, and popular articles were all consulted, both online and, where available, in hardcopy.

Keywords used for the literature survey were – marine plastic, plastic leakage, recycling, repurposing, mechanical recycling, chemical recycling, pyrolysis, municipal waste management, municipal solid waste, landfills, plastics economy, national plastics budgets, national plastics revenue, single-use plastics and bans of single-use plastics, waste to energy, plastic burning, plastic disposal, waste collectors (formal and informal), waste pickers, waste disposal, plastic treatment, transfer stations, material recovery facilities, plastic regulation, plastics manufacturers, plastics converters, health impact, greenhouse gas emissions, recycling value-chain, ecological/environmental impact, and social impact.

For country-specific searches, the keywords listed above were accompanied by the name of the country. Additional words were used when seeking national reports, plastic action plans, plastics strategic plans, plastic management and waste management plans, and strategies. Environmental policies and legalization were also searched for while seeking formal plastic-related information. A full record was not kept, but hundreds of documents were visited, though few had the desired information. This report includes references cited and documents that may have value to others in the WIO region involved in plastics issues. As several of refences in the list are not cited but are included to be available to others in the WIO region, the list is primarily a bibliography rather than a reference list.

2.2 Interviews with Relevant Stakeholders

In the initial part of the project, questionnaires were sent to 60 stakeholders across the WIO region. This approach proved to be unsuccessful as only four responded. In the latter part of the project, interviews were arranged with stakeholders in most countries. The purpose of the interviews was to build on the information provided by the literature searches, with the goal of trying to fill gaps in knowledge and engage with nationals of the countries on cross-cutting issues. This included data collection and sharing within countries, access to information, the role and state of education/ capacity and skills in each country, evaluations of the overall state of plastic waste management on plastics, the potential role of enabling legislation, research on marine aspects of plastics, the need for regional networking and collaboration, value chains, climate change, and progress with national and regional action plans.

The interviewees were given copies of the questions in advance (with one exception) so that the meetings were structured and effective. The questions and discussion followed the same sequence as given in the tables being populated by information from the literature surveys (Appendix 1). The cross-cutting issues are not included in the tables but are discussed in the section on recommendations below. With one exception, the interviews were recorded on Microsoft Teams, which also provided transcripts.

2.3 Databases

The primary databases for this study are the country tables provided in Appendix 1, which provide the facility for comparing countries and identifying gaps.

In the first report of this project, considerable effort and time was spent in developing models with the view to being able to give indications of the present state of each country in terms of management of plastics and to provide predictive models. The modelling was based mainly on the methods used by authors of the *Breaking the Plastic Wave* publication (The Pew Charitable Trusts and SYSTEMIQ 2020). However, despite great effort, the data collected from the WIO are too sparse to provide robust models. This aspect of the project has been shelved until such time as adequate data are available.

3 ECONOMIC CHARACTERISTICS OF THE VALUE CHAIN

3.1 Life Cycle and Value Chain Approach

Within the life cycle approach to the management of plastics (UNEP 2020), the plastics value chain represents the steps in the life of plastics. Starting from the time fossil fuels (or biofuels) are extracted from their sources and transformed into raw materials, through the various stages of manufacturing, packaging and selling marketable plastic products that are largely discarded by consumers to become plastic litter, to end of life. These different stages are grouped into upstream, midstream and downstream sectors, all of which have different characteristics, costs, and benefits. Each step needs to be considered when developing national and regional action plans. Equally, each step needs to be measured, monitored and, where necessary, modified by those managing plastic and other pollution in each country. For such management to be effective, measurements at every step of the value chain need to be made and shared with governments or other decision-making bodies.

The full value chain is discussed here. It is recognized, however, that not all WIO countries have all the upstream components. For example, only South Africa produces plastic raw materials from coal and oil.

3.2 Characteristics of the Three Principal Stages of the Value Chain

This section describes the general characteristics of plastics value chains because the steps in the value chain are focus points for evaluation and management and should provide key indicators of the trends relative to baselines in local and national contexts. This approach also identifies gaps. While this section may seem superfluous to some readers, it is clear that there are different interpretations of the steps in the value chains between organizations and individuals. This section aims to provide uniformity in communication.

Upstream components of the value chain are those involved in producing the raw plastic materials, principally plastic pellets (nurdles), flakes, and powders/resins from fossil fuels (oil, coal, gas) and biofuels. It also includes the conversion of raw materials into manufactured plastic products and the provision of the plastic products by the brand owners and packagers to the retailers who sell to the consumers. Those steps most directly involved in producing/manufacturing the plastic end products, which retailers sell to consumers, are the true upstream aspects.

Retailers and consumers that use and discard plastic packaging and plastic products are defined, in this report, to represent the midstream sector of the value chain.

Once plastics are used and discarded, they become plastic waste, or litter, or debris, and have entered the downstream sector of the value chain and are subject to waste management requirements.

Waste management activities dominate the downstream components of the value chain and are diverse, ranging from municipal waste management in terms of collection and transport to the management of landfills. Informal waste sectors are involved in the sorting, collection, transport and upcycling and waste. The waste is received by recyclers and those who transform plastic waste into other materials (repurpose plastics), which are, in turn, sold to consumers.

Each of the three sectors is now examined in more detail to assess their contribution to managing or preventing waste.

3.3 Upstream Characteristics

Upstream components are run along business lines, in a competitive industry, by knowledgeable people who must provide products to the market at affordable prices and remain profitable. Employment opportunities are numerous, and the industry builds capacity. Economic inputs from the industry contribute to national GDPs. Plastic products are developed to meet market demands by providing retailers, and hence consumers, with finished products that are easy and convenient to use, lightweight and relatively inexpensive (metal or glass containers would be heavier and more expensive). Figure 5 shows some of the plastic products that are commonly used by consumers in different fields, many more can be added to this list including textiles, household appliances, indoor and outdoor furniture, electrical appliances and many more.

Figure 5. Some of the items that provide convenience to the everyday lives of people in all walks of life. The source of the figure is South African Plastics Recycling Survey 2019. (Published in 2020, ***Figure modified by SST***)

Plastic containers for food and drink are a safe way to keep food for longer periods. Plastics also contribute positively to the health sector, particularly in clinics and hospitals. Very little plastic is wasted during manufacturing processes because none of the factories can afford to lose plastic fragments or off-cuts as profit margins are narrow. The industries run collective campaigns to reduce loss (for example, Operation Clean Sweep, a global campaign to help every plastic resin handler achieve zero loss to the environment; (https://www.opcleansweep.org) and are conscious of the need to avoid criticism from governments and environmentalists. Further information on Operation Clean Sweep is given below in the discussion of upstream and midstream waste management.

Value is added at every step, from the production of raw materials from fossil fuels, to reach a maximum value at the point of sale to the consumer. However, the moment the consumer uses and discards the product, there is an immediate loss of value.

From a purely economic and human convenience perspective, the benefits of plastics during the upstream steps outweigh the costs (Figure 6). Environmentalists, however, are critical of the upstream components, indicating that there are environmental costs every step of the way (Hamilton *et al*., 2019), including Green House Gas (GHG) emissions (Figure 6). Some environmentalists argue that the plastics industry is entirely responsible for the downstream waste crisis and that plastic production should be stopped. Alternatively, the upstream and midstream sectors of the value stream should pay for the cleaning of the environment, such as through Extended Producer Responsibility (EPR) initiatives (Ellen MacArthur Foundation, 2021; Dimitropoulos et. al., 2021).

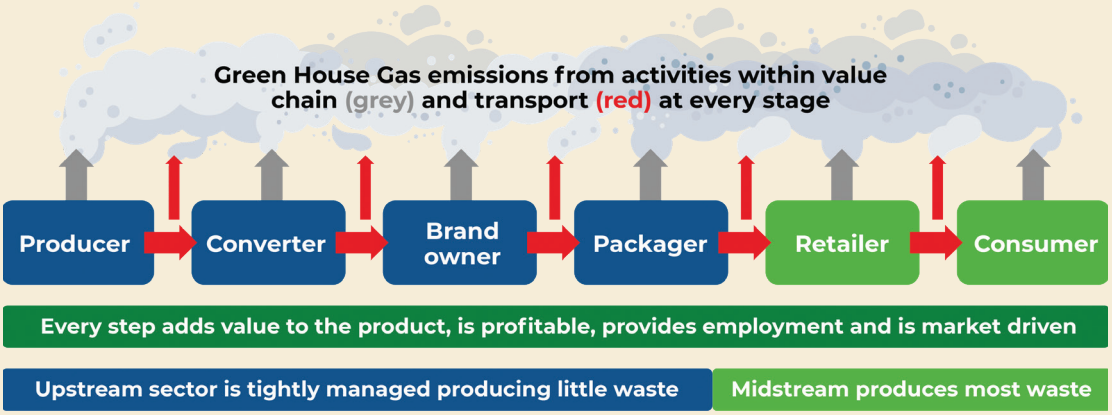

Figure 6. Every step of the value chain impacts the environment due to their operations and the transport of materials, including contributions of GHG to the atmosphere. Both the upstream and midstream components are driven by market objectives and are financially well-managed. The upstream steps produce little plastic waste, whereas consumers are major contributors to the waste streams, followed by retailers.

3.4 Midstream Characteristics

Retailers are the crucial link between the manufacturers of plastic products, principally with the brand owners and packagers on the one hand, and the consumers to whom they sell the final products, on the other. The role and interactions of retailers are complex, but in the context of this discussion, they are involved in considerable repackaging and discarding of packaging. Retailers sell high volumes of plastic-wrapped materials, particularly food and drink, to consumers and plastic products, which most consumers discard, often after single-use. Collectively, the retailers and, particularly, consumers are primary contributors to discarded packaging and other waste materials, which are the source of downstream challenges.

3.5 Downstream Characteristics

There is frequent mention of formal and informal downstream paths for waste management in African countries (UNEP 2018). Each of these downstream paths plays a significant role in waste management. The formal and informal waste management streams complement one another and sometimes overlap.

3.5.1 Formal downstream

In their simplest form, the formal downstream components require that city managers or municipal waste managers be responsible for collecting waste, whether from households and businesses or litter from the streets and elsewhere within municipal boundaries. The collected materials are then usually transported to a landfill, which is maintained by the municipality. Overall, the execution and management of the formal sector is costly and unable to keep up with the expanding waste problems (UNEP 2018).

Effective management depends on the consistent collection, management, analysis, and sharing of data on trends and impacts at every step of the formal downstream management process. Waste managers in municipalities or city councils are expected to not only manage all the activities of waste collection, transport and maintenance of landfills, they also have the responsibility of ensuring that appropriate data are gathered and used to provide the evidence for informed decisions. Sometimes the data gathering, analysis, and modelling is outsourced to research institutions.

Formal waste collection systems and their management are usually paid for by governments, normally from funds derived from the taxation of citizens (usually taxation at the national level) and, at the local level, from rates and levies charged to urban residents that receive municipal services.

3.5.2 Informal downstream components

In contrast, the informal sector is geared towards collecting discarded materials and selling them to recyclers and others who require waste plastics. The informal stream provides job opportunities, puts money into local economies, lifts some of the burden off municipal waste collectors, and contributes positively to cleaning the environment. Whereas the formal sector is cost-dominated, the benefits of the informal sector are tangible. Still, they are dependent upon a) a sustainable market for the recycled and/or repurposed goods and b) a relatively high oil price.

3.6 Generalizations of Cost-Benefit Analysis of Upstream and Downstream.

From a purely economic and human convenience perspective, the benefits of plastics during the upstream steps outweigh the costs. In contrast, the costs of the downstream steps outweigh the benefits, particularly as the formal sector of the downstream aspects are dominant and responsible for the bulk of waste management. The convenience and benefits that plastics render to people in their daily lives are so great that a future without plastics is unlikely in the immediate future. There is, however, a growing urgency to curb the increase in plastics at every stage of the value chain. The literature is dominated by recommendations, ideas and initiatives to reduce plastics to secure a better future for humans and the environment, but two recent reviews that summarize realities and point to a way forward are given by the *Breaking the Plastic Wave* (The Pew Charitable Trusts and SYSTEMIQ 2020) and the from *Pollution to Solution* publications (UNEP 2021). Considerable work is being undertaken to find alternatives to plastics that will offer the same benefit but will not have the environmental costs. Studies related to finding such “plastic replacements” are in their infancy, and successful results are probably decades away, so for now, the critical focus is on improvements that may be made to the plastics value chains, particularly the downstream chain.

4 COSTS OF INACTION AND BENEFITS OF ACTION

Estimating the costs of inaction in the WIO countries is a requirement of this contract. However, it is a largely academic exercise as there is at least some action taking place in each country (Appendix 1). It is also a valuable exercise to assess the costs of inaction. It provides a hypothetical baseline against which to demonstrate how taking action increases financial, human and environmental benefits.

In assessing the costs of inaction in this document, it is assumed that the production, manufacture, packaging, and sale of products continue to pour plastic waste into the environment at a constant rate. Accordingly, this discussion is only about the costs of inaction in the downstream component.

Four scenarios are given below, starting with the costs of inaction, and then demonstrating the theoretical benefit of increasing action. An overarching hypothesis is that one of the pivotal keys to success in better managing waste plastics is developing and growing sustainable end-markets for recycling products. This discussion is based mainly on inferred data as direct measurements of the correlations were not found and may not be available.

The Scenarios are:

1. Costs of inaction;
2. Costs and benefits of formal waste collection;
3. Costs and benefits of an end-market for plastic waste through at least one recycling enterprise; and
4. Costs and benefits of additional end-market opportunities.

4.1 Scenario 1: Costs of Inaction

The theoretical scenarios are set within an average WIO coastal continental (mainland) city with a large, growing population spread centrally in urban circumstances and more peripherally in peri-urban localities. The principles described here would not apply as effectively to small island states as their populations are smaller (see also below).

In a scenario dominated by inaction, the moment a plastic item is discarded, it loses all value and becomes a waste problem. This is because a value chain is a set of activities or steps within an industry that adds value at every stage to deliver a valuable product for the market. It is market-driven. As plastic precursors, and then plastics themselves, move up the value chain from fossil fuels to raw materials and ultimately to the final products sold to the consumer, they increase in value (Figure 10). The plastic article sold to the consumer, whether a plastic bag or another container, a toy, piece of furniture, a vehicle component, or clothing, is at its highest value when sold. At this point, the plastic article leaves the upstream and midstream sectors of the value chain and is "in use" until it is discarded, at which point it enters the downstream sector. Some single-use items may be "in use" for minutes only, whereas other items may last years before being discarded. If there is no market for the discarded plastics, then that value cannot be realized despite the inherent value of the polymers that form the plastics. With time, plastic waste accumulates in the environment, and so do negative, costly impacts. Without action of some form to realize the value of plastics, inaction results in costs only, including:

Opportunity costs

Lost opportunities to transform the plastic waste into valuable resources.

The Ellen MacArthur Foundation publications (e.g., World Economic Forum 2016; Ellen MacArthur Foundation 2020) show that plastics lost to the environment are worth many millions of dollars. They argue that if those discarded plastics were not lost to the environment but were instead used to make other products, they would have positive economic consequences for the country, including the benefits of employment and a cleaner, healthier environment. In a situation of inaction, all opportunities for benefiting financially and in other ways from the discarded plastic polymers are lost.

Lost tourism opportunities

Preventing waste from entering the environment, and cleaning waste in the coastal environment, increases the competitive income-generating and employment opportunities that would accrue from becoming a preferred tourism destination. In a scenario of inaction, such tourism-related employment and economic growth opportunities are likely to approach zero.

Human health costs and loss of wellbeing

Initially, most papers on the health risks of plastic pollution focused on how macroplastic pollution might increase diseases. These included the potential of plastics to increase the rate of transmission of diseases by insects and other vectors and the risks from bacterial or viral contaminated plastics (UNEP 2018, 2021, The Pew Charitable Trusts and SYSTEMIQ 2020). Since 2015, however, the growing

appreciation of the capacity of microplastics to concentrate adsorbed and absorbed toxins, pathogens, and endocrine inhibitors s has led to concern (UNEP 2021). This concern is heightened by the recognition of how contaminated microplastics bioaccumulate in marine animals, and are then biomagnified up the food chain, before they enter the human body (UNEP 2021). It is now known that at least some microplastics may cross the cell walls of the human brain, liver and other tissues, which is a further worry (UNEP 2021). These risks grow every day in a scenario of inaction, and a likely outcome would be an increasingly unhealthy population with all the associated costs.

Living in polluted conditions, and being subject to increased risk of disease, is unpleasant and must lead to depression and a decline in the feeling of wellbeing. This, too, is a probable negative, costly consequence of inaction.

Environmental costs

The negative impacts of plastics on the terrestrial and aquatic environments are well-documented. A particular focus has been on the devastation that plastics cause to marine ecosystems and biodiversity (The Pew Charitable Trusts and SYSTEMIQ 2020; UNEP 2021 and many others). From an economic perspective, the loss of ecological goods and services is valued at many trillions of dollars per annum globally, and it is growing (The Pew Charitable Trusts and SYSTEMIQ 2020; Beaumont *et al*., 2019).

There is also growing evidence that plastics in the environment, especially when exposed to sunlight, give off GHGs, contributing to climate change (Royer *et al*., 2018; Beaumont *et al*., 2019). While this is a negative consequence of inaction, the contribution to GHGs in a scenario of inaction may, however, be less than the contributions to GHG emissions during scenarios of action when emissions from transport, pyrolysis, energy use in mechanical and chemical recycling, incineration and illegal burning are calculated. Collectively, however, the environmental and human health costs of inaction far outweigh the costs of action and are devoid of any of its benefits.

Agricultural costs

Growth, reproduction, and the survival of livestock are costs to agriculture when animals eat plastics. There are also increased veterinary costs as the frequency of operations to remove plastics from cattle, goats, and other livestock is increasing in Africa. In a state of inaction, the increasing numbers of plastics covering grazing lands and other food sources for domestic animals will have negative costs.

Fishing industry costs

Plastic accumulation in fishing waters from land-based and sea-based sources, including ghost gear, reduce the capacity to catch fish and reduce habitat suitability for target species.

In the Scenario of Inaction, formal and informal waste collection does not occur, and plastic waste accumulates in the environment. Unless actions are taken to combat waste accumulation, all the costs listed above will grow each year, leading to an unhealthy, impoverished society with depauperate natural resources. Such situations are untenable. Fortunately, none of the WIO countries is in these circumstances as all take some action.

4.2 Scenario 2. Costs and Benefits of Formal Waste Collection

The logical first step in building from a base of inaction is introducing formal waste management in cities. This includes the collection of waste from source, transporting waste to landfill structures, and managing those landfill sites (Figure 7).

The costs of municipal solid waste (MSW) collection and management services are typically borne by government, whether local and/ or national. Government obtains its funding from taxes and fees paid by residents and businesses (Prevent Waste Alliance, 2021).

Figure 7. In a simple formal waste management system, the value chain is short: collection of waste from home and office (and hopefully the environment) from where it is transported to the landfill, which should be managed. (Picture source Plastix 911, ***modified by SST***)

In an ideal situation, the immediate benefits are that the public becomes active insofar as they prepare their waste for collection and have expectations of a cleaner city. The city itself does become cleaner as waste is transported to landfills that are normally out of the city. To function properly, the formal waste management sector employs people at every level to meet a variety of tasks, including those who collect and transport waste, and who manage the landfills. Keeping plastic and other waste out of tourism areas to promote tourism is usually an important role of the formal waste management section. It follows that a reduction of plastics in places where people live, work, and study is likely to see an improvement in health and feelings of wellbeing. Environmental costs are expected to be reduced when plastics are removed from the environment. This, in turn, facilitates, in part, the retention of ecological goods and services, decreases potential to lose biodiversity and, provided costs of transport are not excessive and burning of landfills is prevented, plastic waste management may reduce costs of GHG emissions (Beaumont *et al*., 2019; Hamilton *et al*., 2019). Agriculture and fishing costs are reduced, and the overall economy should improve.

In principle, therefore, the key to success in waste management lies with the formal waste managers. If they can keep cities and the country clean, then the economic, human, and environmental health as well as all other benefits will flourish. In reality, achieving the ideal is tremendously challenging. All WIO countries have invested in formal waste management, with varying degrees of success (Appendix 1), but nowhere is formal waste management truly effective. All are struggling to cope (UNEP, 2018; Jambeck *et al*., 2018). Anecdotal information received suggests that city managers do not have the human, financial, and infrastructural capacity to manage existing waste loads fully (see also UNEP, 2018; Jambeck *et al*., 2018). Currently, they are also ill-prepared to manage the anticipated burgeoning volumes of waste that will accompany the predicted population growth, and urban and economic development over the next two decades (UNEP, 2018; Jambeck *et al*., 2018; The Pew Charitable Trusts and SYSTEMIQ, 2020). The consequences of a lack of resources are that this waste management cannot be adequately implemented, with the result that plastic leakage from cities and peri-urban areas is growing. Leakage of plastics from landfills is increasing too (UNEP, 2018), leading to public and corporate initiatives, such as that headed by Plastics SA to work towards achieving "zero plastics to landfill". The burning of plastics in landfills is another negative consequence as it has human health (UNEP, 2018; UNEP, 2021) and climate consequences due to GHG emissions (The Pew Charitable Trusts and SYSTEMIQ, 2020). A concerted plan to prevent plastics from going to landfills is a laudable, aspirational goal that needs attention.

Principal conclusions are that:

1. Waste management by city authorities is essential and is an enormous advance on a no-action scenario.
2. Despite the costs of waste management, including waste collection and transport, and the construction and maintenance of landfill sites, the overall benefits to humans, the environment, and the economy make formal waste collection and management worthwhile, indeed essential.
3. Given the pivotal responsibility and key role of city managers (municipalities or city councils) every effort should be made to build their capacity to meet present and growing challenges.
4. The task is too large for any single organization, such as municipalities or city councils, to succeed alone, so every effort should be made to engender support from businesses, NGOs and academia in a collaboration to win citizen support.

4.3 Scenario 3: Costs and Benefits of an End-Market for Plastic Waste Through at Least One Recycling Enterprise

Promoting recycling enterprises is the first step in adding another waste management stream to complement the formal waste sector. The success of the upstream steps of the plastic value chain was attributed to the manufacturing being geared to meet the demands of the consumer market. If sustainable end-markets can be found for products made from plastic waste, and if the volumes of discarded plastics are great enough, then a sustainable enterprise developed to supply the market would immediately transform the scene. Plastic waste would become a valuable resource required by the recycling factory. In addition to the factory collecting the appropriate plastics itself, informal collectors also would be rewarded when selling to the enterprise. Sorting and washing the plastics gathered by collectors becomes a priority because the recycler pays more for clean, well-sorted plastics that have not been damaged through weathering. When collectors go to homes, offices, and schools to collect plastics, they too may reward the providers who sorted and washed the plastics. The recycling enterprise transforms the scenario from one in which there is no incentive to collect plastic litter to one in which the market demand for litter provides compelling incentives. As a recycling enterprise is likely to require specific recyclable plastic polymers (e.g., PET) there is now also an incentive to separate plastics and clean them at source or collect only discarded PET plastics. The development of the recycling enterprise creates a new dynamic in which there is an incentive to collect, sort, wash, and transport waste to the factory.

Figure 8. Adding a recycling enterprise adds steps and employment opportunities to the processing of plastic waste with numerous social, economic and environmental benefits. (Illustration by Plastix 911, ***with modification by SST***)

Each of these steps offers earning opportunities (creates jobs) and, relative to the scenario of inaction, brings a moribund value chain to life. The value chain becomes more complex as each new step involves additional activities (Figure 8).

The benefits of the informal sector contributing to reducing waste in and entering the environment reduces the load on the formal sector.

The informal sector contributions have the following potential outcomes:

Opportunity costs

- Employment opportunities increase as plastic waste now adds jobs in the informal sector, which, when added to those employed by the formal sector, is a further step toward poverty alleviation.
- Tourism opportunities are promoted as the combined collection of waste by both the formal and informal sectors is likely to be more effective.

Human health and wellbeing costs

- The reduction of waste is likely to lead to a healthier, more contented human population in areas affected by the positive developments.
- Increased employment rates promote feelings of wellbeing and pride.

Environmental costs

- Removing plastic waste from the environment in greater quantities and preventing it from entering the environment at source, leaking to the seas, and will reduce negative pressures on every aspect of the environment, thereby increasing environmental health and slowing the loss of ecological goods and services.

Economic costs and benefits

- Plastic waste collected by the informal sector reduces the burden and costs that city managers would otherwise have to bear.
- The additional economic activities stimulate local economies, and, if the system is scaled up, then significant contributions to national GDP could become possible.

Agricultural costs

- The number of domestic livestock which have their growth inhibited or perish because of eating plastic is expected to decrease, leading to better economic returns to farmers.

Fishing industry costs

- Impacts of plastics on the fishing industry will decline if less plastic enters the waters.

Potentially, these are all encouraging results with positive impacts (Figure 9), but since most mechanical recycling enterprises require only one type (polymer) of plastics for recycling, such as PET, only PET would be collected for recycling, leaving all other plastics in the environment. In essence, the "non-recyclable plastics" are left polluting the environment at a cost to the country. All plastics, however, are made of valuable polymers that have the potential to be used in an economically viable enterprise, provided the end-products are marketable.

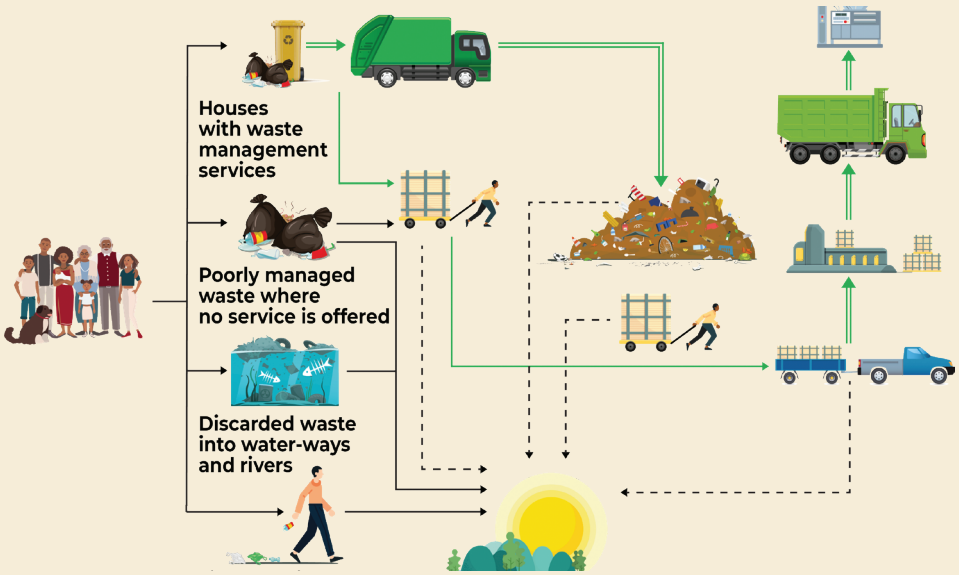

Figure 9. The activities of the formal and informal waste collectors are shown here: the municipal collection goes to the landfill and the informal collectors take their plastics to recyclers. Some waste pickers also retrieve plastics from landfill. (Illustration Source Plastix 911, ***modified by SST***)

4.4 Scenario 4: Costs and Benefits of Additional End-Market Opportunities

The process outlined above for one form of recycling enterprise can be expanded so that other forms of plastics are removed from the environments, with commensurate benefits.

Figure 10. The plastics industry is geared to transform raw materials (pellets/nurdles, flakes, powders, resins) and move them up the value chain by producing progressively more sophisticated products. In this way, the plastics industry remains viable, meets consumer requirements, and contributes positively to economic development. Plastic products have their greatest value at their point of sale. Once plastic products are discarded, their value drops to below zero if there is no demand for them, as in a scenario of inaction (a). In this figure (a), discarded plastics deteriorate over time due to weathering and fragmentation, both of which increase over time. This is portrayed as a decreasing potential value and probable increasing costs of collection and management if ever required.

Figure (b), does not imply that formal collection and transport to a landfill increases the value of the plastics, but rather that there are economic benefits of reducing the negative effects that discarded plastics have on human and environmental health. Other benefits are increased employment and the possible growth of tourism. It is also preferable to confine plastic debris to landfills rather than leave them unmanaged in the environment (but see also comments on plastic leakage from landfills).

If, however, there is a demand from recyclers, then discarded plastics acquire value, with the precise value varying according to demand and local circumstances. Figures (c) and (d) indicate that as the plastics move up the waste hierarchy, their value increases at every step, but in (d), the demands are greater than in (c), so the overall value at each step is higher. In this scenario, the plastic products made from recycled material do not ever match that of the original plastic products, but they achieve considerable value.

An assumption for all figures is that the upstream components of production, manufacture, and sale of products remain the same, so these are constants in each figure. Note these illustrations are simply to show trends, and give a better appreciation of principles; they are not based on specific data from any sector of the plastics industry, nor those of any town or country; they are hypothetical.

Principally, the demand for those additional plastic polymers will create further job opportunities and remove those plastics from the environment with consequent positive returns to the economy, as well as to human and environmental health (Figure 10).

4.5 From Theoretical Scenarios to Reality

The theoretical scenarios described above provide key principles indicating that:

- The consequences of inaction are untenable, carrying the burden of a wide variety of costs.
- Formal waste collection has numerous benefits but is overwhelmed by the growing challenges. Municipalities/ city councils would be better able to cope with improved capacity (human, financial, and infrastructural capacity) and greater assistance from business and civil society.
- Sustainable end-markets for recycled or repurposed plastics are key for success in establishing local recycling economies.
- Once enterprises establish a demand for plastic waste to satisfy the requirements of the end-markets, many economic opportunities become available, which, in turn, provide economic incentives to, and benefits for, local communities and contribute to poverty alleviation.
- Provided the volumes of waste plastics generated by each country are adequate, and local or export end-markets can be secured, continental countries of the WIO can develop robust recycling economies.
- Collectively, these activities will reduce the amount of unmanaged plastics already in the environment and reduce the flow of "new" plastic waste entering the environment each day. It follows that leakage into the seas will decline too.

The principles outlined above apply better to countries with the involvement of significant numbers of informal waste collectors. This is not the case in the island states which do not have the volumes of waste, nor the local markets, to have sustainable, large scale recycling.

5 WASTE MANAGEMENT IN THE UPSTREAM AND MIDSTREAM SECTORS

The upstream section of the value chain begins with the production of plastic raw materials from fossil fuels and/or biological precursors through to when the retailers sell plastic products and packaging to consumers. In general, the manufacturing components of the upstream sectors of the value chain are well-managed and produce little waste because losses at any stage of the manufacturing processes constitute a decline in income and a reduction of profit. Given that plastic profit margins are tight for almost all aspects of production and that quality products must be delivered to the markets at competitive prices, the industry cannot afford to lose plastics and is largely self-regulating. For example, Operation Clean Sweep is a global campaign of the plastics industry dedicated to helping every plastic resin handling operation achieve zero pellet, flake, or powder loss to the environment. (https://www.gpca.org.ae/operation-clean-sweep; https://www.opcleansweep.org).

Members of Operation Clean Sweep pledge their support and become part of a global partnership in which plastic industries in various countries benefit from the collective wisdom of many organizations. Each industry sector; resin producers, transporters, bulk terminal operators, and plastics processors; has a role to play in eliminating loss of resins, pellets, flakes and powders. There are mechanisms in place to stop loss and collect materials on factory floors, on and from vehicles, planes, ships, and machinery, thereby stopping the flow of plastics to the roads, drains, and other channels to the sea. South Africa is the only signatory among Western Indian Ocean countries. However, every country should provide guiding policies and, where necessary, legislation to reduce loss of plastics at every step of the upstream value chain.

5.1 Plastic Production and Importation

Production of polymers

Among the WIO countries, only South Africa produces plastic raw materials (polymers) from petrochemicals. The principal producer is the polymers division of SASOL (South Africa Synthetic Oil Liquid), which supplies polyethylene, including low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), polypropylene (PP) and PVC. (https://products.sasol.com/pic/products/home/polymers/index.html). Kenya and Mozambique have the oil and gas resources to produce polymers but are not doing so

In the early stages of production, the greatest vulnerability in terms of leakage of plastics into the environment is not in the factories, where spills and production trimmings are retrieved and returned to the production streams. Rather, it is in the transport of these materials from where they were produced to where they are to be converted into plastic products (Figure 11). This is a concern in all ten countries.

Figure 11. Fossil fuels and biofuels provide the raw materials for the production of plastic raw materials such as nurdles/ pellets, flakes, powders, and microbeads. There are relatively few losses of plastics within the factories that can enter the environment. There can be significant losses when transported from the producer to the converter. Such waste streams need to be managed.

There are losses of nurdles/pellets from road vehicles, especially during loading and offloading, but also while travelling, and from cargo planes. The most dramatic losses are from ships, which can lose containers of billions of nurdles overboard, such as the loss from the Durban spill of 2017, in which two billion nurdles (49.6 tonnes) poured into the Indian Ocean. (https://lavaplastic.co.za/project/nurdle-spillage-in-durban-harbour).

Figure 12. The X-Press Pearl on fire and sinking off Sri Lanka gave rise to millions of plastic pellets (nurdles) on the beaches. These pellets were destined to be the raw materials for the manufacture of plastic bags. X-Press Pearl Fire Could Mean Environmental Disaster For Sri Lanka : NPR (photo 1); X-Press Pearl: Sri Lanka braces for environmental disaster as ship sinks | Stuff.co.nz (photo 2); X-Press Pearl: Sri Lanka braces for environmental disaster from sunken ship - BBC News (photo 3)

In June 2021, the spill from *X-Press Pearl* off Sri Lanka resulted in many millions of nurdles pouring from the containers into the sea, seriously pollutinglocal beaches (Figure 12) and travelling great distances via currents to have measurable impacts thousands of kilometres away.

5.2 Importation of Plastics

All 10 WIO countries import plastics, ranging from raw materials (pellets, nurdles, flakes, powders) to manufactured end-products, principally consumer products (Appendix 1). These products include electronics, kitchenware and furniture, textiles, parts of vehicles, packaging, and much more. Frequently, imported products are wrapped in plastics and protected by bubble wrap or polystyrene. The costs of importation are considerable and increase costs to consumers, but the increasing affluence of the growing middle-class in WIO countries is resulting in an annual growth rate of between 10 and 20 % of imported plastic, which in turn is leading to greater volumes of discarded plastics that need to be managed.

In every country, imported raw materials are converted into plastic products by the manufacturing section, which is larger in the continental states than in the island states.

6 EXTENDED PRODUCER RESPONSIBILITY

Mechanisms are urgently required to better finance improvements in formal plastic waste management and to assist the informal sectors, including aspirant recycling entrepreneurs. One such mechanism that is gaining traction is the Extended Producer Responsibility (EPR) initiative. These movements stem from the "Producer Pays Principle", in which those organizations which produce and sell plastic products pay a fee that is to be used in a carefully controlled manner to reduce the flow of plastics into the environment and remove plastics that are already in the environment. The principles which underpin EPR and their potential applicability to WIO countries are discussed in this section.

As indicated above, in the WIO countries, the collection of post-consumer solid waste, including packaging waste, is largely unregulated, with little widespread municipal separation-at-source and associated collection systems in place (UNEP, 2018). Recyclables are mostly recovered from co-mingled waste by a network of informal collectors and micro-entrepreneurs. The packaging waste is either directly collected by the relevant state authority or by private companies working on the state's behalf.

In these types of systems, funding often only covers the cost of collection of municipal solid waste, transport, and disposal at landfills or open dumpsites. Transitioning towards sustainable waste management and a circular economy requires a new approach, one that involves all stakeholders at every stage of the packaging value chain (Figure 13).

The international principle of EPR is a proven policy tool gaining increasing support as it has the potential to provide sustainable financing to better manage specific waste streams, such as discarded packaging (OECD, 2016). In EPR systems, producers are responsible for health and safety issues associated with their products as well as the management thereof, including funding collection, sorting and recycling of their packaging waste. The required costs are internalized into the product price, and higher costs for non-recyclable or difficult to recycle packaging are intended to motivate industry to eco-design their packaging (EXPRA, 2021). These financial flows from the obliged industry are an effective way of implementing the 'polluter pays principle'.

While voluntary EPR can be helpful in the short to medium term, through creating markets, building systems and processes required for a well-designed EPR scheme, they do not represent a sustainable, long-term funding solution when used in isolation. Mandatory EPR, which is currently only legislated in South Africa and Kenya within the WIO region, provides incentives to prevent waste at the source, promotes eco-design, drives consumer choice for well-designed products, and supports the achievement of public recycling while enhancing the efficiency and transparency of the system.

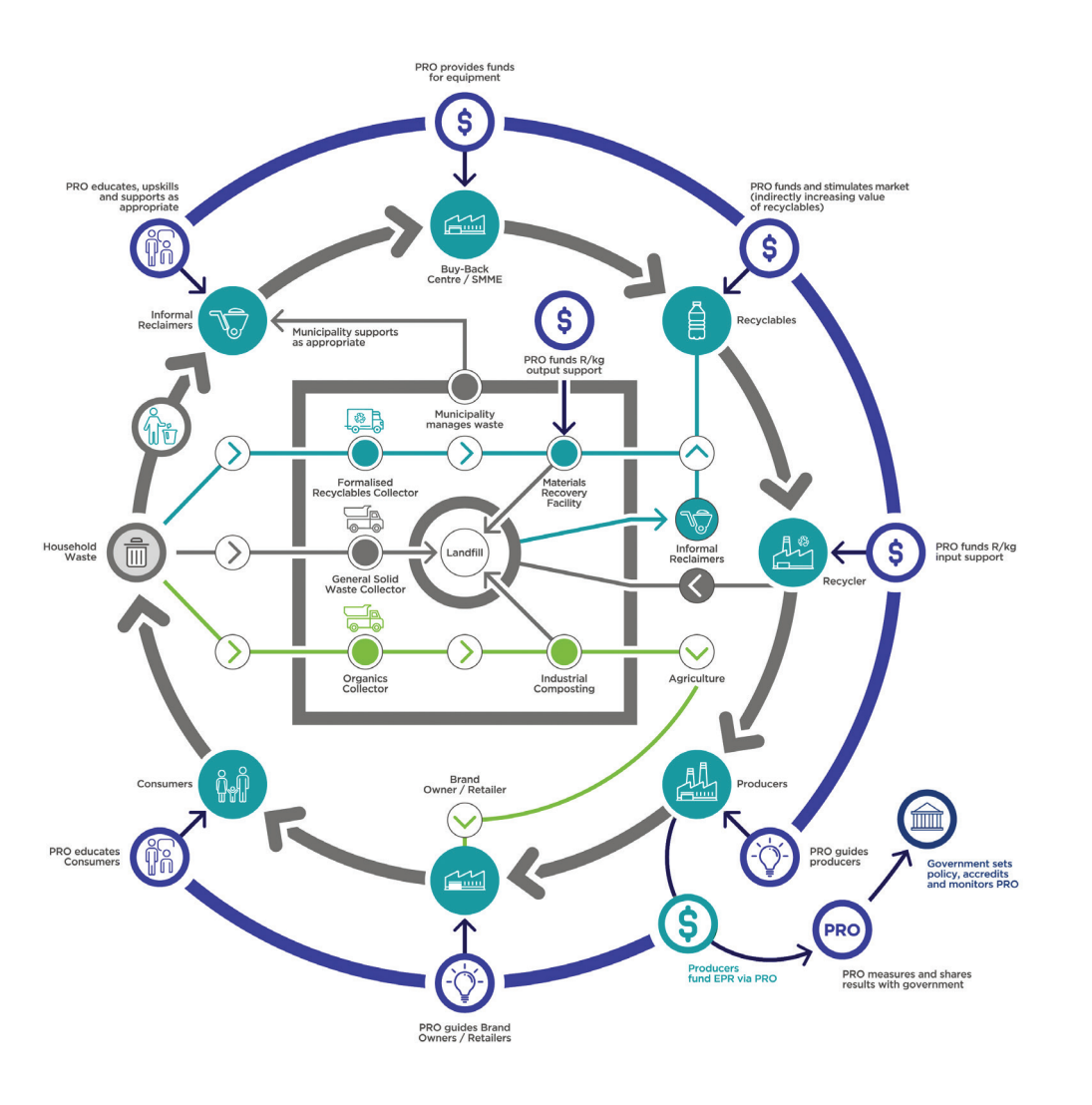

Figure 13.: The role of Extended Producer Responsibility (EPR) in improving waste management. (The figure was kindly provided by PETCO South Africa, which holds the copyright)

6.1 The Economics of Recycling

The process of collection, sorting, and recycling of packaging comes at a net cost, globally amounting to a funding gap of tens of billions of dollars per year (EMF, 2021), which has been identified as one of the main barriers to a circular economy for packaging. EPR closes this economic gap for collection, sorting, and recycling to continue sustainably. The higher the target for collection and recycling, the larger the gap due to higher costs associated with collectors and waste aggregators (formal and informal) needing to travel increased distances to collect material that is often more contaminated and less ideal for recycling. Practically, EPR is the most likely pathway to secure dedicated, ring-fenced, sustainable and sufficient funding to ensure that recycling continues even when it does not otherwise make economic sense (Prevent Waste Alliance, 2021).

Importantly, EPR is a tool that can be used in countries relying on both formal or informal collection systems. Although it may be more complex when collection is informal, informal collection can still be supported financially, which sets EPR apart from other solutions (such as deposit return systems) that are generally better suited to developed economies.

6.2 Designing Extended Producer Responsibility Schemes

The design and implementation of EPR schemes are key to their effectiveness (Prevent Waste Alliance, 2021). Generally, the legal framework leaves it optional to companies to fulfil their responsibility individually, by putting in place their own collection, sorting, and recycling system, or collectively, through a Producer Responsibility Organization (PRO), which fulfils the obligations of their members in the most efficient and effective way.

The specific roles and responsibilities assigned to each stakeholder depend on the local context, including the applicable legal and institutional framework. For example, the framework defines if waste is collected by the municipal authorities or not.

All EPR schemes, regardless of context, should be designed to balance between managing producers' obligations and ensuring that appropriate environmental policies are implemented in line with the "polluter pays principle."

Key considerations when designing an EPR system include:

- Clarify the roles and responsibilities of stakeholders involved, specifically the 'Producer'. It is important to clearly define who will bear what part of the financial and operational responsibilities to fulfil the objectives and targets.
- Ensure funding that is dedicated and ring-fenced, ongoing and sufficient. Every producer pays a fee when introducing a packaged item into the market. This fee is proportional to the amount of packaging being introduced and should cover the costs of collecting, sorting, and recycling the packaging waste.
- Ensure robust target-setting and transparent reporting, monitoring, and enforcement. Effective EPR regulations should not only clearly set out targets but should also outline the methods for measurement.
- Discourage overreach. EPR policy tends to evolve. Therefore, policymakers are advised to start with the most pressing challenges rather than attempting to implement EPR across the board, which can result in the scheme being difficult to manage and enforce, leading to subsequent low compliance.

6.3 The Benefits of Extended Producer Responsibility Schemes

EPR schemes, if implemented effectively, can provide several benefits and opportunities (OECD, 2016), including increased collection, recovery and recycling rates, reduction of public spending on waste management, and design for the environment, such as increasing the durability and reusability of products. There is further significant potential benefit from including the informal sector in EPR systems in terms of effective waste management operations and facilitating affordable and sustainable financing in countries with limited waste management systems. Inclusion also provides opportunities for providing informal workers with sustainable livelihoods, income opportunities, and improved health and social protection.

7 PLASTICS PACT

The Plastics Pact Network is an initiative of the Ellen MacArthur Foundation, which, like the EPR programme, focuses on the producer phases of the plastics value chain. The objective of the network is to reduce, at the manufacturing stage, the probability that plastics will become waste. To achieve this, the Ellen MacArthur Foundation encourages networks of key stakeholders within countries to work in a coordinated manner, sharing knowledge and implementing solutions that enable businesses, government institutions, NGOs and civil society to work towards achieving nationally agreed-upon targets. The global approach aims to develop international networks so that progressively, increasing numbers of countries pledge to strive to reach the targets, which include:

- Eliminating unnecessary and problematic plastic packaging through redesign and innovation;
- Moving from single-use to reuse;
- Ensuring all plastic packaging is reusable, recyclable, or compostable;
- Increasing the reuse, collection, and recycling or composting of plastic packaging; and
- Increasing recycled content in plastic packaging.

Examples of actions include ceasing the production of unnecessary or problematic plastics, designing plastic products that can be reused multiple times as viable alternatives to single-use plastics, and designing products using plastics that can be recycled with a view to eliminating plastic products that cannot be recycled.

South Africa became a member of the Ellen MacArthur Foundation's Plastic Pact Network at a launch in January 2020 (South African Plastic Pact a first in Africa; https://www.wwf.org.za/?30741/South-African-Plastics-Pact-a-first-in-Africa#) and was the only member from Africa until 8 October 2021, when the Kenya Plastic Pact (KPP) was launched (Kenya Plastics Pact launched | Food Packaging Forum; see also https://kpp.or.ke/). In both countries, the commitment from business, government, NGOs and civil society has been swift and encouraging.

8 PLASTIC WASTE FROM SEA-BASED SOURCES

A common generalization is that 80% of plastics enter the sea from land-based sources while the remaining originate from sea-based sources. The accuracy of this generalization has not been tested in WIO countries. It is apparent, however, that, while these approximations may be roughly accurate for the five continental states, the five island states receive more than 20% from sea-based sources. This is especially true for Seychelles islands, which are in the direct path of the South Equatorial Current that carries plastic debris from South East Asia (Figure 1). Seychelles also receives plastics from fishing fleets (discarded or lost fishing gear) and passing ships (waste dumped illegally overboard). Indeed, several islands receive 100% of their plastic pollution from sea-based sources (see Aldabra and Alphonse Islands below). In addition to the plastics leaking into the seas from land-based sources, which have dominated the discussion thus far, sea-based sources of plastics wash onto the shores of all WIO countries from sources that include:

1. Other countries, carried by ocean currents.
2. Abandoned or lost fishing gear.
3. Plastic waste dumped overboard by-passing sea-going vessels.

8.1 Global Context

Sea-based activities have been highlighted as a significant source of leakage of plastics into the marine environment (Laville, 2019; Macfadyen and Huntington, 2009; WWF, 2010). Of the streams of leakage from sea-based activities, maritime and fishing-related operations are significant contributors to the increased accumulation of marine debris globally and more specifically in Africa ("Environmental pollution in Africa | SpringerLink," 2017; Ferronato and Torretta, 2019; Macfadyen and Huntington, 2009; Parks *et al*., 2019; Pew Charitable Trusts, 2010; Van Rensburg *et al*., 2020). Literature shows that the fishing sector is significantly unregulated in Africa whilst providing more than 12 million jobs and almost 50% of Africa's source of dietary protein (FAO, 2019; PeSchAk, 2011). The causes of fishing gear loss have been reported in several studies (Macfadyen and Huntington, 2009; Raes *et al*., 2021; Randall, 2020; Richardson *et al*., 2021; WWF, 2010), while the reasoning behind ships dumping waste at sea has been attributed to the high cost of waste disposal at port reception facilities. Furthermore, waste lost at sea has been attributed to high seas conditions, operational vessel faults, and fishing gear entanglement with the seafloor or other vessels (Global Ghost Gear Initiative, 2020; Randall, 2020). Studies on the quantities of waste leakages from at-sea activities are often estimated relative to leakages from land-

based activities (Jambeck *et al*., 2015), presenting a research gap in understanding the true abundances and trends of sea-based sources of pollution. However, recent studies by the African Marine Waste Network (AMWN), Santorini Mozambique, Seychelles Island Foundation, and other African institutions have determined that litter monitoring activities along beaches present a more realistic representation of waste resulting from the maritime sector (Duhec *et al*., 2015; Marlin and Ribbink, 2020; Raes *et al*., 2021). It is essential to acknowledge that although there is still significant paucity in the contributions to the understanding of at-sea activities to marine plastic pollution, the culminating effects of these operations can be seen in studies across Africa (Chapman, 2010; Lane, 2018; Lebreton and Andrady, 2019; Pinto-Rodrigues, 2021; Randall, 2020).

8.2 Economic Impacts of Sea-based Sources of Plastic Waste

The economic costs of plastic pollution, including the carbon footprint of plastic and the loss of ecosystem services, are estimated to be as high as USD2.2 trillion a year (Forrest *et al*., 2019). However, estimates vary greatly and are not always comparable since they refer to distinct sets of data, are based on different techniques, and cover different time periods or countries. The figures need to be explained and clarified further. The term 'marine debris,' rather than 'marine plastic,' is frequently used in economic damage assessments. Even though plastic makes up roughly 80% of marine waste,, no attempt is made to distinguish between estimates of harm caused by marine debris as a whole and plastic items.

Estimates of Marine Plastic Pollution's (MPP's) economic implications should be viewed with caution due to challenges with measurement, delays in discovering effects, and generally weak causal links between MPP and observed effects. The inclusion or exclusion of damage categories and the assumptions used in accounting for damage where there is a lack of empirical research all lead to estimation disparities. Some estimates factor in clean-up costs, whereas others do not.

According to (UNEP, 2014) the environmental cost of plastics is estimated at USD75 billion per year, while Lord and Trucost (2016) estimate the global revenue loss to fisheries and the aquaculture sectors to be around USD2.2 billion per year. Data for the countries of the WIO are sparse.

8.3 Economic Costs to the Fishing Sector

Global losses to the fishing sector are estimated at USD2.2 billion per year (Lord and Trucost, 2016). Lost fishing time, fouled propellers, stopped pumps, fouled nets, separation of plastic from nets and catches, contamination from ingestion and disposal of Glass Reinforced Plastic (GRP) vessels, waste fishing gear, and plastic collected in nets all have negative consequences on the fishing sector, causing significant indirect losses due to increased fish mortality as a result of Abandoned, Lost or otherwise Discarded Fishing Gear (ALDFG) (Koslow *et al*., 2000; Merrett and Haedrich, 1997). According to certain studies, over 90% of species caught in ALDFG have commercial value (Al-Masroori *et al*., 2004), resulting in a substantial financial loss for fishers.

The expense of removing ALDFG can be substantial, and while the fishing sector is usually not responsible for these expenditures, the sector may be able to receive financial aid. Fishers may be paid to collect lost gear, making the practice profitable. The cost of removal is governed by a range of site-specific or case-specific parameters, including depth, kind of gear, the density of lost gear, bottom topography, and a variety of other site-specific or case-specific factors. Removal costs are projected to range between USD65 and USD25 000 per tonne. The cost of net removal in the Puget Sound (USA) ranged from USD1 685 to USD3 075 per tonne; in Sweden, the cost was USD800 per km of net; in Hawaii, the cost was USD2 467 per tonne; and in Korea, the cost ranged from USD1,685 to USD3,075 per tonne (Kelleher, 2021; Macfadyen and Huntington, 2009). Data to make similar calculations are apparently not yet available for the WIO countries.

8.4 Economics cost to the Maritime Sector

Ropes and nets foul propellers, impede cooling water intakes, and cause engine damage while in transit. In Korea, marine debris was involved in nine percent of shipping incidents (1996–98). (McIlgorm *et al*., 2020). When ships lose control of their navigation, there have been several reports of propeller or rudder entanglement producing catastrophic disasters and, in some cases, fatalities. This affects shipping insurance rates as well as expenditures for maritime safety and emergency services for both commercial and small vessels (Mouat *et al*., 2010). The clean-up costs incurred by marinas and tiny landing sites are typically not included in these numbers. Similar calculations have not been made for countries in the WIO region.

8.5 The Cost of Cleaning Beaches

Additionally, time spent removing and repairing nets and lost catch due to contamination can cost fishing companies up to USD2,900 per incident, with annual costs ranging from USD10,000 to USD51,000 depending on one occurrence per year and a 40-hour workweek (Hall, 2000). Fouled propellers and pierced hulls may also jeopardize human life if the vessel is unable to return to port or steer to avoid collision (Bergmann *et al*., 2015). Harbour authorities must also bear the costs of maintaining navigational channels clean. Specific ports in the United Kingdom spend up to USD44,200 per year to clear fouled propellers and debris from the water (Hall, 2000).

The global cost for cleaning up marine debris from beaches is estimated at USD7.8 million (Lord and Trucost, 2016). According to an environmental survey of beachgoers, fishing debris such as lines, nets, buoys, and floats is the second most prevalent beach litter in the United Kingdom (14.1%) (Campbell, 2007; Tudor and Williams, 2008). Local authorities, industry, and coastal communities in England and Wales spend over USD23 million a year cleaning up coastal marine debris (Werner *et al*., 2016). The research and cost calculations still need to be undertaken in the WIO countries.

Additionally, the effect that polluted beaches has on the tourism sector for the African continent ranges between USD90–98 million each year. The overall costs to the countries of the WIO have not been found but given the key role of tourism in these countries, this comprehensive research is required.

8.6 Plastic Clean-Up Operations on Remote Islands of the Seychelles

Aldabra, a remote African island of Seychelles and a UNESCO World Heritage Site, consists of rich, biologically diverse fauna and flora (Koester *et al*., 2020; Smith, 1957; Stobart, 2005; UNESCO World Heritage Centre, n.d.). Aldabra has been shielded from human interference because of the general difficulty of access to the atoll, which conserves the world's largest population of giant tortoises (approximately 152 000).

According to the Seychelles Island Foundation, Aldabra is said to have more plastic trash than any other island globally (Pinto-Rodrigues, 2021). One of the primary sources of pollution on Aldabra is fishing gear such as buoys, nets, ropes, and fishing aggregating devices (Burt *et al*., 2020) due to the South Equatorial currents transporting the fishing gear waste, predominately from the tuna-fishing industry off the coast of Seychelles, to Aldabra Island (Seychelles Island Foundation, 2020). The atoll is now home

to approximately 550 tonnes of marine litter, of which 83% is ALDFG (Pinto-Rodrigues, 2021). The costs associated with clearing approximately 95% of all litter is USD4.68 million, which neither the Seychelles Island Foundation nor the government of Seychelles can afford (Pinto-Rodrigues, 2021).

Alphonse Island is another outer island of Seychelles. Although remote and still pristine, Alphonse Island is a major attraction for saltwater and pelagic fishers (Duhec *et al*., 2015). Anthropogenic activities on the island have led to the increased accumulation of plastic on its beaches and surrounding waters. According to Bouwman *et al*. (2016), plastic made up 79% of the 50,000 debris items collected from Alphonse and included ALDFG such as floats, ropes, fishing aggregating devices, and stranded ghost nets (Bouwman *et al*., 2016). The associated cost of removing marine debris, calculated relative to Aldabra island, is estimated at USD224,600 per 25 tonnes and equates to USD10,000 per day of clean-up operations or USD8,900 per tonne of litter (Burt *et al*., 2020).

The increased presence of plastic waste on Alphonse is attributed to poor management systems, non-existent infrastructure, inadequate cleaning of islets, and improper waste handling (Bouwman *et al*., 2016).

8.7 Cost to the Ecosystem Services

Although it is difficult to accurately measure the loss of ecosystem services caused by marine plastic garbage, Beaumont *et al*., (2019); determined a one to five percent decline in global ecosystem services in 2011 as a result of marine plastics. Based on the USD49,7 trillion in yearly value of marine services to society, this corresponds to an annual loss of USD0,5–2,5 trillion in the value of benefits derived from marine ecosystem services owing to marine plastic waste (Arabi and Nahman, 2020). The annual cost in terms of lost marine natural capital is between USD3,300 and USD33,000 per tonne of plastic, according to a 2011 estimate of 75–150 million tonnes of plastic in the marine environment (Arabi and Nahman, 2020).

Data on costs for the countries of the WIO have not been found, so it is possible that they still need to be researched. Nevertheless, the global examples discussed above illustrate that ghost fishing can have major economic implications, but they vary depending on the fishery and location investigated. Moreover, along with the aforementioned potential repercussions of ghost fishing, the effects will vary depending on the type of fishing gear employed.

8.8 Maritime Legislation

The WIO region has taken significant legislative steps toward addressing sea-based waste sources, specifically maritime dumping, fishing operations, and port control. This section provides an overview of countries' legislative commitments to addressing sea-based pollution in the ten WIO countries. Data for the Comoros and Reunion (France) have proved to be difficult to find.

All WIO countries are signatories to the United Nations Law of the Sea in terms of international legislation. All WIO countries are also signatories to the International Convention for the Prevention of Pollution from Ships (MARPOL) which prohibits the disposal of plastic and fishing gear waste from vessels into the marine environment, except for Somalia.

In contrast, the WIO countries have not subscribed to the FAO Conduct for Responsible Fisheries, an international overarching strategic plan to limit fishing gear loss that advocates for the protection of countries' fish stocks.

Regionally, all WIO countries are signatories to the Nairobi Convention of 1985, and the *Strategic Action Programme, and its Protocol for the Protection of the Coastal and Marine Environment of the Western Indian Ocean from Land-based Sources and Activities*.

Regionally, eight WIO countries have laws that address dumping into the marine environment; however, in some instances, the legislation does not clearly state the sources (i.e., vessels) being addressed by specific legislation. This result excludes the Comoros and Reunion (France).

In particular, Seychelles, Mauritius, Somalia, and Tanzania do not have legislation for ports and harbours, while Somalia also does not have national laws addressing the fishing sector. The rest of the WIO countries have some legislation pertaining to ports, harbours, and the fishing sector. However, further research is required to determine the extent to which plastics are addressed within national legislation for WIO countries and, more so, the extent to which their legislation addresses plastics from sea-based activities.

8.9 Microplastic (Microbeads, Capsules and Nurdles) Legislation

Microplastic pellets, capsules, or nurdles (plastics less than 5 mm in diameter) are potentially the most significant sources of pollution into the marine environment as they are manufactured and transported globally by sea (Schumann *et al*., 2019). It is estimated that more than 230,000 tonnes of nurdles (the size of approximately 33,000 African elephants) enter the environment each year from accidental spills in production, transportation and manufacturing (Spear, 2021). The WIO has experienced two major nurdle spills, resulting in billions of nurdles entering the marine environment. The Durban Nurdle Spill of 2017 resulted in 50 tonnes of nurdles entering the Indian ocean (Blue Marine Foundation, 2018; Schumann *et al*., 2019). Approximately three billion nurdles were retrieved from the environment, leaving potentially more than 70% of the nurdles unaccounted for (Mafolo, 2020; Spear, 2021). The effects of this 'disaster' could be seen as far as the island of St Helena, which is approximately 4,830 km away from the epicentre (Blue Marine Foundation, 2018).

Further to this event, the Nurdle spill off the coast of Plettenburg Bay in August of 2020 resulted in approximately 175 tonnes of nurdles being lost into the marine environment (Mafolo, 2020). At present, clean-up operations are underway to reduce the environmental implications of this event. However, it is impossible to completely retrieve 175 tonnes of nurdles from the marine environment.

Although microplastics pose many significant threats to marine life and human health, at present there are no regional or national frameworks in WIO countries that address the safe transportation of microplastics on land or by sea (Dena, 2020).

9 DISCUSSION AND RECOMMENDATIONS

9.1 Formal City Waste Management

The key to success in waste management lies in the ability of those in charge of waste management in cities, the municipalities or city councils, to perform well. However, none is able to adequately meet the challenges of the backlog and keep abreast of managing new plastics coming on the daily waste stream (UNEP 2018). As indicated above, waste managers do not have the human, infrastructural and financial capacity to meet the tasks. Of these, inadequate financial capacity is the most critical because, if funds are available, building human capacity and purchasing the required infrastructure is affordable. Evidence suggests that the root cause of poor waste management is inadequate funding of city waste management. As all governments of the WIO region have expressed a wish to have clean cities and countries, a first step is to emphasize that investment in the principal waste management institutions is a priority. To these ends, it might help to demonstrate that plastic and other waste is a responsibility of every ministry in the government. Plastic waste affects finances and the economy, health, trade and industry, water and sanitation, agriculture and fisheries, legislation and policy (justice), education, tourism, and more, not just the environmental ministries. In WIO countries, the ministry that is most commonly tasked with the responsibility for the environment bears the greatest budgetary commitment to, and the primary responsibility for, waste management. Sharing the costs and responsibilities across ministries is worth considering.

The waste challenge is too great for central and local government to bear alone, so other funding instruments need to be considered in addition to the usual taxes and rates charged to citizens and business. In this regard, the EPR opportunity should be considered as a viable mechanism to provide regular additional support activities of both the formal and informal sector.

There is a hesitancy in some countries regarding a commitment to and implementation of EPR because it is believed that the costs of EPR that are passed on to the consumers would be too harsh for their impoverished communities. While it is true that costs are passed onto the consumers, the additions to the end product that is purchased can be kept to an absolute minimum, and yet the EPR would still benefit the country as whole. This is possible because of the high volumes of items sold: each item will cost marginally more, but the total income from the EPR could be considerable. If that income is dedicated to supporting the informal sectors, then the funding would be boosting the communities in which they live, thereby contributing to poverty alleviation. However, the discussions are spurious until a full analysis is undertaken to calculate the costs and benefits of EPR in the unique circumstances that prevail in each country,

The Africa Waste Management Outlook (UNEP 2018) alludes to the need to have sustainable waste management plans and solutions built on reliable, quantitative economic and scientific data for project finance. Much more work needs to be done in African countries to gather such data before generous investments can be attracted. The next section addresses the issues of data.

9.2 Data, Evidence and Information

9.2.1 Sparsity of data

When Jambeck *et al*., 2015 undertook their global analyses, they noted a lack of data and information about plastics in Africa as a whole. This finding was confirmed in the Africa Waste Management Outlook (UNEP, 2018) and other publications, including Jambeck *et al*., (2018). The biggest, most time-consuming challenges to researchers of this WIOMSA project were the literature searches for data. It is concluded that numerical data from proper assessments and measurements, at national and regional levels, are sparse and difficult to find in the literature, including reports and grey literature from within the WIO region. Interviews with individuals from various countries confirmed that finding reliable data on plastics is challenging. An exception is South Africa, for which relatively comprehensive data were obtained. South Africa has a systematic way of gathering data and has done so in detail for several years and are able to compare each year with other years. Figure 14 shows the tonnage of all plastics recycled over a period of 20 years which provides a valuable baselines against which to measure trends and the impact of interventions and policy changes.

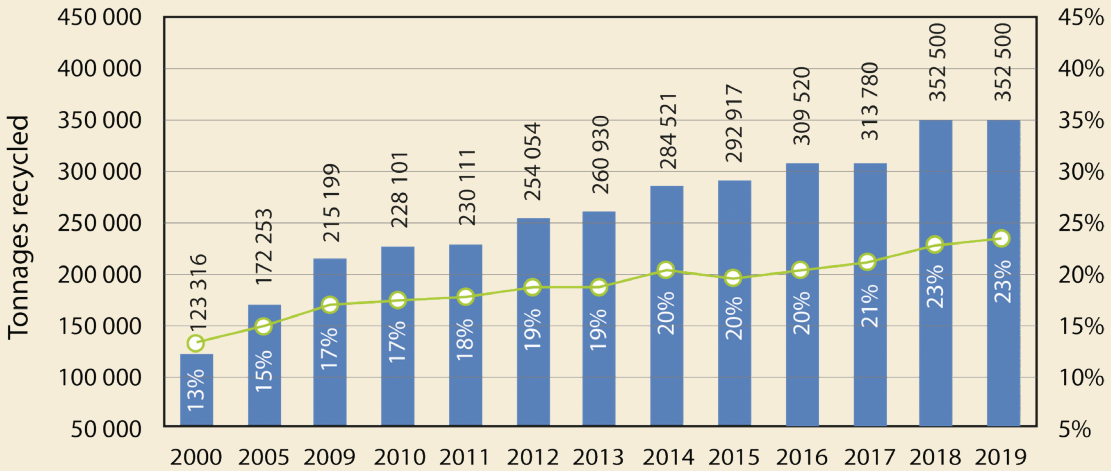

Figure 14. Recycling data for all plastics in South Africa in the last 20 years. The percentages on the vertical right-hand axis give the domestic plastics output rate. (The Source of information for the figure is South African Plastics Recycling Survey 2019 (published in 2020). ***The figure was redrawn by SST***)

The plastics industry depends on virgin feedstock, namely pellets, powders, flakes and so forth derived from raw materials such as oil, coal, gas and to a small extent biofuels, as well as feedstock derived from recycled plastics (Figure 15).

*Figure 15. Virgin plastic pellets on the left and recycled plastic pellets on the right. Plastic pellets can be almost any colour, which is often determined in advance depending on the colours required for the end products. (*Both photographs by © Douw Steyn*)*

The annual South African Plastics recycling surveys measure the tonnage of both virgin and recycled feedstock. This enables trends to be noted, and if necessary informed actions to be taken, and for comparisons to be made. Figure 16 shows that the proportion of recycled plastic pellets has grown very little over the last 10 years, suggesting that there is potential for growth and improved marketing of the products of the recycling industry.

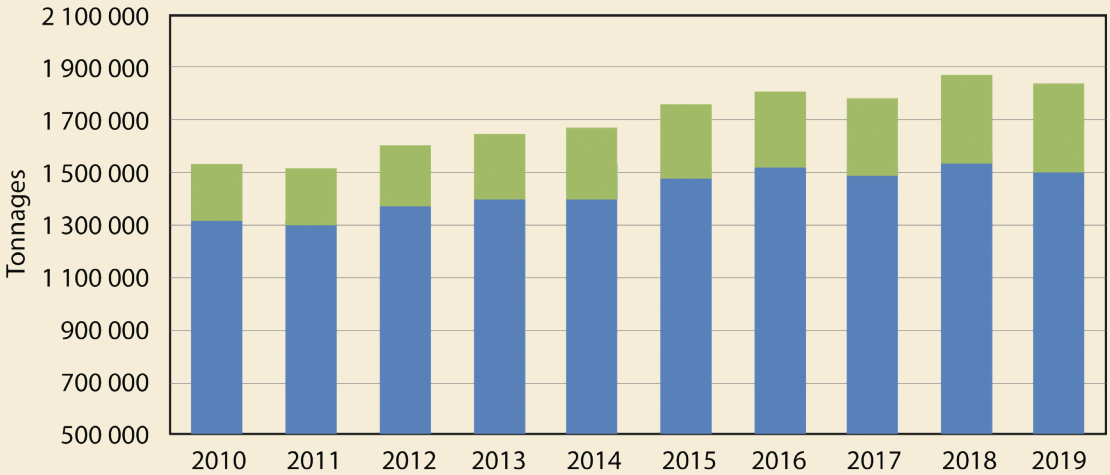

*Figure 16.: Domestic polymer consumption in South Africa - virgin consumption (blue) and recyclate consumption (green). The source of information for the figure is South African Plastics Recycling Survey 2019. (*Published in 2020, ***The figure was redrawn by SST****)*

Finer resolution and hence greater capacity to detect trends, changes and areas in need of improved management or assistance can be found if the data on individual polymers that are being recycled. Such data are gathered in South Africa annually (Figure 17).

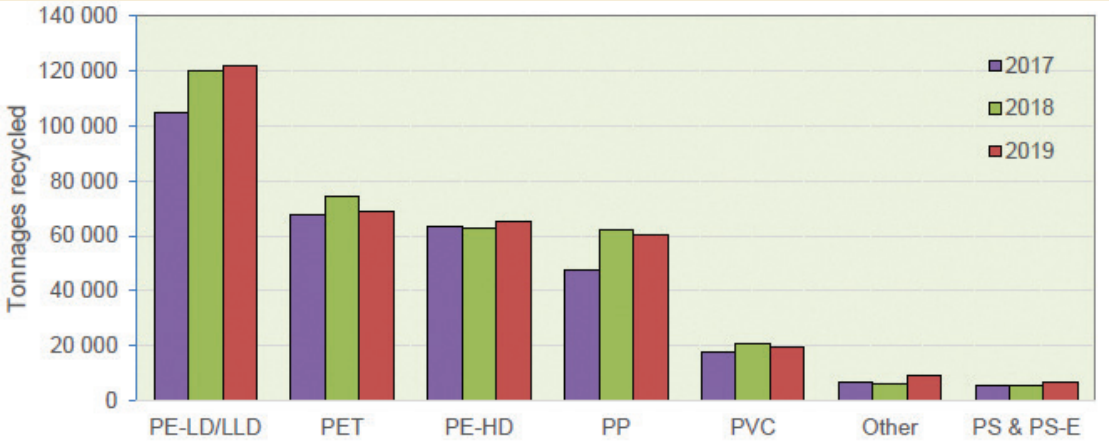

Figure 17. Plastics recycled in South Africa in 2017, 2018, and 2019 show the performance of the different plastic polymers in each year, measured in tonnages. The source of information for the figure is South African Plastics Recycling Survey 2019 (Published in 2020, ***The figure was redrawn by SST***)

The South African Plastics Survey also provides annual data on the amount of plastics imported and exported, the amount of recycled plastics imported and exported, the number of jobs created within the recycling industry, the full spectrum of end markets for the recycled products, it plots the annual contribution of the recycling industry to GDP, depicts the plastics material flow chain for the country. The plastics survey also deals in detail with every polymer so the capacity of South Africa to know precisely where it is with respect to the various aspects of the recycling industry is finely tuned. In addition to the industry managed South African Plastics Survey, a complementary survey is also undertaken by the National Government National Waste Management Strategy (DFFE) see https//www.environment.gov.za/sites/files/docs/2020nationalwaste_managementstrategy1.pdf) which increases the extent of evidence-based information thereby strengthening holistic understanding. Similarly, the IUCN Hotspotting project has also provided valuable information (IUCN-EA-QUANTIS, 2020; Pucino *et al*., 2020).

In those instances where data were acquired, the researchers were able to personally visit government, including municipal/ city council personnel, members of the plastics industry including plastic manufacturers and recyclers, academic institutions, and NGOs. Apparently, personal visits are necessary to acquire data on plastics, particularly when financial and economic data are required as organizations and companies are protective of such data. WIOMSA did make provision to enable visits to various WIO countries when this project was planned, but the protracted persistence of the COVID-19 pandemic prevented such personal research visits. Had such visits been made, more information and numerical data may have been found. It is unlikely, however, that sufficient data would have been found to change the conclusion that the WIO region is data-poor.

Another factor experienced by the research team, and confirmed by those who were consulted during the research, is that there is a reluctance of interviewees to share economic, business, or even municipal data, particularly when approached via telecommunications or in writing. Reasons for this were not given, but it appears that many organizations protect their information, especially if concerned that company information may be leaked to their competition or they consider it too private to give to an unknown enquirer. Other possibilities include that the data were so poorly recorded that there was a reluctance to share, or that data were not collected, or were inconsistently collected, or that the incorrect form of collection was used.

Measurements are essential to the management of plastics as they set baselines against which to accurately track progress and trends, identify gaps and areas of concern, and provide an evidence-based platform upon which to plan for the future. Without measurements, municipalities will be unable to accurately assess their performance and evaluate whether interventions undertaken achieve the intended impact. Measurements are essential to management, and data are critical for planning. In the early part of this project, researchers began modelling the information stemming from each country. This was before it was fully realized that data were as sparse as they are. The early models were included in the first draft of this document. Some reviewers were justifiably uncomfortable with the robustness of those early models. Despite considerable effort to bolster the models with additional data, to provide predictive models and the facility to compare one country with another, the data were not available from almost all countries, or were collected in different ways, such that they were not comparable across countries. The models are no longer part of this report, but is should be an aspiration of each country to acquire sufficient data to be able to accurately track and model their progress and use predictive models to plan management strategies for the future.

Appendix 1 provides the datasheets for each country. The exception here is South Africa, for which the data can be modelled or depicted in pictorial form (Figure 11). The datasheets are of questionable value as they range over various time scales. They were also collected inconsistently. Even across a single country, data were not collected in the same way nor harmonized. Different areas or cities in the same country gathered data in a unique way. Further, publications from a country, by different authors, gave inconsistent information for identical time periods.

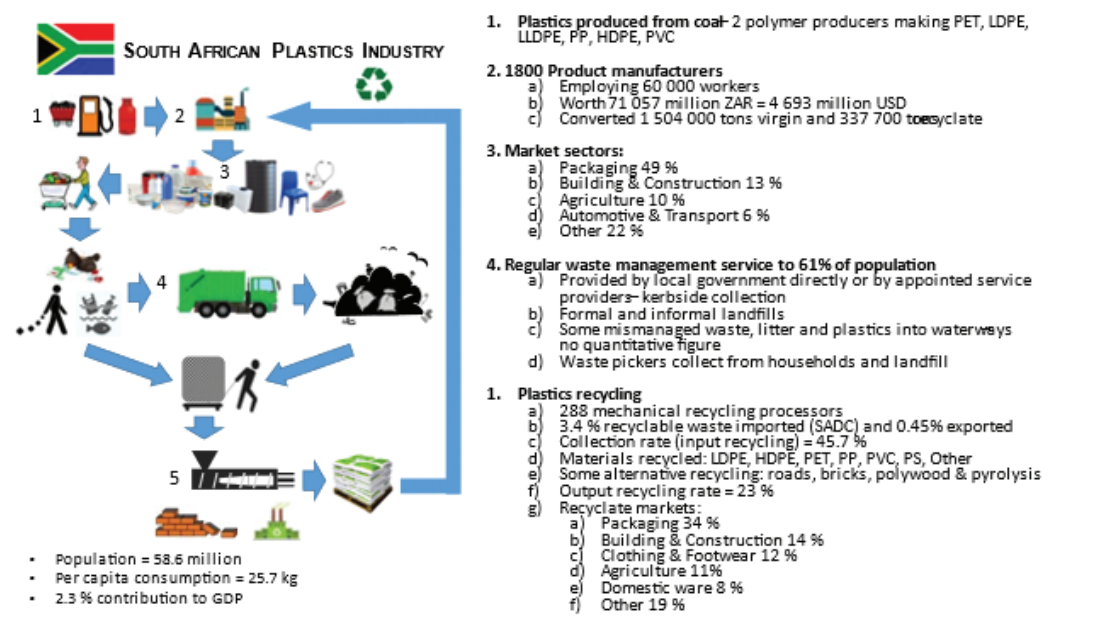

*Figure 18. A diagrammatic summary of the economics of the plastics value chain in South Africa using data from 2019. (*Illustration from authors of this document*)*

9.3 Recommendations on Data

It is strongly recommended that countries of the WIO convene a workshop under the leadership of the Nairobi Convention or WIOMSA to develop consensus on how best to collect data following consistent, agreed-upon methods within and across countries so that a) national and b) regional data may be compared. The gathered experts could recommend the following:

- The most practical and informative method to collect data on plastics in a regular and uniform way at every stage of its life-cycle.
- The manner in which data are shared and made available within and between Nairobi Convention countries; and
- The way data should be managed, analysed and used in models to set baselines, track trends, evaluate the impacts of interventions, and develop predictions (predictive models) that are linked to growth and development profiles so that waste management can be geared to anticipated changes.

These steps could, with increasing accuracy, provide management tools that:

- Define the status of waste management in each country and the WIO region as a whole;
- Evaluate the performance of management strategies and the impact of planned interventions;
- Demonstrate trends; and
- Support evidence-based planning for the future.

The capacity to have strong data for predictive modelling is a valuable tool given the current rapid growth and development of the WIO region, which is expected to accelerate (Jambeck *et al*., 2018; UNEP 2018; The Pew Charitable Trusts and SYSTEMIQ, 2020).

A principal challenge is that, in almost all countries, data on waste management combine all waste and do not separate plastics from other waste materials. Plastic data should be separate from data on other components of the waste. Separation of waste at source, including different plastic polymers, would be the ideal. Failing effective separation at source, it is recommended that waste streams are sampled frequently, at several points in the life cycle, not simply from the waste arriving at a landfill.

Currently, data collection is understandably geared to answering questions that are related to waste management, and do not normally deal with the primary plastic pollution related issues such as precisely evaluating the amount of plastic that is leaking into the environment and what proportion of that is leaking into the sea. If targets are to be set to reduce plastic leakage into the sea, then baselines are necessary. The only evaluations regarding leakage were in the IUCN papers on hotspotting (Pucino *et al*., 2020).

9.4 Education, Building Capacity, Skills and Sharing Knowledge

The Nairobi Convention and WIOMSA are concerned that the current level of knowledge about marine litter in the WIO is still insufficient to make region-wide recommendations to solve the problems related to marine litter. Although plastics have been impacting the lives of people everywhere since the 1950s, they have only become management, health, environmental, and economic challenges in the last few decades. Until now, there has not been any real pressure to fully incorporate the teaching of the spectrum of plastic related issues into the school and university curricula.

Given that managing plastics is a new field that has not yet been fully integrated into education and training systems, relatively few people in WIO countries are trained in the broad spectrum of plastic-related disciplines. Those who were interviewed in this study were unanimous: a high priority is to address the capacity building, education, skills development, and the need for knowledge to be shared throughout the populations of every country. It is apparent that almost all in leadership and decision-making roles in the WIO region who are responsible for the management of plastics are new to the field and have had to learn while working and are therefore self-taught. Furthermore, their knowledge is confined principally to those aspects with which they need to deal on a daily basis. According to those interviewed, few of those working in plastics know the differences between plastic polymers, the intricacies of the plastic industries, and the complexities of manufacturing plastic products or recycling. Preliminary results from an ongoing survey by Sustainable Seas Trust (SST) show that only 12 out of 60 WIO universities examined thus far run courses with any plastic-related content or supervise plastic-related post-graduate studies. None of the universities covers the full spectrum of plastics-related disciplines, but rather each tends to follow the interests of the staff members who lead the courses.

Despite the preliminary nature of this evaluation, it is clear that while well-qualified experts are present within the WIO region, they are too widely distributed. The need to collaborate in building regional teaching and research capacity in tertiary education institutes is apparent. Similarly, a preliminary survey of education curricula in the countries of Africa by SST shows that the majority do not yet have the teaching of plastic-waste issues in the school syllabus.

A coordinated, collaborative approach to education is recommended. In planning the way forward, all countries must have access to accurate information, valuable academic and technical training courses, and good instructors. Further educational priorities are to build capacity in municipalities/ city councils and strongly promote understanding among members of the public, particularly consumers. Interviewees also recommended that governments regularly share knowledge about the state of plastics in their countries and what should be done by all communities to enable the achievement of goals, thereby benefiting all citizens. A prerequisite to this is for governments to share their goals and targets with all citizens to encourage citizens to feel a sense of ownership. Part of this process would be to announce progress towards local and national goal achievement regularly.

Given that understanding the full spectrum of plastics, from the production of raw materials to end-of-life, is critical to appropriate planning and management development of education and skills, training to build competent capacity must become a priority.

It is recommended that the Nairobi Convention and WIOMSA consider drawing together experts from within the WIO region to plot a regional strategy for education and capacity building, including the types of resources required for the different groups and how such materials should be delivered and in which languages.

9.5 Enabling Legislation and Incentives for Recycling

An objective of the Nairobi Convention and WIOMSA in commissioning this report is to harness the inherent value in plastic waste to build WIO economies and address poverty issues. To achieve such goals, one of the recommended actions is to promote recycling within most of the countries of the region. Recycling has not reached its full potential in any country. From the literature, and particularly through the interviews, the following barriers to recycling were recognized:

- Lack of sustainable end-markets for recycled products.
- High capital costs of recycling, particularly when expensive equipment needs to be imported.
- Taxation, sometimes at every step of the process, imposed on imported equipment, on transport, and those related to preparation, production, and sales render recycling unaffordable.
- Lack of capacity, particularly of those with appropriate technical and/ or entrepreneurial/ business skills.
- High costs of collection, sorting and washing, particularly when those who offer such services elevate their charges.
- Fluctuation in the oil price and its direct impact on costs of plastics to be recycled and of feedstock from recycled plastics relative to those of virgin feedstock.
- Bureaucratic imposition of excessive paperwork.
- Inadequate or inconsistent flow of the volumes of the plastics required for recycling.

The island states also face the challenges of inadequate volumes of plastics to sustain profitable recycling enterprises, and local-end markets are limited.

Recycling, down-cycling, up-cycling and repurposing have the potential to play a positive role in reducing plastic waste, removing it from the environment, providing employment, reducing costs to government, improving human and environmental health, and contributing positively to local and national economies. Further arguments are that removal of plastics from the environment through successful recycling is likely to have positive impacts for the fishing industry, on aquaculture and mariculture, on costs of operating marine vessels, in promoting tourism, in reducing GHG emissions, in conserving biodiversity and restoring ecological goods and services.

Given the potential benefits of promoting recycling enterprises, it is recommended that, in those countries which have the plastic volumes and end-markets to support viable recycling industries, enabling legislation should be introduced (Figure 19). Such legislation could have positive ramifications for the informal communities of waste retrievers (waste pickers/ informal collectors) and contribute to local and national economies. It is suggested that governments, including municipal authorities, should consider::

- Waiving tax and other tariffs on the importation of recycling equipment (it is understood that Kenya does this already);
- Providing land and facilities at reduced rates or free; and
- Reducing or eliminating all forms of taxation relating to recycling.

These actions may marginally reduce revenue to governments in the short term, but the long-term benefits will outweigh the costs.

Figure 19. Investment in even simple machinery such as those shown here for recycling is costly and needs support if recycling is to be promoted. Enabling legislation to support development is recommended. (Photo by: © Douw Steyn)

A further, potentially significant form of enabling legislation would be for city managers to commit to purchasing only recycled materials for their own projects, such as for buildings, pavements, poles, signage, garbage containers and so forth, as these provide reliable, sustainable, large end-markets for the recycled products that would incentivize the growth of the recycling industry and have positive impacts on the reduction of waste in the environment, and hence leakage to the seas.

There is no doubt that recycling and associated industries do play a significant role in reducing plastic pollution to the environment and leakage to the sea, it is, however, only one of a suite of actions that need to be taken to reduce plastics in the environment. The authors of the *Breaking the Plastic Wave* publication give values of the contribution of recycling to the overall strategy to reduce the flow of plastics to the seas, and they stress that it is one of many steps that need to be taken (The Pew Charitable Trusts and SYSTEMIQ, 2020).

9.6 Marine Debris, Research and Management

Stopping plastics from land-based sources has been the principal focus of this report, partly because most plastic pollution takes place on land and that is where management of plastics needs to be most intensively directed. There is, however, a need to give consideration to understanding and better managing sea-based sources of plastics. Given the economic issue, both in terms of benefits and costs, and the environmental costs and impacts, it is recommended that a regional study of sea-based sources of plastics is developed with the aim of:

- Developing a Guide on Methods for collection and analysis of data from sea-based sources of plastic litter that would:
    - Facilitate the collection of data in a manner that is comparable across the entire Nairobi Convention.
    - Establish baselines against which trends and the effectiveness of management plans could be tracked.
    - Develop and host training workshops.
- Developing education, capacity building and skills programmes in the discipline of Sea-Based Sources of Waste.
- Developing end-of-life recycling initiatives for fishing gear waste, ideally with the employment of local communities as an objective.

9.7 Regional Collaboration Through Networking

The Nairobi Convention and WIOMSA noted that while many national initiatives deal with marine litter-related aspects within the region, there is little coordination, communication and mutual learning among WIO countries, experts, and partners working in this field. They recognized a need for mechanisms that can facilitate communication between practitioners and experts and between different programmes and funding agencies. A coordinating network could help reduce duplication of work, establish partnerships, improve coordination, and provide a forum for sharing information and knowledge among experts, managers, and funding agencies, as well as facilitate joint regional planning and implementation. They noted that such regional efforts are of particular significance, as marine litter is transported widely by ocean currents and impacts distant localities both in the region and globally.

In response to these needs, the *African Waste Network Maps* project of the AMWN has been developed and is now a growing online platform (https://sst.org.za/maps/african-waste-network-maps/)

It uses a mapping platform on which to place information and locality of plastic waste-related organizations, institutions, businesses, and projects. The maps are searchable and interactive and aim to promote coordination, provide information, share knowledge, and promote partnerships. Currently, more than 3 000 entries populate the maps, which are growing (Figure 20). It is recommended that the AMWN mapping programme is further developed to meet the requirements, starting with organizations and institutions of the WIO placing their information on the maps at https://sst.org.za/maps/african-waste-network-maps/. As the information on the maps grows, so their value as a comprehensive information source increases. The maps will soon reach a point where they will be a valuable information tool that is available to decision-makers, researchers, policy developers, educators, planners, and indeed to anyone in the WIO region who seeks information on plastic pollution related questions within the WIO.

It is recommended that this initiative is supported and grown so that its capability to serve the region is strengthened.

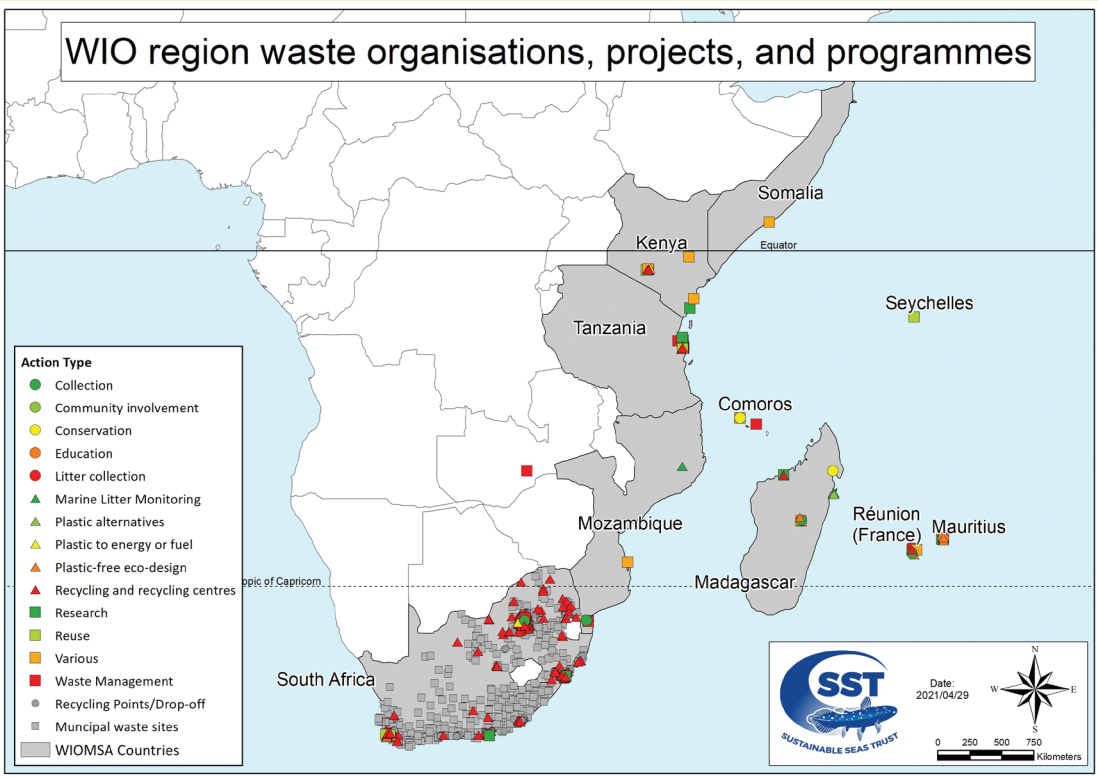

Figure 20. The African Waste Network Maps are searchable. Some of the topics that can be searched are given on the left part of the map. When online, by hovering over any of the entries, information is displayed on the nature of the organization, what it does, by whom and where, plus contact details and other information that the organization wishes to share.

9.8 National and Regional Action Plans

The multifaceted nature of the plastics issues throughout every step in the life cycle suggests that it is unlikely that any single institute will have the full range of expertise to develop national and regional action plans alone. Instead, the collaboration of a diversity of experts is key to ensuring that national and regional action plans can be crafted to achieve the desired outcomes and impacts. As the circumstances of each of the continental and island states of the Nairobi Convention are so different from the others, it is recommended that the development of an overarching guide to what should be included within a national action plan should be a priority. This guide should include a decision-making framework that enables each country to adapt the actions to its own needs. Ideally, the overarching guide on how to

develop national and regional action plans should be inclusively developed by representatives drawn from every step in the plastics life cycle. Contributions should come from academia (education, capacity building, skills development, research), government (including those directly responsible for waste management), economists, and lawyers from every country. Such collaboration will ensure that the guide has a systemic approach and can be adapted to the circumstances that prevail in each country.

The purpose of the national action plans will be to provide a time-based roadmap for combatting plastic waste, and in doing so, assist with the achievement of several Sustainable Development Goals. Regional action plans will promote international collaboration in achieving regional targets. They will define regional policy and open doors to transborder sharing of knowledge and harmonizing data collection methods.

The research and interviews included in this project indicate that every country is either developing national action plans or strategies to better manage plastics or has already published theirs. The only possible exception is Somali, which may have developed its plans, but they were not found during the search.

9.9 Electronic and Hazardous Waste

Electronic waste was not included in this review, but it became apparent from the interviews that there is concern that electronic waste is being dumped in some of the continental countries (e.g., Kenya and Tanzania) under the guise of electronic products that are still functional. However, these computers, mobile phones and other electronic goods are at the end of their life expectancy when they are imported. If they are operational, they cease to function very quickly. It appears that the valuable metals are being removed from these devices, but the plastic casings and internal plastic structures are discarded and are accumulating.

Feedback from the island states in the WIO indicates that these countries do not face the same problem of burgeoning electronic waste volumes as those of the continent.

It is recommended that the issues of electronic waste should be examined in the near future.

10 CONCLUSION

The most encouraging aspect of this study was to discover, from reading and interviews, that there is a growing and improving understanding of the issue of plastic waste, that there is increasing desire to better manage the issues, and to learn that all countries are developing a positive momentum. The finding that virtually all countries are engaged in the development and/or implementation of strategic national action plans to better manage plastic pollution and prevent it from leaking into the environment, and the seas, is reassuring. This development of positive momentum is welcomed and absolutely essential because plastics are not well managed in any country. Plastic litter continues to grow and, at a commensurate level, so does plastic leakage into the seas. It is imperative that the positive momentum and the growing desire to find solutions to the plastic waste crisis are harnessed now, and that national and regional solutions are found, as predictions are that the situation will rapidly become worse if action is not taken (Jambeck *et al*., 2018; UNEP 2018, The Pew Charitable Trusts and SYSTEMIQ, 2020 and many others).

Finding solutions requires careful, inclusive facilitation. The complexities of the plastic waste issues, on the one hand, and the diverse nature and characteristics of the countries of the WIO, on the other, strongly suggest that it is very unlikely that a single all-embracing solution can be found for all countries. Each needs to be considered individually and accommodated appropriately.

The Nairobi Convention countries are particularly interesting as there is a clear dichotomy between the five continental states and the five island states. As a generalization, the island states are more constrained: despite small populations, the pressure of people has greater impacts on limited available land and landfill sites. Small populations also mean that the volumes of plastics are not great enough to sustain significant recycling enterprises. Equally, the local markets are too small for recycling to be profitable. This means that while the promotion of recycling as a powerful solution can apply to mainland (continental) states, the advocacy of recycling in small island states will be met with limited success, except at a small scale. The dependency on importation of fully manufactured plastic goods is disproportionately high in island states relative to mainland states, probably because the island populations are too small to support such industries. Once again, the promotion of plastic manufacturing may be economically justifiable in continental states but would be imprudent in island states except on a small scale. These preliminary examples of general differences between island and continental states indicate the need to carefully consider each country within the full spectrum of its own context. Clearly, recommendations for one country will not necessarily fit the requirements of another, particularly when considering the economics and management of plastics.

There are many common and cross-cutting matters that will benefit all countries and aid harmonization. Furthermore, the underlying principles that are common to all countries, such as those of the circular economy, should be adopted, but the way in which the principles are put into practice needs to be tailored to the special circumstances of each country. The way forward probably lies in a collaboration in which the sharing of best practices, harmonizing methods, networking and sharing of knowledge, development of skills and techniques can be moulded to harmonize approaches, but then crafted to the special circumstances of each country. A useful starting point could be inclusive regional workshops to build a better future together.

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