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Unlocking Demand for Biomaterials in South Africa

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This report is published as part of the Partnership for Action on Green Economy (PAGE) – a joint initiative of the United Nations Environment Programme (UN Environment), the International Labour Organization (ILO), the United Nations Development Programme (UNDP), the United Nations Industrial Development Organization (UNIDO), and the United Nations Institute for Training and Research (UNITAR). In South Africa the PAGE Programme is implemented in partnership with the South African Government (Departments of Forestry, Fisheries and the Environment (DFFE), of Trade, Industry and Competition (**the dtic**), and of Science and Innovation (DSI)).

CITATION

PAGE (2022), Unlocking Demand for Biomaterials in South Africa

DISCLAIMER

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ACKNOWLEDGEMENTS

The Unlocking Demand for Biomaterials in South Africa Report was initiated on the request of the South African Government and was commissioned as a joint initiative by the United Nations Partnership for Action on Green Economy (PAGE) in collaboration with the United Nations Industrial Development Organization (UNIDO) and the South African Government.

The Action Plan Task Team consisted of representatives from government departments as well as relevant PAGE agencies. From PAGE, the Task Team supported the development of the terms of reference for this study and was responsible for overseeing the implementation of the study, review, and completion of the report. Representatives included Ozunimi Iti, UNIDO Industrial Development Officer, Abu Saieed, UNIDO Green Industry Expert, and Siyanda Siko, PAGE National Coordinator, International Labour Organization. From the South African Government, the Task Team provided valuable input into the study and included Jenitha Badul and Leanne Richards (Department of Forestry, Fisheries and the Environment), and Henry Roman (Department of Science and Innovation). Furthermore, the PAGE National Steering Committee had the opportunity to put forward input on the analysis and the report.

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We gratefully acknowledge the support of the PAGE family and all its funding partners: the European Union, Finland, Germany, Norway, the Republic of Korea, Sweden, and Switzerland.

Executive Summary

Plastics are a key component of the chemicals industry and are ubiquitous in modern society. Plastic production is associated with high carbon emissions and, as the world averts from traditional fossil fuels, alternatives such as bioplastics offer substitutes to traditional carbon-intensive materials. Bioplastics offer an opportunity for additional decarbonisation of the South African economy. Bioplastics can compete with fossil fuel products based on quality and sustainability, although cost-parity remains a challenge. A key driver of the growth of bioplastics is the development of demand policy tools to increase their consumption. This report aims to shed light on the often-neglected development of the demand side of the market as it pertains to a new and emerging biomaterials market – that of bioplastics.

Global and South African demand dynamics

Bioplastics currently account for approximately 1% of total global plastic production. Production capacity is expected to increase to 2,4 million tons by 2024 as new technologies emerge and the demand for bioplastics increases. Growth is anticipated to be driven by the demand for biodegradable polymers from Brazil, China, and India. Growth is expected to occur due to increased demand for specific polymers such as polyhydroxyalkanoates (PHA) and polylactic acid (PLA) for their diverse applicability in packaging, fibers, textiles, and medical applications.

The demand side of South Africa's bioplastics market is currently small, but the demand outlook for bioplastics appears promising and growing. Demand is likely to be driven by large multinational organisations (MNOs[1]), domestic firms and industry collaboration initiatives. The initial demand is likely to be from drop-in[2] bioplastics as they can be easily substituted to traditional polymer production. Local firms such as Woolworths, Growthpoint and Optimus Bio are driving demand for bio-based products through inculcating a sustainability focus in their product offerings.

Demand-side policy options

Policy measures intended to stimulate demand for sustainable substitutes such as bioplastics, are comprised of five key options:

- **Bans on single-use plastics** consist of restrictions or prohibition of a particular type, specification, combination, or production levels. They serve to increase the demand for bioplastics as consumers must switch to alternative products. Bans can apply to the manufacture, sale, import, or production of traditional plastics. Bans can apply to all single-use plastics or a specific product, they can be based on the physical properties of plastic, and they can vary by geographical scope, retail segment, and production volumes. Countries such as Rwanda and Bangladesh have instituted bans with varying physical requirements and levels of enforcement which have resulted in changes in the use and consumption of plastics.
- **Taxes or levies** are charges which increase the cost of consumption of traditional plastics. Taxes and levies increase demand for bioplastics as the tax price has a dissuasive effect on consumers.

[1] A multinational organisation is an organization that has assets and owns or controls production of goods or services in at least one country other than its home country.

[2] "Drop-in" bioplastics refer to the production of a similar chemical to the petrochemical plastic however the source is bio-based feedstock instead of petrochemicals, with the same production pathway as the petrochemical plastics. Drop-in bioplastics are advantageous in that they can be integrated into existing production without substantial technology or equipment investments. See (Barrett, 2018a).

Taxes vary depending on what is charged, who is liable to pay, as well as the market entry points. Taxes can also vary by geographical scope and by physical properties. Ireland's tax is an example of an effective tax, as the tax rate was set at six times the consumer willingness to pay. Botswana's tax however is an example of a limitation in policy implementation, as the country lacked an effective revenue collection mechanism.

- **Standards and labels** specify the sustainability, eco-friendly elements of various kinds of materials, processes and services. The standards and labels for bio-based products are classified under ecolabels. Ecolabels increase demand for bioplastics through raising awareness of their sustainability elements. The ISO differentiates between three types of eco-labels; Type 1 are the strictest form and involve third party licensing, Type 2 are self-declarations and Type 3 involve the use of quantitative indicators of environmental performance. Within the ISO specifications, ecolabels vary by sectoral coverage, sustainability assessment and governance. China's ecolabel scheme has garnered success since its introduction based on regular updates and expansions in product categories and products offerings.
- **Green public procurement (GPP)** involves the procurement of green products by the state. GPP increases demand for bio-based products due to the size of the state as a customer. GPP can vary based on the governance level, it can cover various stages of the value chain and can involve synergies with social and political considerations of government. Countries such as Japan and South Korea are leading in Asia in GPP and have legislation enforcing GPP. GPP is also supported through the use of NGO/NPOs and an online reporting platform.
- **Social awareness** increases demand through the persuasion and education of the general public regarding the sustainability of low-carbon and/or bio-based products. Social awareness requires regular and engaging messaging through appropriate channels. Social awareness campaigns can make use of traditional and online media, social nudging, social proofing, education curriculum, promotional activities, awards, and other incentives. Social awareness messaging needs to be consistent and targeted, involving multiple stakeholders. Malaysia's go green campaigns aimed at encouraging green behaviour among consumers and achieved higher behavioural change among families, women, urban residents, and high-income individuals.

Policy insights for South Africa

From the demand-side policy measures analysis, key insights can be drawn to develop the South African bioplastics market.

Bans and taxes

South Africa has a ban on plastic bags less than 0.3 millimeters (mm) thick and a levy (0.25 cents in 2020) on the manufacturing of thicker bags. The levy has been criticized for being too low to influence behaviour. Given the review of international literature, the following steps should be taken if bans and taxes are further pursued.

- Extensive public consultation as in countries such as Rwanda, Ireland, and the State of California where stakeholder engagement mitigated the political economy tensions.
- Ensuring the availability of cost-effective alternatives.
- Sufficient disincentives where the punitive measures are effective in deterring consumption of traditional plastics.
- Effective enforcement is a crucial cornerstone to stimulating demand for bioplastics through bans and taxes.

Standards and labels

Currently, ecolabels in South Africa have a sectoral focus. There is currently no legislation or regulation surrounding ecolabels and ecolabeling occurs voluntarily. Leading departments and organizations such as **the dtic** and NCPC should formulate clear guidelines and frameworks.

Specific guidance should be provided on the following:

- The types of assessments that are accredited and desirable. This refers to whether complete LCA is required for labels or whether other types of sustainability assessments are acceptable.
- The types of ISO labels that are accepted. ISO distinguishes between three types of labels, each with differing requisites. **The dtic** and NCPC should provide clear guidance on which labels are acceptable in consumer markets.
- Periodic review of labels. **The dtic** and NCPC should set out the criteria for which ecolabels are reviewed and allowed to continue with periodic reviews to ensure consistency in accreditation.

Green Procurement

Green Public Procurement (GPP) in South Africa is currently implemented by certain municipalities and metros. For GPP to work as a tool to increase the demand for sustainable products such as bioplastics, a comprehensive framework and plan should be developed that consists of the following key interventions.

- Mainstreaming GPP in national government. GPP should be incorporated into the central government as a mandatory element in procurement and should be developed in conjunction with a credible system for ecolabels that aid in procurement decisions. Although, a sustainable public procurement approach has been pursued, for example, by the DFFE.
- Centralized procurement. In South Africa, the Public Finance Management Act (PFMA) prescribes decentralized procurement. For GPP to occur within this framework, each organization would have to invest in separate skills development, awareness training and manage the use of local suppliers to implement GPP.
- Creation of centralized systems using platforms to link public and private consumers in the economy with verified suppliers is essential.

Social awareness

Social awareness and education in South Africa occur through different stakeholders with differing methods of raising awareness. South Africa has been criticized for a lack of effort in raising awareness and having a unified voice from all stakeholders concerning sustainable plastics use.

Recently several notable projects that seek to ensure collaboration between stakeholders and focus on bioplastics, have been initiated. These include the South African Plastics Pact and the South African Initiative to End Plastic Pollution. These awareness campaigns aim to build networks within the state, among communities, consumers, and industry. These recent alliances are a positive move forward for gaining traction for bioplastics as well as for raising awareness around sustainable plastic use. Since the alliance is newly formed, it remains to be seen how effective the alliance will be in achieving its goals. It is imperative that awareness messaging occurs on a continued and targeted basis behaviour change to occur.

From an education perspective, while awareness of pollution is taught as part of the national curriculum, gaps within climate awareness and how to limit plastic consumption and use are still prevalent. A greater emphasis on climate change, the impact of plastics and the circular economy, have been identified as necessary.

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List of Definitions

Biodegradable:	In the context of plastics, this refers to a property of plastic where the plastic decomposes through interacting with living organisms into water, carbon dioxide, and biomass. Biodegradable plastics can be produced from renewable raw materials, micro-organisms, petrochemicals, or in combination of all three.
Biomaterials:	Biomaterials refer to products that are produced from renewable bio-based feedstock inputs as contrasted to those products derived from non-renewable (and generally fossil-based) feedstock inputs.
Bioplastics:	Polymers that are produced from bio-based, renewable feedstock that include agricultural products (crops and plants), organic waste products, marine plants (algae/seaweed), and bacteria.
End-of-life stage:	The end-of-life stage of a product refers to the stage of the product's life after it has been consumed or used.
Feedstock polymers:	Chemicals produced in large quantities which serve as inputs into the production of a variety of downstream chemicals and chemical products. Feedstock polymers include propylene and ethylene.
Microplastics:	Fragmented pieces of any plastic that are typically less than 5mm in length.
Polyhydroxyalkanoates (PHAs):	A family of polymers that are produced naturally through bacterial fermentation of sugars or lipids.
Polylactic acid (PLA):	PLA is a polymer derived from lactic acid, which occurs in the fermented plant starch in corn, cassava, sugarcane, or sugar beet pulp.

List of Acronyms/Abbreviations

3Rs – Reduce, Reuse and Recycle

ASTM – American Society for Testing and Materials

BFL – Bags for life

Bio-PE – Biodegradable polytacic acid

Bio-PET – Bio polyethylene terephtalate

CEN – European Committee for Standardization

CO_2 – Carbon dioxide

CSIR – Centre for Scientific and Industrial Research

DALRRD – Department of Agriculture, Land Reform and Rural Development

DBSA – Development Bank of Southern Africa

DFFE – Department of Forestry, Fisheries and the Environment

DSI – Department of Science and Innovation

EQMP – Environmental Quality Management Plan

FMCG – Fast moving consumer goods

FSC – Forest Stewardship Council

GDP – Gross domestic product

GHG – Greenhouse gas

GPIS – Green Products Information System

GPP – Green public procurement

HDPE – High density polyadic acid

ILO – International Labour Organization

ISO – International Organization for Standardization

LCA – Life cycle analysis

MFMA – Municipal Finance Management Act

MNOs – Multinational organizations

NCPC – National Cleaner Production Centre

NGOs – Non-Governmental Organizations

PAGE – Partnership for Action on Green Economy

PE – Polyethylene

PET – Polyethylene terephthalate

PEF – Polyethylene furanoate

PHA – Polyhydroxyalkanoates

PLA – Polylactic acid

PP – Polypropylene

PS – Polystyrene

PUR – Polyurethane

PVC – Polyvinyl chloride

RSB – Roundtable on Sustainable Biomaterials

SA – South Africa

SCL – Standards, certification and labelling

SEIAS – Socio-economic impact assessment

SMRI – Sugar milling research institute

SPP – Sustainable Public Procurement

TIA – Technology Innovation Agency

TIPS – Trade & Industrial Policy Strategies

The dtic – The Department of Trade, Industry and Competition

UN Environment – United Nations Environment Programme

UNDP – United Nations Development Programme

UNIDO – United Nations Industrial Development Organization

UNITAR – United Nations Institute for Training and Research

1. Introduction

Plastics are a key product of the chemicals industry and are ubiquitous in modern society, where a number of consumer products use plastic inputs such as toothbrushes, carrier bags, food packaging, mobile phones, computers, carpets, clothes, and furniture. Plastics also serve as vital inputs into other manufactured goods such as electronic equipment, agricultural products, and pharmaceuticals. Despite their immense utility, plastics have destructive impacts on the environment and ecosystems. At the production stage, the production of input feedstock polymers is associated with high carbon emissions, particularly in the case of South Africa (SA) where upstream production is coal-based. At the end-of-life stage, plastics pose a threat to ecosystems when disposed of, leading to a release of carbon into the atmosphere. Marine systems are also heavily impacted upon, and significant lethal threats are posed to marine life. In addition to the impact on ocean life, microplastics enter various types of water systems and can accumulate in organisms to such an extent that it further threatens various lifeforms.

Increasingly, the world is averting from traditional fossil fuels and exploring the potential for biomaterials to substitute for traditional carbon-intensive materials.

Historically, the discourse on the development of biomaterials has mainly centred on the development of biofuels markets and on the development of the supply of biomaterials. While progress has been made in this regard, biomaterials extend beyond biofuels and consist of an array of other bio-based products which can contribute to sustainable production and consumption. Globally, bio-based products include bioplastics/biopolymers, biochemicals, bioceramics, biorubber, and biocement to name a few applications.

After biofuels, bioplastics have seen growth in supply capacities as well as research and development, with the other bio-based markets still at their infancy both globally and in South Africa. Among biomaterials, bioplastics are a sector anticipated to see significant growth in the next five to ten years. This growth occurs on the back of the urgent need to substitute for fossil-based plastics, increased consumer concerns around plastics use, climate change legislation, and the lack of other substantial decarbonisation options for the plastics industry. Given the presence of some bioplastics capabilities within the country, with some manufacturers having already absorbed bio-based polymers into production, the investigation of the bioplastics market is feasible, while the investigation of other bio-based products still have some way to go as domestic supply capacity. For these reasons, this report focuses on a specifically identified subset of biomaterials with potential for growth – bioplastics.

Bioplastics offer one possible intervention to support the decarbonisation of the SA economy that is based on a renewable source, which can use purpose-grown feedstock or can be used as part of a circular economy approach through the use of waste as feedstock.

With respect to focus on the supply side, a common barrier to the growth and scaling of sustainable markets in general and biomaterials markets in particular, is the lack of demand for sustainable alternatives. This is evident both on a global scale and in South Africa. This report aims to shed light on the often-neglected development of the demand side of the market as it pertains to a new and emerging biomaterials market-bioplastics.

Bioplastics have the ability to compete with fossil fuel products on the basis of quality, as certain bioplastic products are chemically identical to their fossil fuel counterparts. However, biodegradable, bio-based plastics can have superior environmental properties when compared to conventional plastics. For example, certain bioplastics are fully biodegradable without the production of harmful by-products, as is the case with conventional plastics. These plastics can be environmentally beneficial in South Africa, given the prevalence

and impact of plastics in landfills on the environment. Bioplastic products also have a role to play as carbon sinks, which defer the leakage of carbon into the environment through the incorporation of non-biodegradable bio-based polymers as a substitute for traditional polymers such as polyvinyl chloride (PVC) and polyethylene (PE). The development of the domestic bioplastics economy could aid South Africa in meeting its development goals, by creating new markets and employment, therefore leading to increased economic opportunities. The development of bioplastics also provides benefits in targeted sectors, such as energy security (electricity), and lower cost feedstock in chemical industries (accounting for externalities[3]).

Given that fossil-based plastics are currently cost-effective, bioplastics still have some way in penetrating the various downstream markets. A key component to the growth of bioplastics is the development of demand policy tools to increase the appetite for bioplastics consumption throughout the numerous value chains where traditional plastics are used. South Africa has a strong incentive to support the development of the biomass-based economy on the demand side. A strong link is required between policymakers and bioeconomy stakeholders, and notable strides have been made in this direction in the past few years through multi-stakeholder initiatives such as South African Initiative to End Plastic Pollution in the Environment and the South African Plastics Pact. Many countries have instituted policies to drive demand for bioplastics and there is a rich precedent to draw from. It is important for South Africa to draw from these policy experiences and tailor these demand policy measures to the local context and country needs.

This report is structured as follows:

Section 2 explores the various polymers that can be produced from biological and renewable sources, their properties, and end-uses.

Section 3 provides an analysis of global markets and trends in bioplastics and which bioplastics are likely to be higher in demand in the future.

Section 4 reflects on the South African bioplastics market and examines the existing and likely consumers of bioplastics in the country.

Section 5 examines supply side dynamics, summarizing previous work and looking at current supply initiatives.

Section 6 also examines the different policy tools that can be used to stimulate demand for bioplastics. Section 6 furthermore includes country experiences which are drawn upon to examine five policy options – bans and quotas on traditional plastics, taxes or levies on traditional plastic, the use of standards and labels to indicate sustainability, green procurement, and social awareness.

Section 7 draws on the demand policy options and draws policy insights for South Africa.

Section 8 provides a conclusion.

[3] Externalities refer to the environmental costs imposed by production of plastics that is not financially incurred or received by that producer. Once these costs are accounted for in production, the benefit is that feedstock for bioplastics can be cheaper than fossil fuels.

2. Properties and uses of bioplastics and biopolymers

Bio-based plastics can play multiple roles in a sustainable economy. Bioplastics can be designed to be totally biodegradable to carbon dioxide (CO_2) in a matter of months or years. This flexibility in the design of biodegradable characteristics decreases the carbon emission time frame when compared to conventional plastics. Bioplastics also can be used as carbon sinks through their use in long-term infrastructure, whereas bioplastics can substitute traditional plastics in municipal water and sewer piping, building, and roofing materials, and road surfaces (Karan et al., 2019).

Approximately 99% of plastics globally are produced through petrochemicals (Karan et al., 2019). Plant and bacterial biomass are capable of producing a number of bio-based polymers and feedstocks for bioplastic production. Early models for bioplastics production utilize agricultural crop-based feedstocks, such as carbohydrates and plant materials (Karan et al., 2019). While renewable, these feedstock options compete for resources such as arable land, fresh water, and food production. Table 1 lists some products and uses of bioplastics and biopolymers.

Table 1: Biopolymer/plastic feedstocks and uses. *(Source: Karan et al., 2019)*

Biomass component	Precursor	Uses	Degradability characteristics
Starch-based polymers	Starch	Packaging food trays Trash bags Flowerpots	Degradable in: - Water - Soil - Compost
PHA/PHB/PHV	Polyhydroxyalkanoates (PHAs)	Packaging adhesives Fibers Medical implants	Degradable in: - Water - Soil - Compost
Polylactic acid (PLA)	Lactic acid	Packaging Textiles Medical implants Films	Degradable in: - Soil - Compost - Water (can be a source of micro plastics)
Cellulose-based polymers	Cellulose	Wound Dress Textiles Air filters Coatings	Degradable in: - Water - Soil - Compost
Polyethylene (PE)	Ethanol	Bottles Ship containers Container lids Adhesives	None
Polyvinyl chloride (PVC)	Ethanol	Packaging Window frames Railings Pipes	None

Biomass component	Precursor	Uses	Degradability characteristics
Protein-based polymers	Amino acids	Cast Film Injection Moulds Compression Moulds Extruder Sheets	Degradable in: - Water - Soil - Compost

NB: 1. This list is not exhaustive as biomass components can be combined in a multitude of ways and their characteristics can be modified through the addition of other chemicals which can enhance their properties. 2. The above products can be sourced from both plant crops, microalgae and bacteria.

Based on the information provided in Table 1, some polymers are not biodegradable, such as PE and PVC. For example, these polymers are the highest produced polymers in the world for their use in packaging. In certain applications, biodegradability is not desirable, for example for infrastructure purposes. Non-degradable bioplastics can be used to develop sustainable infrastructure, such as plastic-based municipal water and sewer piping, building and roofing materials, and road surfaces. These products, in the long term may act carbon sinks (Karan et al., 2019). For example, bio-based PE (bio-PE) can substitute for fossil fuel-based PE in packaging applications.

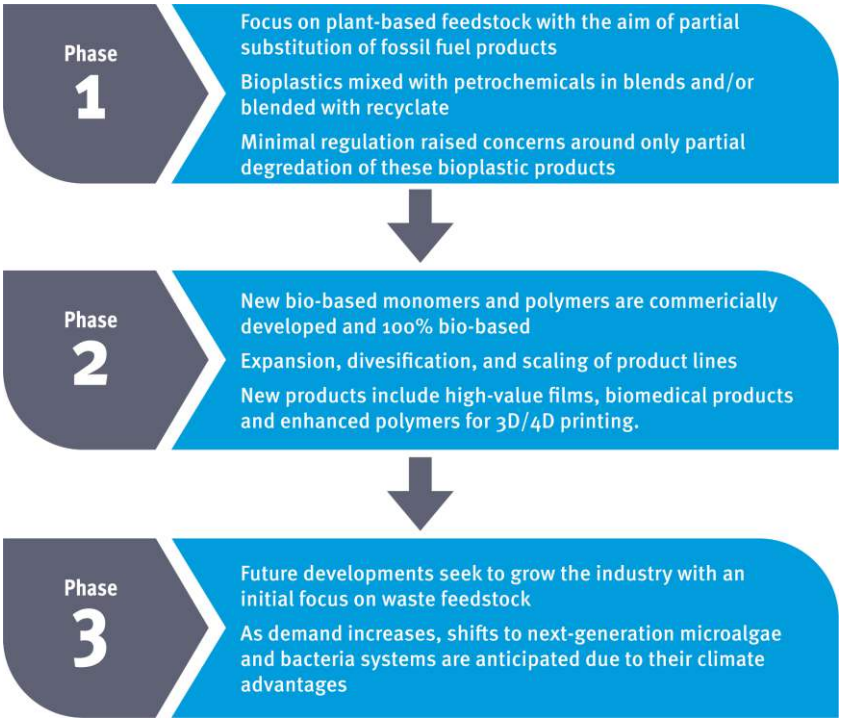

Figure 1: Development of the bioplastics market.
(Source: Karan et al., 2019)

Early efforts in the development of the industry focused on demonstrating commercial viability based on plant feedstocks and combinations with existing fossil fuel-based plastics (Phase 1 in Figure 1). With improvements in technological deployment and efficiencies, the focus subsequently shifted to proving the commercial viability of exclusive bioplastic production (Phase 2). At this stage, agricultural and waste feedstocks were focused on as sources of feedstock. These feedstocks, particularly in the case where crops are grown specifically for bioplastic production, competed with food crops and utilized arable land and water resources. Another important transition would involve the combinations of recyclate with bioplastics to enable the transition to full bioplastics production.

Newer developments in the form of algae and bacteria feedstocks dealt with the challenges of using agricultural and waste sources (Phase 3). Increasingly, future efforts are being devoted to scaling up technologies based on microalgae and bacteria systems. These new feedstock options are advantageous given that they can be produced on non-arable land, require less nutrients and fertilizer, can utilize wastewater, can degrade in natural or industrial composting sites, and allow for distributed production, making production suitable for clusters (Karan et al., 2019).

3. Global biomaterial market trends

Plastics are one of the chemical sector's main products and are abundant in modern society, where a number of consumer products are based on plastics such as toothbrushes, carrier bags, food packaging, mobile phones, computers, carpets, clothes, and furniture. Plastics also serve as vital inputs into other manufactured goods such as electronic equipment, agricultural products and pharmaceuticals. Plastics ensure food security throughout the global food system in transportation, preservation and consumption. Plastic packaging used for food and beverages accounts for the largest share of single end-use plastic demand, accounting for approximately 36% of demand globally (IEA, 2019).

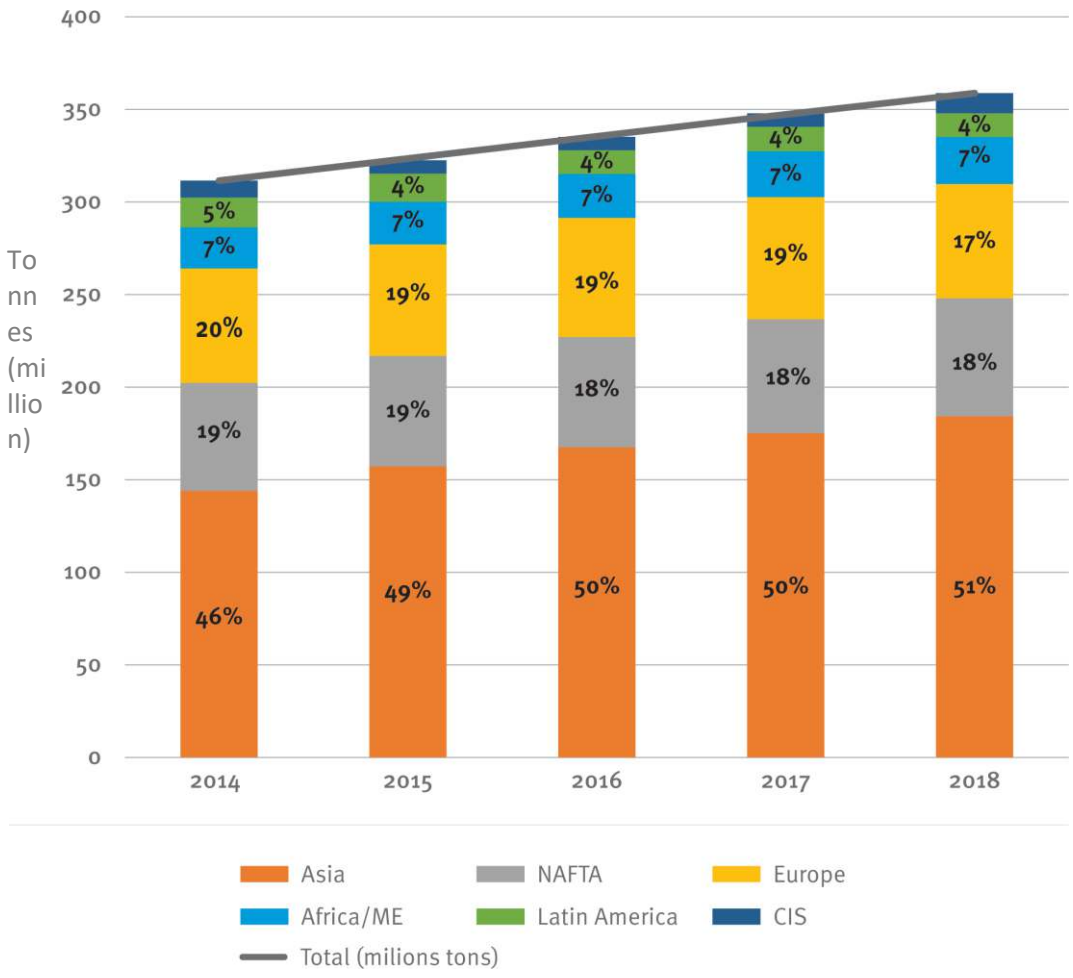

Figure 2: Global production of plastics, by region.
(Source: TIPS, based on (Plastics Europe, 2019, 2018, 2017, 2016, 2015))

From a production perspective, China dominates the global landscape accounting for approximately 30% of global production. This is followed by European and North American production which account for approximately 20% of global production each. By the year 2050, plastic production is expected to have tripled and will account for a fifth of global oil consumption, indicative of the conflict between plastic's utility to society and its environmental impact (Statista, 2020).

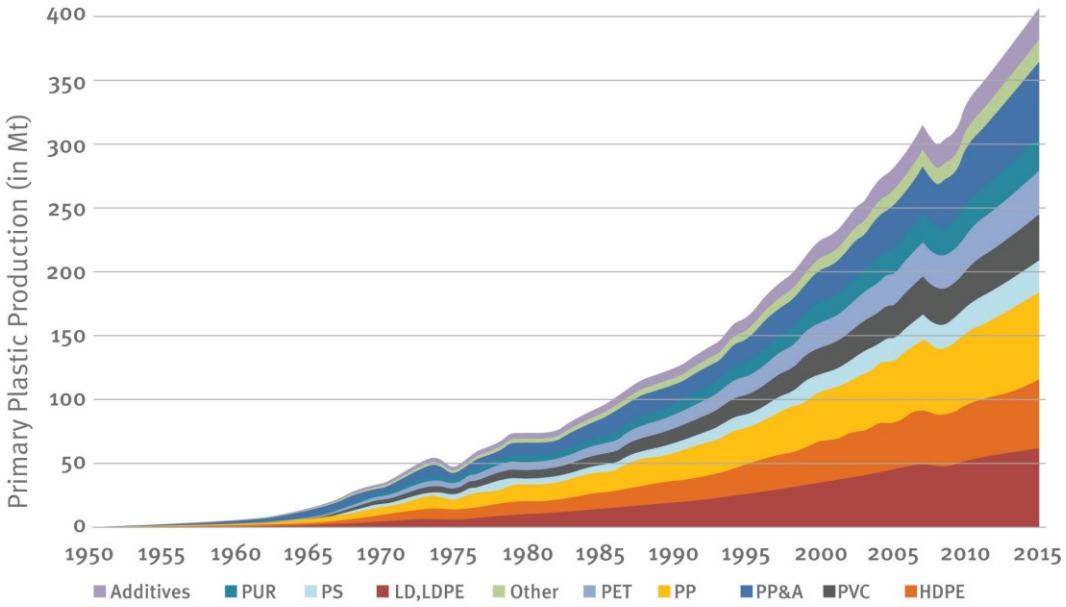

Figure 3: Global primary plastics production according to polymer type, 1950 to 2015.
(Source: Geyer et al., 2017a, 2017b)

In Figure 3, the largest groups in global plastics production are PE (36%), polypropylene (PP) (21%), and polyvinyl chloride (PVC) (12%), followed by polyethylene terephthalate (PET), polyurethane (PUR), and polystyrene (PS) (all below 10% each). Polyester (majority of which is PET), accounts for 70% of all PP&A production. These seven groups account for 92%of all plastics produced.

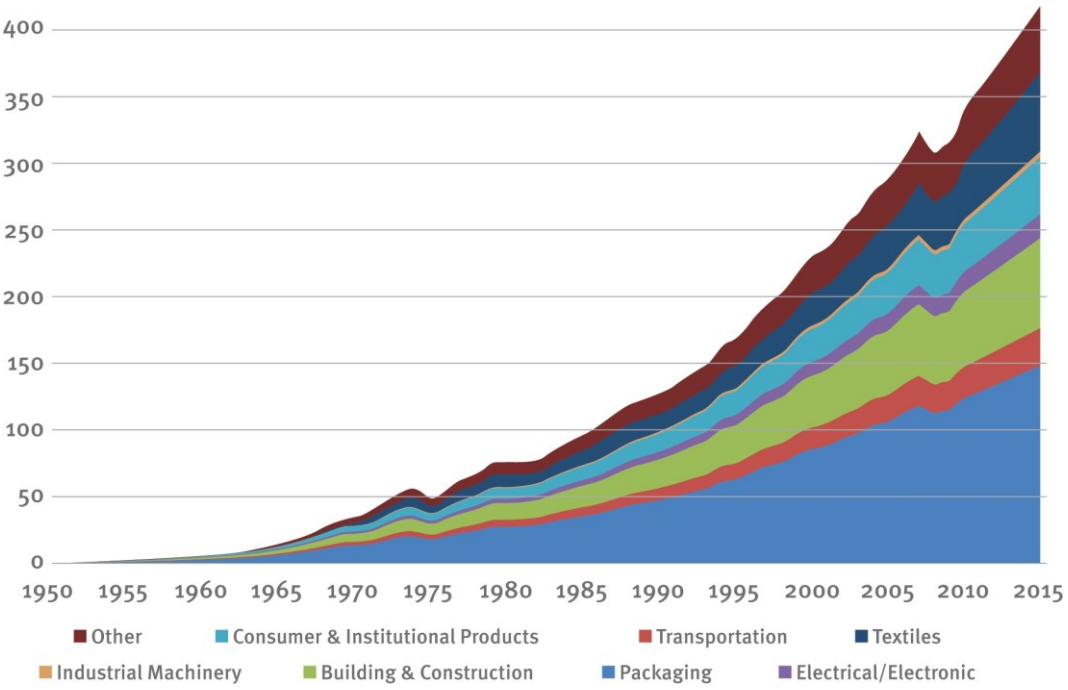

Figure 4: Global plastics production by industrial use, 1950 to 2015.
(Source: Geyer et al., 2017a, 2017b)

From an industrial use perspective, approximately 42% of all plastics have been used for packaging, which mainly comprise of PE, PP, and PET (see Figure 4). After packaging, the building and construction sector consumes 69% of all PVC, consuming 19% of all plastics.

Tracking the evolution of plastics production, the global production of plastics has increased tenfold since 1970 (see Figure 5), exceeding the growth of any other group of bulk materials and almost 60% faster than growth of global GDP.

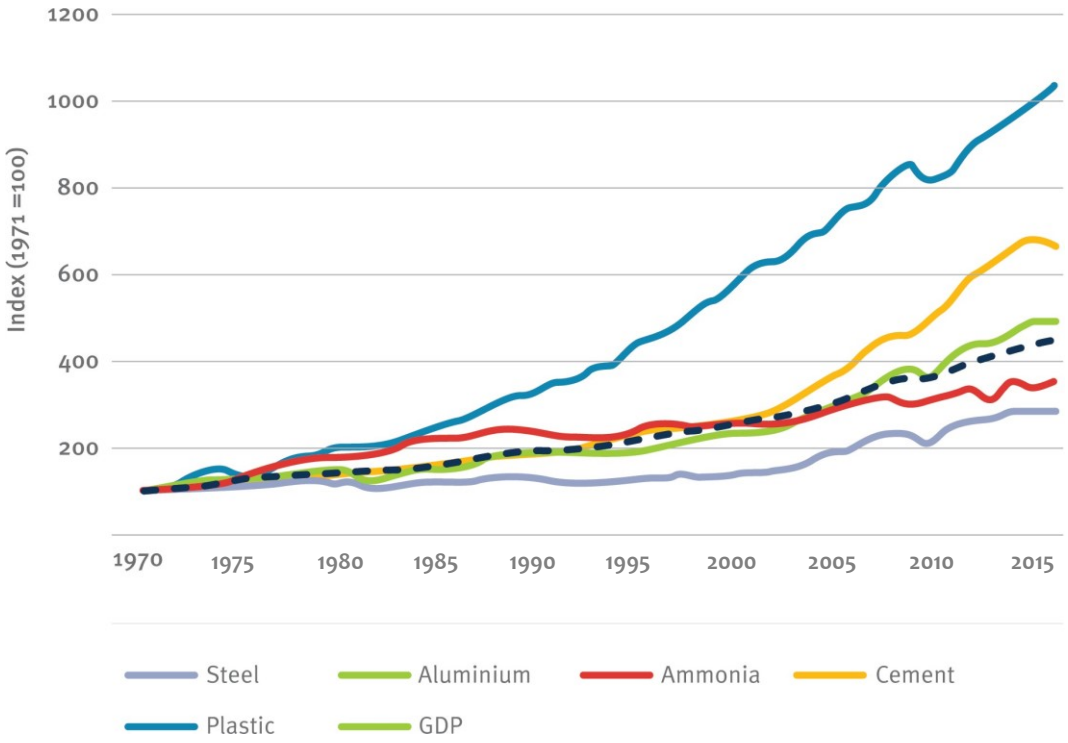

Figure 5: Growth in production of plastics with selected bulk products and global GDP.

(Source: IEA, 2019)

(NB: Outputs of different industrial sectors are displayed on an indexed basis referred to 1971 levels. 'Aluminium' refers to primary aluminium production only. 'Steel' refers to crude steel production.)

Plastic consumption patterns for several important plastics indicate that consumption is positively correlated with wealth (measured in GDP per capita). In lower-income and rapidly developing regions such as India, China and Africa, demand for plastics is rising at a rate of between 1% and 2% per annum. Based on modern consumption patterns there are limited substitutes for plastics, and bioplastics stand to gain substantial demand if their production is ramped up to replace traditional plastics, based on fossil fuels. This transition would be difficult to directly substitute and transition strategies employing the increase of recyclate content of fossil-based production routes can be staged, with gradual changes employing blends with recyclate and fossil-based plastics and recyclate combined with bioplastics.

Globally, much attention within biomaterials has been devoted to the market development of biofuels. However, less attention has been given to other viable products from the bio economy, such as bioplastics. Despite this historical lack of focus, the bioplastics sector is becoming a major area of research, innovation and market growth in recent years (Imbert et al., 2017).

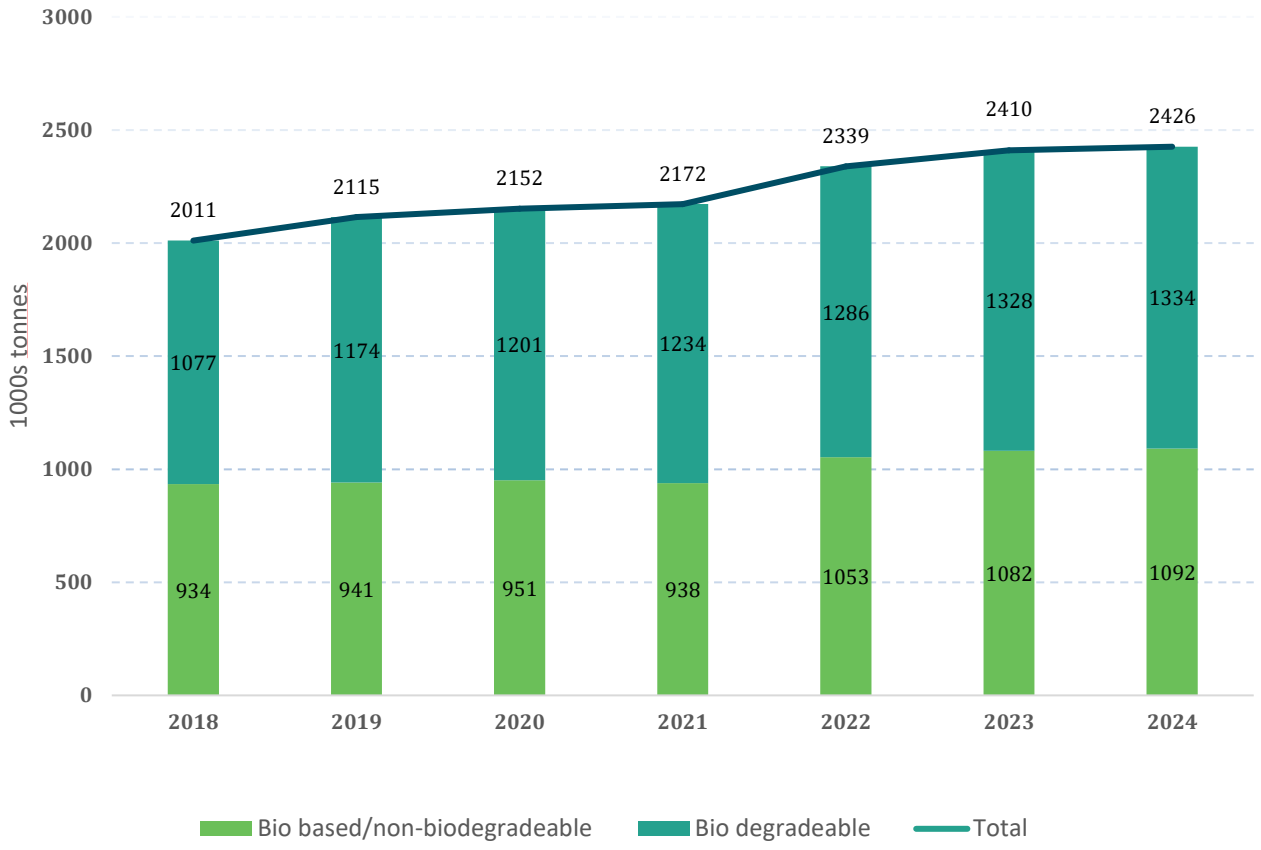

Figure 6: Global production capacities of bioplastics until 2024.
(Source: European Bioplastics, 2019)
(NB: Quantities beyond 2019 are projections.)

Currently, bioplastics account for approximately 1% of total global plastic production. The continued increase in the demand for bioplastics and the emergence of new technology, methods and products are expected to increase production capacity from approximately 2,1 million tonnes in 2019 to a projected 2,4 million tonnes in 2024 (European Bioplastics, 2019). Other estimates indicate that the global biodegradable plastic market is projected to move from US$3 billion to over US$6 billion in 2025 (Narancic et al., 2020). This market increase is anticipated to be driven by rising demand for biodegradable polymers from emerging economies such as India, Brazil, and China.

Bioplastics alternatives are set to substitute conventional plastics, and production capacity is expected to diversify in the medium term (approximately 5-10 years).

Currently, starch-blends have the highest share in the biodegradable plastics production as evidenced in Figure 7. Growth in bioplastics is expected to occur via increased demand for polyhydroxyalkanoates (PHA) and polylactic acid (PLA), due to their diverse applicability in packaging, fibres, textiles and medical applications. PHA and PLA currently have a market share of 1.2% and 13.9% of the bioplastic market respectively. PHA is anticipated to see a 6.3 times increase in global production from 25 320 tonnes in 2019 to 159 700 tonnes by 2024 (Narancic et al., 2020). In addition, PLA is expected to see an 8% increase production from 293 290 tonnes in 2019 to 317 000 in 2024.

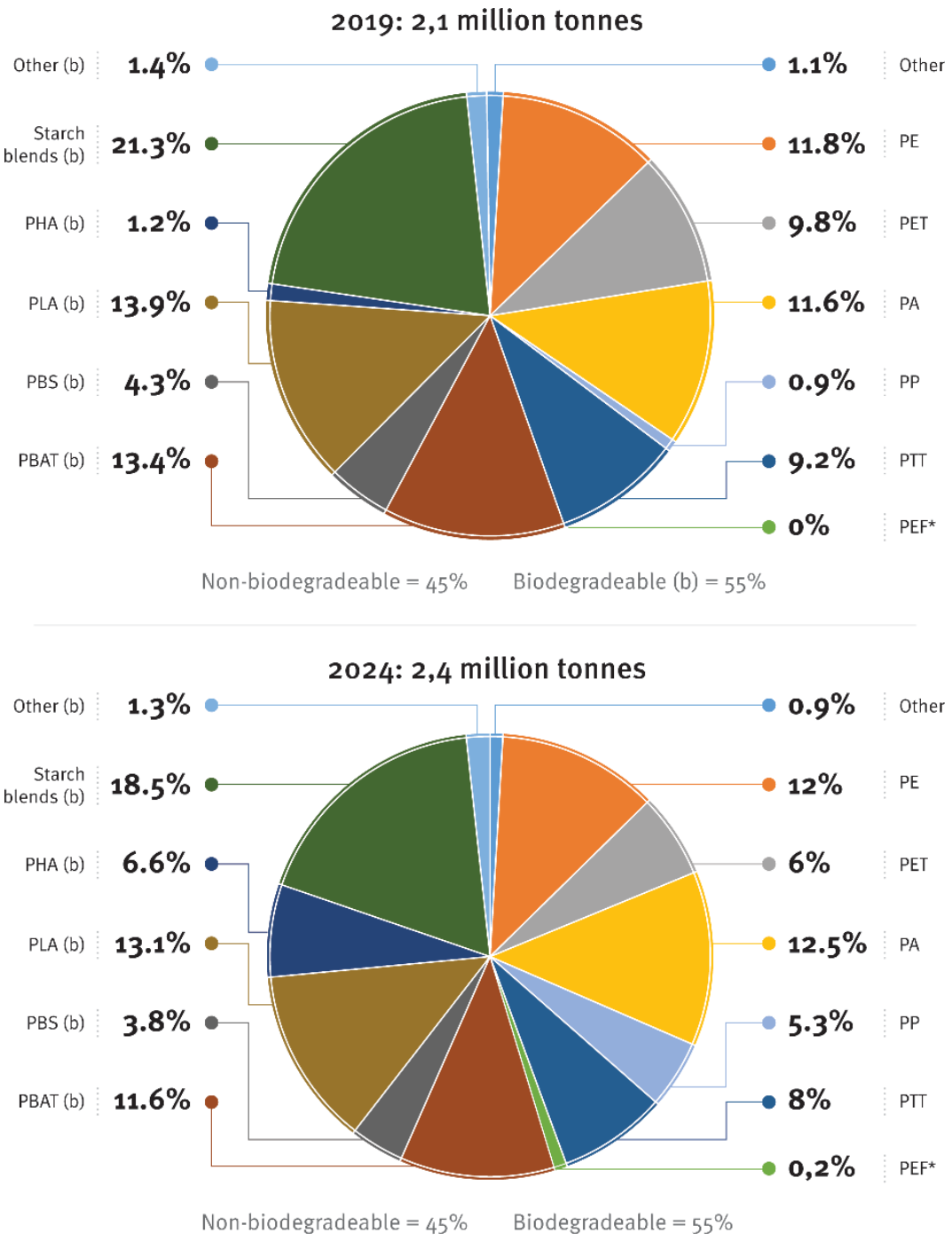

Figure 7: Bioplastic product mix in 2019 and 2024.

(Source: European Bioplastics, 2019)

(NB: 1. Polyethylene Furanoate (PEF) is expected to be commercially available from 2023
2. "(b)" refers to "biodegradeable")

Box 1: South African bioplastics demand drivers and market activity.

The demand-side of the domestic bioplastics market in South Africa is currently small, however as consumers throughout value chains increasingly align with sustainability and circular economy principles, the demand outlook for bioplastics appears promising and growing. The demand for bioplastics is likely to be driven by large Multinational Organizations (MNOs) with head offices out of the country, domestic firms and through industry collaboration initiatives.

Large MNOs create demand for bioplastics where sustainability decisions are made beyond South African borders. Globally, firms are increasingly accounting for climate risk in their corporate decisions and this filters into the South African market, through MNOs. Such decisions can serve to create linkages with domestic plastics producers and drive higher demand. Coca Cola, for example, uses a 30% bioplastic component (Bio-PET) in its PlantbottleTM packaging which is derived from sugar cane and used in products, such as the Valpre bottle in South Africa. Currently, the bio-component of the plastic is imported and combined locally by Safripol to produce the bio-PET. In this instance, demand for bio-based polymers was driven by Coca Cola, at an international level. Fast-moving consumer goods (FMCG) firms such as Unilever, have also invested into investigating the potential for bioplastics integration into production with several bio-plastics suppliers exploring new technologies and next-generation materials as part of a medium term (2015-2020) strategy (Unilever, 2015). These decisions will likely drive future demand for bio-based polymers. The initial demand is likely to be for drop-in bioplastics which can easily be substituted into traditional fossil-based polymer production before transitioning to complete bioplastics.

In addition to MNOs, large domestic firms are also increasing focus on sustainability in their product offerings. Woolworths launched its Green Bottle for milk products in 2016, through its Doing Good Business strategy. This involves importing sugarcane-derived polymers from Braskem in Brazil and Polyoak Packaging combines the polymers into the final packaging product domestically (SABC, 2016; Woolworths, n.d.). Growthpoint Properties has a strong sustainability focus through green building design principles on its property portfolio. The design and green star rating includes analysis of water, energy, transport, indoor environmental quality, materials, management, land use and ecology, emissions, and innovation (Growthpoint, n.d.). As part of the green focus, Growthpoint procures sustainable materials in the management of their buildings such as green cleaning equipment and supporting newer bio-based firms such as OptimusBio.

Collaborative efforts among stakeholders serve to further develop sustainability and circular solutions for the domestic plastics industry, increasing demand for

bioplastics. In January 2020, the South African Plastics Pact was launched which is a collaborative initiative that aims to stimulate industry led innovation, dialogue and collaboration, to create new business models and generate job opportunities to unlock barriers in moving towards the circular economy for plastics. This would lead to improved economic, environmental and societal outcomes overall (SA Plastics Pact, 2020). The initiative links to a larger Plastics Pact network where the approach has been used in other countries. In South Africa, members include retailers such as the Clicks Group, Danone, Massmart, and Pick 'n Pay; and manufacturing firms such as Nampak, Polyoak, Tiger Brands RCL Foods. Stakeholders have committed to pursuing joint targets and aiming for significant change by 2025. Targets for 2025 include improving the sustainability of packaging through redesign, innovation or alternative (re-use) delivery models, ensuring that all plastic packaging is reusable, recyclable or compostable, targeting 70% of packaging to be recycled, and targeting 30% recycled content in plastic packaging. This radical change in plastic production, use and disposal, will certainly drive demand forward for innovative solutions such as bioplastics.

While these developments in international and domestic markets are encouraging the growth of the domestic bioplastics value chain, policy tools that incentivize demand can encourage further activity and investments by consumers into substituting bioplastics for traditional plastics.

4. Supply-side Considerations

Managing the widespread use of plastics products is a pressing environmental issue, with important considerations for trade and industrial policy. Biomaterials – plastics and composite-like technologies derived from waste and plant matter – offer an opportunity to help reduce the environmental impact of traditional plastics, while safeguarding the economic contribution made by the plastics and chemicals industry. Because most biomaterials are produced using a set of platform chemicals and fibres, the industry can further reinforce the chemicals sector, and meet the changing demands of high-technology composites fabrication in the automotive and aerospace industries.

However, biomaterials are a category of goods, rather than a specific product. Individual biomaterials can differ markedly, in everything from material inputs, production process, and end-use. This diversity complicates efforts to construct a focused set of policy interventions, as individual biomaterials differ in their stage of technological development, the raw materials they use as feedstock, and the supporting industrial policies they require. Within this complex context, early investment in the technology and productive environment is crucial to develop the industry and to maintain pace with early adopters.

For South Africa, biomaterials offer an opportunity to leverage a strong technological base and a rich agricultural environment to position the country for the long-term development of the biomaterials sector. Biomaterial research efforts in South Africa are primarily driven by the Centre for Scientific and Industrial Research (CSIR) and a collection of university initiatives, with overarching support from the Department of Science and Innovation (DSI). The CSIR's efforts can broadly be grouped into two streams. The first stream is a Biocomposites Centre of Competence in Port Elizabeth, which aims to create biomaterials. The second stream includes biorefinery pilot projects, which aim to process various biomass sources to produce a spectrum of products. The private sector is also active in the biomaterials space, but less so on primary technology development or prototyping of new technologies.

Barriers to developing a competitive South African biomaterials industry, nevertheless, persist. As summarised in Table 2, three broad challenges along the biomaterials value chain can be identified: the creation of viable technology; the availability of affordable and reliable feedstocks; and the core productive competitiveness of biomaterial manufacturing.

Table 2: Barriers along the biomaterials value chain in South Africa. *(Source: Wood et al. 2019)*

Area	Barrier
Innovation environment	**Deficiencies in the broader innovation environment:** including poor commercialization and limited and/or unstable pool of funding.
	Selection of high potential biomaterials: extreme diversity of technology risks which make targeted support difficult.
	Institutional environment: innovation is almost entirely state-led and will require ongoing support from stakeholders.
	Importing available technology: lack of education initiatives and readiness support make it difficult to import existing production technology.
Feedstock	**Uncertainty on feedstock availability**: including a lack of systems to categorise and record available biomass.
	Accessing leading feedstocks: restricted by alternate uses for biomass (such as energy generation) and regulations.
	Developing new feedstocks: many of the most innovative crops are not yet at commercially viable

Area	Barrier
	levels of production.
	Waste management: poor waste collection and management systems limit the use of non-agriculture feedstocks.
Competitiveness	**Short-term efficiencies:** biomaterials are not competitive on a cost-basis against traditional plastics and are unlikely to be so until appropriate scale is achieved.
	Few gaps or product niches: outside of the green premium and some chemicals imbalances, the ubiquity of plastics means few productive niches exist.
	Enterprise development: high upfront costs and large-scale economies complicate efforts to diversify the sector.

In light of these challenges, an action plan and implementation strategy to enhance the development of the sector in South Africa was created in the previous phase of the biomaterials work. It aimed to both reinforce existing initiatives, and offer suggestions for new approaches, with the goal of deepening the value chain and removing barriers. It took a problem-solving approach, which involved identifying barriers and gaps in the market for biomaterials and identifying government policies that could fill these gaps.

Removing these barriers and improving general support for biomaterials in South Africa would need a multitude of small interventions, implemented by a wide range of departments and agencies working in collaboration towards reaching this goal. Six priority projects are highlighted first, to better enable focus in the implementation of the action plan and a number of supporting interventions are explored. Table 3 provides an overview of key interventions.

Implementing the action plan would require specific planning and coordination by the government agencies assigned to the various action items. To aid this planning process, a draft implementation plan was compiled. The plan should not be considered in any way final, but rather as a guideline to the sequencing and linkages between the various components.

The implementation plan is divided in two ways. First is a set of workstreams, which target key gaps according to the barriers identified (feedstock, innovation, and competitiveness) and the administrative requirements that underpin them, as reflected in Table 2. Second, while each of the four workstreams targets a specific set of problems, the implementation of the action items is linked, particularly via a set of institutional arrangements that oversee the action plan. This includes four new structures – a liaison committee in the Department of Trade and Industry and Competition (**the dtic**), an industry partnership team developed by **the dtic** and the Department of Agriculture, Land Reform and Rural Development (DALRRD), a feedstock matching team in the National Cleaner Production Centre (NCPC), and a biomaterials expert committee overseen by Department of Science and Innovation (DSI). The remaining initiatives are over- seen by existing programmes, namely the Technology Innovation Agency (TIA) and the CSIR's Biorefinery Development Facility.

Table 3: Summary of key interventions. *(Source: Wood et al. 2019)*

Intervention	Lead agency	Support	Timeframe	Cost range	Workstream
Priority 1: The creation of a matching programme for feedstock	NCPC	GreenCape, **the dtic**	44 months	Mid	Feedstock
Priority 2: Bridge funding for biomaterials research	TIA	DSI, IDC	51 months	High	Innovation
Priority 3: Identification of priority clusters of platform biochemicals	**the dtic**	DSI	21 months	Low	Administration
Priority 4: Development of a biomaterials centre of excellence	CSIR	DSI, universities	42 months	High	Innovation
Priority 5: Reinforcing support to pilot biorefineries	CSIR	DSI, **the dtic**	60 months	High	Competitiveness
Priority 6: Development of a task team to lead on industry partnerships	**the dtic**	CSIR, IDC	55 months	Low	Competitiveness
Secondary 1: Promote training programmes at universities and colleges	DHET	Universities	27 months	Low	Innovation
Secondary 2: Reinforcing existing research infrastructure	All	All	n/a	n/a	Innovation
Secondary 3: Awareness programmes and promoting the green premium	DFFE	**the dtic**, DALRRD	12 months	Mid	Competitiveness
Secondary 4: Creating new standards for biomaterials and feedstock	DALRRD	DFFE, SABS	55 months	Mid	Feedstock
Secondary 5: Adapting existing standards for biomaterials	SABS	**the dtic**	12 months	Low	Competitiveness
Secondary 6: Facilitating cross-border movement of feedstock	**the dtic**	SARS, DALRRD	54 months	Low	Competitiveness
Secondary 7: Facilitate engagements with existing industrial policy	**the dtic**	Investment agencies	33 months	Variable	Competitiveness
Secondary 8: Further research and ongoing support	CSIR	PAGE, TIPS	n/a	Variable	Administration

These institutions oversee six branches of the implementation plan and are each assigned a set of milestones that should be achieved sequentially:

1) a **dtic** biomaterials liaison group, in charge of three initiatives, namely the integration into existing industrial policy, adapting standards for biomaterials, and creating new standards for feedstock and unique materials,
2) an industry partnership programme, led by **the dtic** and DALRRD, to partner with end-users of bio-materials and match them with local production capacity,
3) a feedstock programme, managed by the NCPC, to match the demand and supply of feedstock in South Africa and ultimately the region,
4) a biomaterials expert group, composed of universities, the CSIR and DSI, to provide expert technical guidance and lead on action items that require more technical support and develop a centre of excellence,
5) the further development of biorefineries under the leadership of the CSIR and DSI, and
6) the creation of a bridge funding facility under the auspices of TIA.

Box 2: Company initiatives related to biomaterial production in South Africa.

Biomaterials production is still at an early stage in South Africa with a limited number of companies engaging in the space. Data on market size and the distribution of volumes by product and sector are not available. Despite this, there are a few firms that are trying to increase products and volumes of bio-based products. The main firms involved in the production of biomaterials and bio-based products are outlined below. While biomaterials production is still at an early stage in South Africa, several large and well-networked firms are involved in the production space. Given that these firms are important suppliers to downstream industries, they possess key leverage to influence the input choices of downstream markets and orient products towards greater biomaterials and bioplastic content.

Sappi Global, through the Sappi Biotech Unit, is involved in the development and commercialization of bio-based products. Given its access to forestry feedstocks (eucalyptus and pine in South Africa), the biomaterials are wood based. Specifically, the bio-based products that Sappi are involved in are nanocellulose, lignin, Sappi Symbio (plastics and composites), and hemicellulose sugars (Sappi, n.d.). In South Africa, Sappi key initiatives in biomaterials include:

The production of lignin from the Tugela Mill in South Africa since 2012, with a view to expand the lignin product range applications. These products can be used in biodegradable plastic products, in the production of cement, and in water treatment among others (Sappi, n.d.).

Sappi has commissioned a sugar extraction demonstration plant at Ngodwana Mill in Mpumalanga. The process will extract hemicellulose sugars and lignin from Sappi's existing pulp. The key processes will include beneficiation to higher value organic acids, glycols and sugar alcohols which are utilized in numerous consumer products.

Sugar producers in South Africa are also seeking diversification options in their industry. Bagasse is produced as a traditional waste product and is currently used to produce electricity through cogeneration in South African mills. When sugar mills produce ethanol, they can then increase scale and scope to produce biorefinery products that can feed into chemicals value chains. Mills in South Africa have already produced some inputs, such as fertilizer inputs, potable alcohol and industrial alcohols, however the scope for expansion is much larger. Sugarcane-derived ethanol is a suitable feedstock for the production of ethylene and the resulting bio-PE, specifically high-density PE (HDPE), is identical to that produced from petrochemicals. This means current downstream production facilities could use it as a replacement to petroleum-derived HDPE. Another potential bio-feedstock is polylactic acid (PLA), a biodegradable polymer produced from lactic acid obtained through fermentation of carbohydrates such as sucrose. PLA is a new product in the South African market and is mainly used to produce packaging items and bottles. The Sugar Milling Research Institute (SMRI) has undertaken research into the most economically attractive products or processes for bio-refining, to identify them at a preliminary design stage. Given the demand for plastic polymers in Africa and globally, the potential exists for export as well.

Safripol produces key input polymers into the downstream domestic plastic manufacturing market, competing with Sasol to produce polymers. In addition, Safripol is the only producer of traditional fossil fuel PE in the country. Given the changing landscape and the move away from fossil fuels, Safripol has recently embarked on a strategic redirection towards increased sustainability in production. Currently, Safripol is the only producer of Bio-PET in the country, which feeds into downstream products, such as the Valpre Plant Bottle which contains 30% Bio-PET. The input polymer is currently imported into the country, however Safripol is investigating domestic production at its manufacturing facilities. Bio-PET is seen as an easy transition as it forms part of "drop-in" bioplastics which can be produced without technical disruption to existing infrastructure, polymerization processes and value chains. To extend sustainable production, Safripol is further investigating the production of PE (Bio-PE) from sugar cane, given the trade deficit in ethyhlene in South Africa.

LignoTech is a joint venture between Sappi and Borregaard AS of Norway, which has a lignin extraction plant in KwaZulu-Natal that was opened in 1999. LignoTech beneficiates the effluent stream from Sappi's Saiccor mill, to produce binding and dispersing agents are used in agricultural and industrial applications. The plant has been regarded as a success, with expansions in 2003, 2008 and in 2017. The products are sold in the domestic market as well as exported to countries in Africa, Asia-Pacific, the Middle East, and South America (Forestry, 2019).

OptimusBio manufactures biodegradable and biologically active products for water treatment and industrial markets. The feedstock is based on indigenous bacteria. OptimusBio was formed as a business from the CSIR, and the technology is licensed by the CSIR. The products have applications in personal care, domestic cleaning, automotives and water and sanitation.

KwaZulu-Natal-based agro-processing company RCL foods is involved in the production of a succinate monomer.

The community of firms working directly on biomaterials is small. A far larger and more developed set of firms operate in composites, plastics, and chemicals. Biomaterial development would certainly benefit from their active involvement in the industry. Sasol is the key player. While experts report Sasol is undertaking work on biomaterials, little information on these projects is publicly available. Sasol does have some experience in biomaterials, through a distribution agreement between the company's Chinese joint venture Wesco, and Australian bioplastics firm Cardia Bioplastics, but its biomaterials operation otherwise remains confidential.

5. Policy Tools for Increasing Demand

Based on the available evidence and review of the literature, policy measures which intend to stimulate demand for sustainable product substitutes such as bioplastics comprise five key options:

- plastic bans and quotas,
- taxes, levies and fees,
- standards and labels,
- green public procurement, and
- raising social awareness.

These policy measures are not mutually exclusive and typically some form of combination is implemented by countries. For each of these demand-side policy tools, the following factors are analyzed to draw out the policy-relevant characteristics: the mechanism by which demand is increased for bioplastics, variations in how the policy is instituted, and the country approaches.

5.1 Bans and quotas on single-use plastics

A plastic ban seeks to make traditional plastics derived from fossil fuels illegal with the aim of minimizing negative environmental impact of these materials. A quota sets the maximum level of production for plastic products. Both policy mechanisms can serve to increase demand for bioplastics as consumers would need to switch to alternative products.

Globally, bans on plastics have increased as plastic waste accumulates in landfills, clogs waterways, pollutes rivers and oceans, and endangers marine life. Since the first regulatory measures were targeted at plastic bags in the early 2000s, approximately 127 countries have introduced some form of legal limit or regulation related to plastic production and consumption (World Resources Institute, 2019). Of these countries, 91 have bans and/or quotas related to plastic bags and 27 related to single-use plastics. Plastic quotas grew significantly between the period of 2014 - 2019, where over 60 countries introduced a ban or restriction on plastics and more countries are committing to banning all single-use plastics. Africa stands out as the continent with the largest number of countries that have instituted a total ban on the production and use of plastic bags. In 2019, the European Commission released a circular for banning of selected single-use plastics, by 2021. Canada has committed to banning all “harmful” plastics by 2021. Taiwan, China and South Korea have recently introduced policies that are aimed at prohibiting all plastic bags and single-use products by 2030.

5.1.1 Variations and components

There is considerable variability in how countries institute bans. Bans can be based on the physical properties of the plastic and consider the plastic-type, specification, and combination. Bans can also be instituted at various entry points in the value chain and can apply to the manufacturing, sale, retail distribution and/or import stages (Conservation Law Foundation, 2019). Further, limitations may be placed on how much traditional plastics can be produced in an economy where production levels are regulated. There is also variation in how countries set policies that seek to limit traditional plastic use. The most common policies target the banning or limitation of plastic bags and single-use plastics.

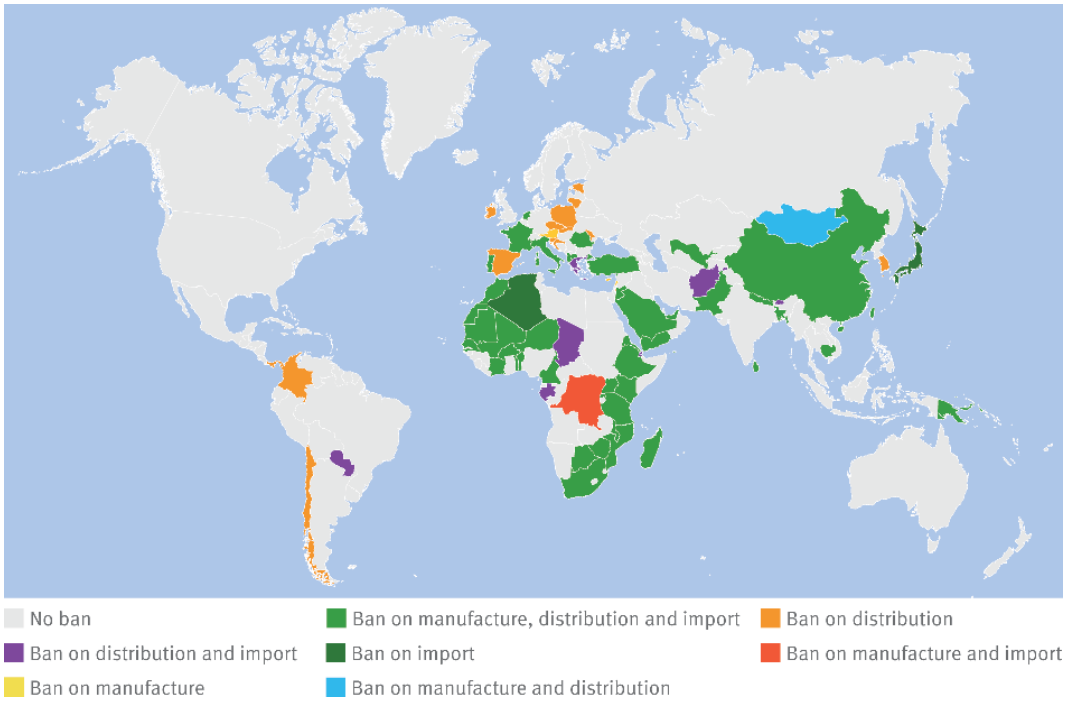

Figure 8: Global bans on plastic bags.
(Source: United Nations Environment Programme, 2018a)

In 2018, 91 countries had some form of regulation on the market entry of plastic bags from import to retail distribution and production (United Nations Environment Programme, 2018a). South Africa has a partial ban on the manufacture, import and free distribution of lightweight plastic bags as per the 2003 plastic bag regulations (DFFE, 2003). Tanzania introduced its ban on plastic bags in June 2019, and New Zealand and Panama have instituted policies to ban single-use plastic bags as of July 2019.

Bans can vary along the following criteria (United Nations Environment Programme, 2018a, 2018b)

- Juridical level of implementation: This refers to the geographical scope of the ban. Bans can be national in scope, or they can be instituted at a disaggregated level, such as a ban for a specific region or municipality of a country. Regional and municipal bans, for example, are a feature in the United States of America and India.
- The extent of the bans: Full bans or partial bans. Full bans are the prohibition of sale, manufacture or import of all single-use plastics. Taiwan and France have committed to implementing full bans on plastics through a phased-out approach. Taiwan intends to be plastic-free by 2030 and France by 2040. Partial bans are bans which only apply to certain products such as plastic bags, utensils, cups or straws and polystyrene products.
- Product characteristics: Bans or restrictions on the size, thickness, biodegradability, or recycled content of plastics. Globally, most common plastic bag bans aim to stop the use of bags with a thickness of less than 0.05 millimetres. Italy, for example, requires that plastic bags intended to carry food products have at least 30% recycled plastics.
- Retail distribution bans: A full ban on retail distribution would apply to all retail distributors while a partial ban would apply to a particular segment of the retail market. The most common segment being targeted are supermarkets and grocery stores. China introduced a ban on retail distribution of plastic bags which was only applicable to large grocery stores and convenience store franchises.
- Production/manufacturing limits: These bans prevent or limit the market entry of plastics.

Production limits are the least commonly used mechanism for plastics. Cape Verde instituted an explicit production limit for example, first reducing production at 60% in 2015 and moving towards a 100% reduction by 1 July 2016.

However, a typical feature of policies includes exemptions where even countries with the strictest bans on plastic have contained exemptions. The most common exemptions include handling and transport of perishable and fresh food items, plastics used for personal hygiene, plastics used for scientific or medical research, agricultural use, national security and garbage or waste storage and disposal (United Nations Environment Programme, 2018a; World Resources Institute, 2019).

Plastic bag exemptions are based on the functionality of plastic and the availability of suitable substitutes. For instance, for fresh food packaging, plastic ensures food safety and assists in avoiding cross-contamination. Its lightweight also means that it is easier to store and transport. In the medical sector, plastics are important for safety, hygiene, and infection control. Alternatives such as glass have been considered, however, they introduce challenges in transport, cleaning, and availability (Harvey, 2018).

Bioplastics can be suitable as an alternative to the uses where plastic exceptions apply, however this is assessed on a case-by-case basis. For example, polystyrene which is a cheap plastic is valued in packaging as it is inert, cost-effective, long-lasting, energy absorbing, and food-preserving, among other advantages (Barrett, 2018b). Here, PLA has the potential to substitute to a certain extent, although cost dynamics render the material more costly than polystyrene.

Bio-polystyrene, produced through drop-in plastic production also has the potential to be a substitute, however production does not occur on a large global scale currently. Waste and refuse bags also typically fall under exemptions and here too, bioplastics can play a role. Several bio-based refuse bags are available in the EU, which draw on bio-based production routes and use renewable agricultural feedstock (Barrett, 2020).

5.1.2 *Effectiveness of variations*

Globally, bans are widespread and the implications of bans in terms of their environmental and socio-economic impacts vary depending on the type of ban implemented.

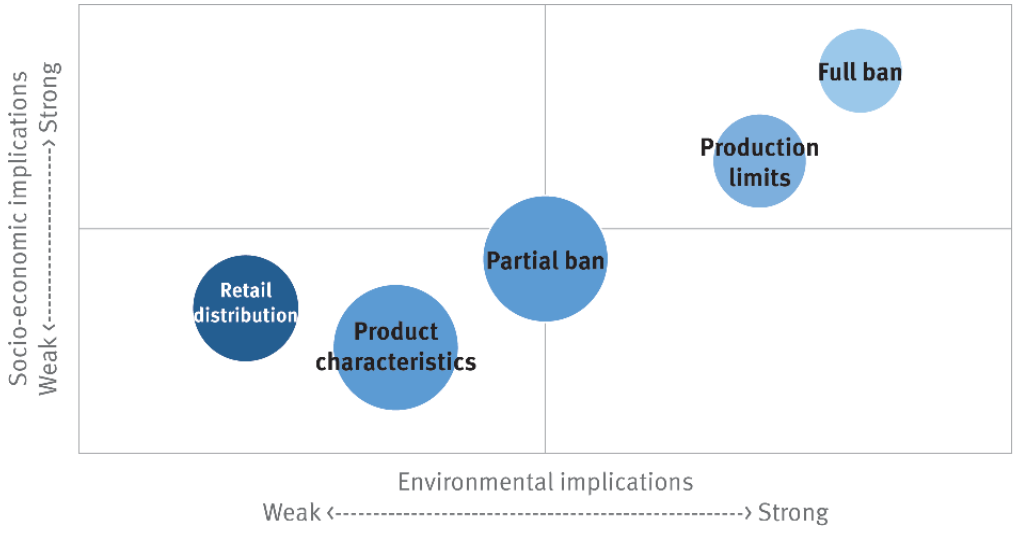

Figure 9: Comparison of ban/quota policy variations.
(NB: The size of the bubble indicates the relative prevalence of usage)

Full bans and production limits on all plastics yield the strongest environmental impacts as they directly prevent or substantially limit the market entry of plastics (United Nations Environment Programme, 2018b). Production bans can still allow products into the market, but their environmental impact depends on the volume of the limits. The higher the volume of limit, the higher the environmental effect.

Full bans and production limits have high socio-economic implications; they can result in the closure of plastic plants and a loss of jobs and revenue for producers and governments (United Nations Environment Programme, 2018b). Full bans and product limitations can also have adverse economic implications for sectors which use plastics in their production processes.

Partial bans and bans based on product characteristics target specific producers and products instead of the entire plastics industry. The socio-economic impact is not as high as that of production limits and full bans, although the environmental implications are weaker as more products can enter the market (United Nations Environment Programme, 2018b).

Retail distribution bans have relatively weaker socio-economic impacts as the scope of the ban is limited only to free retail distribution. The implications largely depend on the market segment in which the ban applies and how the ban is implemented. If the ban is phased in and retailers are given sufficient time to adjust to the ban, the socio-economic impact may not be as harmful. The environmental implications are relatively weaker than the other variants as more plastics can enter the market through other distribution points (United Nations Environment Programme, 2018b).

5.1.3 Country examples

There are multiple dimensions which determine the approach a country follows when implementing a plastic ban, and a mix of different measures is typical. These dimensions generally cover the extent of enforcement, market entry points and product scope. As such, enforcement refers to the ability of the government to ensure that it can collect revenue and set and implement penalties for non-compliance. This can vary from thorough enforcement with strict penalties to weak enforcement or limited or no penalties. Enforcement is not only dependent on a given country's capacity to deter the use and production of plastic but also on the availability of product alternatives or technology to produce alternatives (Principles for Responsible Investment, 2019). Market entry point refers to the point of implementation in the value chain, and whether the ban applies to manufacturers, retail distributions, importers, or consumers. Product scope consists of the extent of the ban whether is a full ban on all plastics or a partial ban on specific products or material properties. Country approaches can be categorized as described in Table 4.

Table 4: Approaches to bans and restrictions on plastics.

Strong approach	Strong to moderate approach	Moderate to weak approach
Thorough enforcement with strict penalties, sufficient market entry points and broad product scope.	Thorough enforcement with penalties, a few market entry points and broad product scope.	Enforcement with limited or no penalties, one or two market entry points, and limited product scope.

Box 3: Minimum bio-based content for single-use plastic bags in France.

In 2015, a French decree aimed to promote bioplastics to comply with the 2012 European Bioeconomy Strategy of reducing greenhouse gas (GHG) emissions and dependence on non-renewable and unsustainable resources (Zhu et al., 2019). The decree applied to single-use bags such as fruit and vegetable bags that were below a thickness of 50 microns. The bags were required to meet the requirements of the French standard for home composting and feature a bio-based content of at least 30%.

The minimum content % has been gradually increased over time. It started from the minimum of 30% bio-based content in the single-use plastic bags in 2017, to 40% in 2018 and 50% in 2020. This mandate is finally planned to reach 60% after 2025. Bioplastics materials were already available on the French market prior to the decree and bioplastics manufacturers were anticipating the decree. The decree also enabled an import substitution strategy as 90% of fruit and vegetable bags are currently being imported. The law made France one of the first European countries to enact specific bioplastics legislation.

5.1.3.1 Strong approach: Rwanda and California State

Although Rwanda's ban is only applicable to plastic bags, Rwanda has taken a strong approach to the ban as evidenced by its wide public awareness efforts, consultation, and thorough enforcement with strict penalties. In 2008, Rwanda instituted a national-wide partial ban on non-biodegradable plastic bags. The Rwandan government banned the manufacturing, use, sale, and importation of all plastic bags. The ban was introduced along with a tax incentive for companies willing to invest in plastic recycling equipment or the manufacturing of environmentally friendly bags (Africa Check, 2018). Over time, Rwanda has increased enforcement efforts with stricter laws, with offenders facing high fines and/or jail time of up to one year, along with public shaming for transgressions. Travelers to Rwanda are subject to searches at the borders, and businesses which flouted the law were raided. The strict enforcement of the law and Rwanda's clean-up campaign called Umuganda has had positive impacts on the environment and visible reduction in pollution. UN-Habitat named Kigali the cleanest city in Africa in 2008 and numerous international environmental agencies have praised the bans for helping to combat the plastic crisis in the country (Freytas-Tamura, 2017; Fullerton, 2019). The decline in plastic use and pollution is notable in Kigali as the city boasts that it has zero plastic waste in its streets.

California's approach has also been strict and is characterized as one of broad product scope and strict enforcement, enforced thoroughly through its market entry points (Senate, 2015). California was the first state in the United States to enact a single-use plastic bag ban on specific plastics. California instituted a state-wide plastic bag ban in 2016. At the time, a state-wide fee of US$ 0.10 was in place for thin plastic bags. The ban applies to retail stores which provide customers with single-use plastic bags of a certain characteristic. In 2019, the state further prohibited the distribution of plastic straws in dine-in restaurants unless customers requested it. This exempted fast-food restaurants, coffee shops and restaurants serving takeout. Violation of the law would cost restaurants US$ 25 a day (Brueck, 2018; Gardiner, 2019). The bans

and prohibitions were met with intense lobbying from industry.

The plastic bag ban was delayed for almost 2 years however voters upheld the law. Although plastic bags and straws are still available in the market, the bans and prohibitions have significantly reduced plastic consumption. California went from consuming 30 billion plastic bags in 2005 to 2 billion plastic bags in 2016. Participating restaurants indicated that 50 – 80% of customers refused straws when offered (Gardiner, 2019; Piper, 2019). California's bans were successful due to the communication behind the bills. The state emphasized the environmental impact of plastic waste, appealing to the environmentally conscious Californians. The ban has also been successful in propelling a national movement to reduce plastic consumption, and seven other states have enacted variations of legal limits of single-use plastic (Gardiner, 2019; United Nations Environment Programme, 2018a).

5.1.3.2 Moderate to strong: China and Kenya

China's approach can be categorized as moderate to strong, due to a thorough enforcement, broad product scope but only one market entry point. The Chinese ban is implemented through retail supermarkets and convenience store franchises. In 2008, the Chinese government responded to widespread plastic pollution by banning non-biodegradable plastic bags in grocery stores and shops around the country. Retailers faced strict fines of RMB 10 000 (approximately US$ 1 400) for illegal plastic distribution and customers who bought bags faced fines of up to RMB 5 000 (United Nations Environment Programme, 2018a). From 2008 to 2018, the use and distribution of plastic bags have decreased by 60% in convenience stores and 80% in supermarkets. In smaller and rural retailers as well as food markets, the policy has not been as effectively enforced, and plastic use is still common. In response to inconsistent enforcement, regulators have been sent to grocery stores around the country to ensure compliance (Block, 2009; Buckley, 2020). Since then, China has also introduced a policy to ban most single-use plastic products by 2022, except for the use of reusable, thicker bags, or other plastic bags through to 2025. The policy is set to ban or restrict the production, sale, and use of disposable plastic products across the country via three stages over a period of five years. The first phase targeted the major cities like Shanghai and Beijing and, the second and third stages planned for smaller cities and towns and villages (Buckley, 2020).

Kenya's approach can be described as moderate to strong, as it has thorough enforcement with strict penalties, several market entry points but a limited product scope. In 2017, Kenya introduced the strictest plastic ban in the world. The ban was on the manufacturing, import, distribution, and use of thin plastic bags. Violators of the ban could face a US$ 38 000 fine and up to four years in prison (United Nations Environment Programme, 2020). Kenya's ban faced challenges upon introduction, where the Plastic Manufacturers Association unsuccessfully took the government to court. As a compromise, the Kenyan government made an exception for plastic wraps for fresh food and meat (Toma-Schade, 2018).

A key pillar to Kenya's success stems from the close relationship between the police force and the Environmental Management Authority to enforce the rules. Since its introduction, 100 manufacturers and sellers have been arrested and fined. The government reports that 80% of its population has stopped using plastic carrier bags. The reduction in plastic consumption is most notable in cattle farming as farmers are finding fewer plastic bags in cows' stomachs and plastic waste is notably less visible (Toma-Schade, 2018; United Nations Environment Programme, 2020). Kenya has not completely eradicated plastic bags, and plastic bags are still common in slums and rural areas as plastic bags are still smuggled illegally from neighboring countries.

5.1.3.3 Moderate to weak: Bangladesh and Cameroon

Bangladesh's approach, while ambitious in its concept, can be categorized as moderate to weak. The approach is characterized by a few market entry points, broad product scope but limited enforcement (although strict penalties exist). In 2002, Bangladesh introduced a ban on polythene plastic bags. There was an initial positive response, however, plastic bags became freely available after some years due to a lack of enforcement. In 2010, the government of Bangladesh introduced the Mandatory Jute Packaging Act, which provides for a penalty of maximum 1-year imprisonment or fine of BDT 50 000 (approximately US$ 590) or both for using any non–biodegradable synthetics for packaging. A lack of enforcement has seen traders continue to use plastic bags (Ruma, 2020; United Nations Environment Programme, 2018b).

Cameroon's plastic ban can also be categorized as moderate to soft due to its limited market entry points (the ban is only applicable to retail stores), weak enforcement and limited product scope. Cameroon introduced a ban on plastic bags in 2014, specifically on the import, production and sale of non-biodegradable plastic bags which are less than 0.06 millimetres thick. The government has been unable to implement the ban and plastic consumption has largely remained the same (Nakinti, 2015). The state has been criticized as failing to promote sustainable alternatives and financial assistance to ease the transition (Nakinti, 2015).

5.2 Taxes or Levies on Plastics

Taxes or fees on fossil fuel-based products can act as a mechanism to foster demand for bioplastics by increasing the cost of consumption of conventional plastics, thereby incentivizing consumers to switch to alternatives, such as bioplastics. The taxes and fees are instituted to have a dissuasive effect and change the behaviour of consumers and businesses by reflecting the full costs of plastic production and consumption. The higher price can reduce the demand for plastic products and can stimulate demand for alternative products to traditional plastic (United Nations Environment Programme, 2018b).

Taxes and fees can take the form of voluntary or involuntary charges levied on consumers and business for the sale, import, production and use of these products. The tax or fees are charged due to the negative impact these products have on the environment and society and force products to capture the true costs of the product, accounting for environmental externalities (United Nations Environment Programme, 2018a).

Taxes on fossil fuel-based products can be taxes which target feedstocks and emissions directly such as a carbon tax, coal tax and oil tax, or taxes which are levied on non-combustible fossil fuel-derived products such as plastic (Convery et al., 2007). From a product tax perspective, taxes on plastics are the most common form of fossil fuel-based product tax. Motivations for taxes are based on a variety of reasons including pollution reduction and to meet climate change goals.

Taxes or fees on plastic have increased since the early 2000s (see Figure 10). To date, 27 countries have taxes on manufacturing and import of plastic bags, 30 countries charge consumer fees for plastic bags at the national level, and 29 countries have taxes on single-use plastic products (United Nations Environment Programme, 2018a). Beyond this, other countries are progressively introducing taxes on certain plastic segments such as single-use plastic. In 2018, the United Kingdom announced its intention to institute a plastic packaging tax for packaging with less than 30% of recycled plastic which will take effect in 2022 (HMRC, 2020). In 2019, France announced its plans to introduce a tax on non-recycled plastic, South Africa announced it is investigating opportunities to tax single-use plastic (Donnely, 2019; Lintott, 2019; Walsh, 2018).

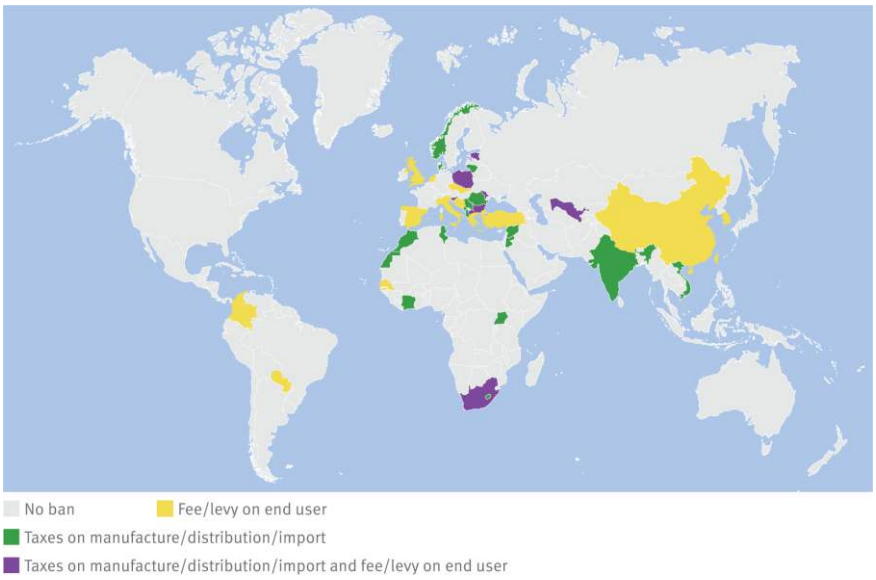

Figure 10: Countries with taxes or fees to regulate the manufacture, distribution/use or trade of plastic bags.

(Source: United Nations Environment Programme, 2018a)

5.2.1 Variations and components

There is variation in the regulatory approaches countries institute to regulate traditional plastic use, with some countries opting for taxes while others have fees. With a tax, the rate is set and collection by authorities is prescribed through the law. Countries with consumer fees typically develop regulations which prohibit free distribution of plastic, combined with legislation which sets a price per plastic product, or the price can be set by retailers.

The variations to taxes and fees centre on what are taxed or charged, who is liable to pay the tax or fee, as well as the market entry points.

- Product characteristics: Taxes or fees can be instituted based on product characteristics such as thickness, size, recycled content, biodegradability, bio-based content, and specific materials such as polystyrene. The most common tax on plastic is on lightweight non-biodegradable carrier bags. For example, in Latvia, the law provides for a 1.5 euro/kg tax specifically on plastic bags with a thickness of more than 50 microns and weight of more than 3 grams.
- The judicial level of implementation: Countries differ in the geographic scope the tax or fee applies to. Most countries with taxes or fees apply the mechanism, nationally. However, in certain countries, such as the United States, Brazil and India, subnational and local level taxes and fees are a feature, where states have the autonomy to set regulation.
- Consumer group: Depending on where the change in consumption behaviour is required, countries vary in the stage of the value chain where the tax or fee is implemented. In Ireland, the plastic bag tax is charged directly to consumers at the point of sale at shops, supermarkets, or other sales outlets. In other countries, the taxes and fees are levied at the manufacturing stage, where manufacturers pay the tax or fee as is the case for the environmental levy in South Africa (SARS, n.d.). In some cases, the tax or fee is instituted at the wholesale level, where retailers incur the cost and are given the flexibility as to whether they pass on the costs to final consumers. In Denmark, the plastic tax is paid by the retailers who in turn pass the tax to consumers by charging them for plastic bags.

5.2.2 *Effectiveness of taxes*

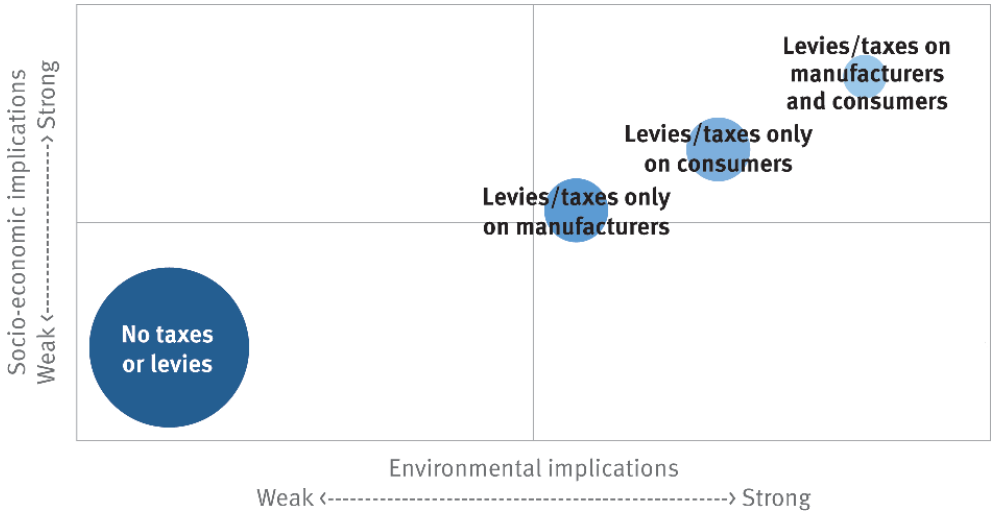

Figure 11: Comparison of tax/levy policy options.
(NB: The size of the bubble indicates the prevalence of usage)

Taxes or fees on plastic similar to other excise taxes are primarily instituted to change behaviour. The effectiveness of these taxes or fees is largely dependent on the price. The price needs to be high enough to have a dissuasive effect and influence consumer behaviour. Estimating the willingness to pay of consumers and retailers can be used to ensure that the tax or fee is high enough to change behaviour. The Irish tax is considered a success as it has set the tax at more than six times consumers' willingness to pay.

Taxes payable by retailers and producers are most effective when the tax is transferred to the end consumer. Taxes which are not transferred do not have an impact on demand or plastic consumption. The effectiveness of taxes or fees on plastics is also dependent on the stakeholder acceptability. Taxes are not popular and can have political implications. Governments need to ensure they have social and industry buy-in when instituting a tax. This will ensure that there is no major resistance to the tax and that opposing political parties do not undo the tax for votes or to appease constituents. In Ireland, the tax has gained such a positive response from consumers that removing it would be politically damaging.

5.2.3 *Country examples*

There are multiple dimensions which determine the approach a country may follow, when implementing a tax or fee policy, and these dimensions are similar to the variants seen with bans and quotas. These dimensions include the price level, the market-entry point at which the tax or fee is charged and the level of enforcement. The price is the amount of the levy relative to consumers' willingness to pay.

Table 5: Approaches to taxes or fees on plastics.

Strong approach	Strong to moderate approach	Moderate to weak approach
Tax rate high enough to influence consumer behaviours, sufficient market entry points which ensure effective collection of revenue and the thorough enforcement of the policy.	Tax rate sufficient to deter consumption that is not informed by adequate data, with single entry points, and inconsistent enforcement.	Tax rate, which is at or below consumer willingness to pay, insufficient market entry points and adequate to limited enforcement.

Box 4: Increasing demand for bioplastics in Germany.

In Germany, the market for bio-based plastics was historically supported through the German Packaging Ordinance (Imbert et al., 2017). Until 2012, the ordinance included exemptions for certified biodegradable packaging from the fees and minimum recycling quotas under the Germany's mandatory recycling system, and an exemption from mandatory deposits for biodegradable, single-use beverage containers with a minimum share of a 75% composition of bio-based materials.

Just before these exemptions expired (in 2012), an amendment of the Biowaste Ordinance (BioAbf), which regulates the recycling of biowaste, implemented a tightened regulatory framework for the inclusion of biodegradable plastics in composting schemes, which has since been limited to compostable biowaste bags. Further, market support through legislation was provided in 2015 via the Closed Cycle Management Act, which mandates municipalities to collect biowaste separately.

5.1.3.4 Strong approach: Ireland

The process followed in Ireland with respect to taxes illustrates an effective example of policy design and implementation. In 2002, the government introduced a tax on plastic bags at point of sale for consumers. The tax was set to trigger behaviour change in consumers and promote the use of reusable shopping bags. The tax applied to carrier bags and not to the plastic used to contain fresh produce or plastics for hygiene purposes. Key to the Irish approach was the extensive consultation with the relevant stakeholders on the design and implementation of the policy and an information campaign which provided information on the allocation of the tax revenue (Convery et al., 2007). These factors secured the buy-in of stakeholders and the public from an early point. Within a year of the introduction of the tax, plastic use declined by 90% and per capita consumption fell from 328 plastic bags per annum to 21 plastic bags per annum. Another crucial element of success was the approach taken to the determination of the tax rate. Surveys were conducted by the state to determine consumer's willingness to pay taxes on plastic bags. Based on these surveys, the plastic tax was set sufficiently high to adequately deter consumption. The tax rate was set at EUR 0.15, which was six times the willingness to pay of consumers in 2002, and the plastic tax increased to EUR 0.22 in 2007. Thorough enforcement of the tax has sustained the beneficial outcomes on plastic consumption (Curtin, 2018; United Nations Environment Programme, 2018b).

5.1.3.5 Strong approach: Wales

The Welsh plastic charge is also an example of effective policy implementation. In 2011, Wales became the first country in the United Kingdom to introduce a 0.05 pound plastic levy on single use carrier bags. Prior to the introduction of the levy, Welsh supermarkets entered into voluntary agreements to reduce the amount of plastic bags given to consumers, through promoting reusable bags in the "Bags for life" (BfL) campaign. In 2016, the Welsh government published the Post-implementation Review, a study of the impact of the plastic bag charge between 2011 and 2014. The study revealed that single use carrier bag consumption declined by 71%. The plastic charge also had a strong impact on consumer behaviour, 50% of consumers purchased less single use carrier bags, 57% of consumers cited the cost as a reason for reducing their plastic consumption while 35.4% said they purchased fewer plastic bags for environmental reasons (Smith et al., 2020).

A 2019 study published by the Welsh government revealed that the number of plastic bags consumed has remained steady after the initial decline between 2011 and 2014, with approximately 94.1 million carrier bags issued in 2018. This is partly due to the low cost of BfL which lead to consumers using the reusable bags as throw-away bags. The substitution effects have had significant adverse environmental effects as these bags are made from heavier materials. The 2019 study also revealed that consumers were supportive of an increase in the plastic charge which has not changed since 2011, consumers surveyed stated that they support a 0.20 to 0.25 pound increase in the charge. In November 2019, the National Assembly for Wales announced a consultation on its Circular Economy Strategy where the carrier bag charge will be reviewed and proposals for the phase out of plastic carrier bags will be considered (Winning Moves, and Icaro Consulting, 2019).

5.1.3.6 Moderate to weak approach: Portugal and Botswana

Portugal's policy is an example of a successful approach, however, challenges in the design and implementation resulted in unintended stakeholder responses, thus rendering the policy less than fully desirable in its outcomes. In 2015, Portugal introduced a tax on thin plastic bags which were previously provided for free at supermarkets. Portugal had the worst plastic consumption rate in Europe at the time where plastic bag consumption was 466 bags per person per year, which was more than double the average European rate of 198 bags per person per year (Martinho et al., 2017). The tax rate was set at EUR 0.10 which was above consumers' willingness to pay, and similar to the tax rates across Europe. Portugal's tax achieved its intended results to reduce the consumption of thin plastic bags. Consumption of these bags declined by 74%, and consumption of alternative reusable plastic increased by 61%.

While this was viewed as a success, certain stakeholder responses resulted in maladaptive and unintended responses. Firstly, Portugal has a culture of using plastic bags for refuse purposes after consumption. Given the consumer switch to reusable plastic bags consumers then increased their demand for refuse bags given that plastic bags were reused for shopping purposes. The result was a considerable rise in refuse bag demand, potentially having negative environmental impacts. Secondly, the tax was only applicable to plastic suppliers of thin plastic (15-50 microns), and supermarkets shifted to procuring and selling thicker plastic bags which were not subject to the levy to consumers (Martinho et al., 2017; United Nations Environment Programme, 2018a).

Botswana's plastic tax is an example of an effective policy design with limited enforcement and implementation. In 2007, Botswana introduced tax legislation to curb the demand and use of plastic bags, where the plastic tax allowed retailers to set the price for plastic bags. The price per bag ranged from 20 Thebe to 35 Thebe. The introduction of the plastic tax resulted in an initial decline in plastic bag consumption, and during the first 18 months of the tax, consumption fell by 50%. The success was due to the high prices for plastic bags charged by retailers. High income retailers experienced the steepest decline in

plastic use with a 64% decline in demand, upper middle-income and low-income retailers declined by 56% and 58% respectively. During the 18-month period plastic prices increased by 31% (Dikgang and Visser, 2012). The tax intended to address the environmental issues related to plastic consumption, discourage the use of plastic and fund refuse collection services.

When the tax was introduced, the collection logistics were not properly worked out as a result the tax has never been collected from retailers. The revenue generated from the levy is part of retailer's profits. The lack of mechanisms or willingness to collect has resulted in confusion between consumers and within the government regarding the tax.

A decade after the introduction of the tax a 2018 study by Mogomotsi et al., evaluated the effectiveness of the levy on consumers in Maun, the fifth largest town in Botswana. They found that the tax achieved short-term success, over time plastic consumption increases as consumers got used to paying the tax. 87% of their survey respondents reported that tax had not affected their consumption of plastic bags, which is a similar dynamic noted in South Africa. The study also found that the levy limited the incentives of retailers to seek environmentally friendly alternatives.

A 2017 study by Madigele and Mogomotsi found that the average price paid for plastic bags was too low. In their survey, half of the respondents reported that they would continue to pay the tax if it increased by 50%. This study also found that the tax failed to maintain public support, as consumers were not pleased that the tax money was not used for its intended purpose to fund waste management, environmental and wildlife efforts by the government. (Madigele and Mogomotsi, 2017).

5.3 Standards and labels

Standards are tools that specify the requirements of products, services, or procedures, which are used to set benchmarks and criteria to harmonize behaviour in industry and society. Standards set out specifications and technical information on various kinds of materials, processes, and services (Ladu et al., 2018). The International Organization for Standardization (ISO), the European Committee for Standardization (CEN) and the American Society for Testing and Materials (ASTM) are the key bodies creating standards, along with national standardization authorities. These platforms bring stakeholders together to agree on standards which serve the safety of humanity, the environment, and products.

Standards and labels for bio-based products are classified under ecolabels (Ladu et al., 2018; UNEP, 2017). Ecolabels are a voluntary method of environmental performance certification and disclosure, which encourages sustainable consumption and production and promotes green markets. Standards and ecolabels disclose the specifications through a tag, brand, mark, picture, or other descriptive manner attached to the packing of the finished product. Ecolabels alone serve to raise awareness and increase the demand for sustainable alternatives to traditional products, such as bioplastics, and can increase demand for them amongst consumers.

Countries that have embarked on ambitious green procurement policies have typically preceded this policy move by developing policies around ecolabels. Eco-labelling schemes simplify procurement and reduce the administrative costs of developing detained customized environmental specifications for each product category (UNEP, 2017). Thus, ecolabels can serve to increase demand for sustainable alternatives through several channels.

5.3.1 Variants and components

Ecolabelling frameworks are typically voluntary and generally specified according to categories depending on whether the product is accredited by a third-party organization and the number of sustainability criteria that is met, among other factors.

The ISO differentiates between Type 1, 2 and 3 ecolabels (Bracco et al., 2019; OECD, 2016):

- **Type 1** are the strongest form of certification, where a seal or logo is based on multiple sustainability criteria, usually aimed at consumers, and are licensed by a third-party programme, and may involve a life cycle analysis (LCA) of the product.
- **Type 2** refers to self-declarations where claims do not involve third party certification, and a firm self-declares the sustainability criterion based on guidelines, where claims should be verifiable and accurate.
- **Type 3** labels involve the use of quantitative indicators of environmental performance based on LCA for objective comparisons between products fulfilling the same function. Type 3 labels are generally used when firms trade between each other or in public procurement.

Within the various types of labels specified by the ISO, there are several ways in which standards and ecolabels can differ in their specification and implementation.

- Sectoral scope of coverage: Standards and labels vary in the sector or industry that they cover. The Protected Harvest label applies to sustainable agriculture for example, while the OEKO-TEX standard applies to textiles.
- Sustainability content: Standards and labels also vary in the type of sustainability content that they cover. These can focus on natural resources, energy, pollution sources, climate change, waste, or a mix of these. Shade-grown coffee labels, for example, target biodiversity preservation in production, while the Energy Star label targets energy efficiency in production.
- Type of sustainability assessment: Some labels involve a full LCA which is typically costly, such as the Environmental Choice Canada assessment, while others, such as the US Department of Agriculture National Organic Programme, adopts a non-LCA approach to assessment.
- Governance: Standards and eco-labels can be mandatory or voluntary with the state deciding on the level of governance. The UL LLC standards, a global safety certification company, sustainability certification, for example, is voluntary, while the Canadian EnerGuide label is mandatory for all key energy consumer items.

While the earlier-mentioned variations are the key variants in how standards and ecolabels are implemented, in practice there are other potential variations, as well. These other variations include the targeted communication channel, the leading institution, the level of transparency behind the label, the organization which conducts monitoring and auditing, and the geographical scope to which the label applies.

5.3.2 Effectiveness and challenges

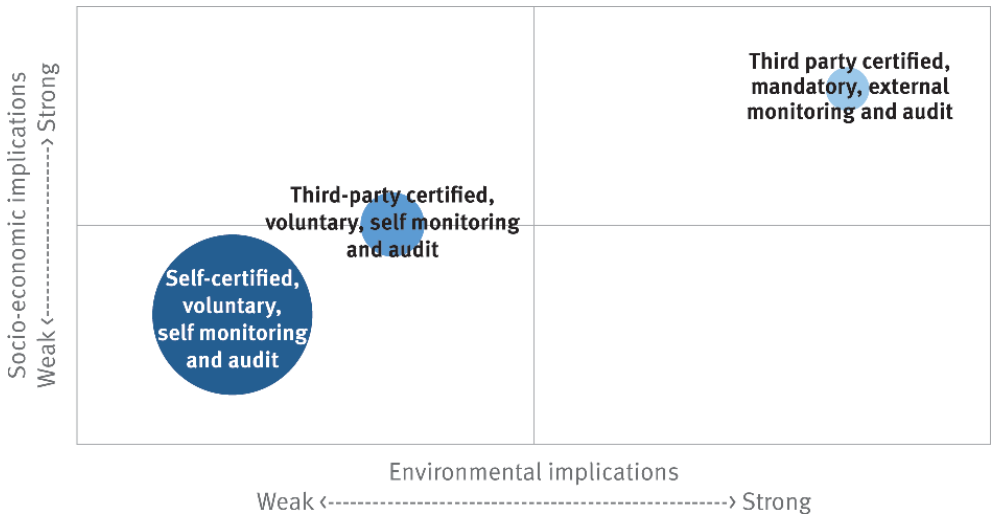

Figure 12: Comparison of ecolabel policy options.
(NB: The size of the bubble indicates the prevalence of usage).

The standards, certification and labelling (SCL) for bioeconomy related sectors can provide useful data which can be used in monitoring and evaluating the bio-economy and provide insights of the sustainability of the bio-economy at the product level and throughout the value chain. SCL helps all value chain actors disclose information about their products and assists in helping actors choose the right products for their purpose.

Information from SCL assists companies to comply with international and national legislation, increases market and brand value, facilitates risk management and increases consumer confidence. SCL can also drive demand for bio-based products as they help consumers to identify environmentally friendly products, consumers, particularly in developing countries, are more prepared to buy goods and services which have a limited environmental impact (UNEP, 2017). The effectiveness of SCL largely depends on the public familiarity and trust with the standard and label. Over the years SCL has have been developed by private and public institutions as well as international organizations. The trust and familiarly depends on the reputation of the certification institution, their links with international certification organizations and companies as well as the market and public information about the certification. Evidence from South Africa indicates poor recognition of certain types of ecolabels. Further, awareness of ecolabels is correlated with gender, age and home language (Struwig and Adendorff, 2018).

5.3.3 Country examples

Countries have employed various approaches to incorporating standards and labels to provide traction to sustainable sectors such as bioplastics. Variances include the sectoral coverage, whether labels are mandatory, the sustainability assessment required, and what sustainability criteria is targeted.

Table 6: Approaches to standards and labels.

Strong approach	Strong to moderate approach	Moderate to weak approach
Mandatory requirements for standards and labels which require a full life-cycle analysis combined with broad sectoral coverage	Voluntary requirements for standards and labels with a preference for a full life-cycle analysis and labelled goods in public procurement	Entirely voluntary requirements for standards and labels with no preference regarding a full life-cycle analysis and labelled goods in public procurement

5.3.3.1 Ambitious and growing: China

In China, the Ministry of Environmental Protection is the authority in charge of the China Environmental Labelling scheme. The scheme is voluntary, and the labels are valid for three years subject to regular review and renewal. Since the regulations began in 2006, the number of product categories has expanded markedly from 14 in 2006 to 74 in 2015, the number of participating companies increased from 81 in 2006 to 1 516 in 2015, and certified products from 800 in 2006 to 115 071 in 2015.

In China, green public procurement (GPP) (discussed in section 5.4) is implemented primarily through eco-labels and energy labels. China's Environmental Labelling scheme serves as a bridge between government as the purchaser and business as suppliers and create strong incentives for product manufacturers to design, build and create greener products (UNEP, 2017). The successes from the Chinese ecolabel policy framework stems from regular updates to labels on products which eases procurement for the state and the private sector, combined with shifts in production to more sustainable products from the demand created by ecolabels. The Chinese government has also steadily increased the budgets for ecolabel and energy efficient products over time to support growth of sustainable industries. Since 2003, China has also cooperated with ecolabel certification agencies in other countries such as Australia, Japan, and Germany, for mutual recognition of ecolabels across economies. This has resulted in the upgrading of Chinese manufacturing and increased international competitiveness of Chinese products.

5.3.3.2 Moderate success with challenges: Thailand

Thailand lacks any formal legislation for ecolabels; however, the country has used its Environmental Quality Management Plan (EQMP) to increase the prevalence of ecolabels in the economy. The EQMP includes requiring the increase in the ratio of ecolabel products to total products in the market as one of the indicators in its Strategy 1: Shifting towards environmentally friendly production and consumption. In terms of the number of product categories and number of products with ecolabels, Thailand has a smaller number of product categories and number of products that contain ecolabels when compared with other Asian countries such as China, South Korea, and Japan (UNEP, 2017).

A select number of challenges have prevented further uptake of products with ecolabels. First, given that ecolabels typically are developed prior to GPP policies, the fact that GPP is voluntary in Thailand does not necessitate the purchase of products with ecolabels by the state. In other countries, such as Japan and South Korea, mandatory GPP has increased the penetration of products with ecolabels. In certain instances, only 40% of Thailand state agencies voluntarily submitted intentions to procure products with ecolabels (UNEP, 2017). Second, the lack of a national footprint of products with ecolabels remains problematic, with ecolabel products only being available in certain parts of the country, preventing national consumption of these products.

Box 5: Promoting plant-based plastics in the procurement of ballpoint pens in Japan.

The implementation of GPP for goods and services is carried out in accordance with Japan's Basic Policy. In January 2001, the "Act on Promotion of Procurement of Eco-Friendly Goods and Services" (including the "Law on Promoting Green Purchasing") was enacted. For ballpoint pens, procurement is principally based on Eco Mark certification criteria which accounts for the entire life cycle of the product. The GPP criteria for ballpoint pens include (Ministry of the Environment, Government of Japan, 2020):

- Recycled or plant-based plastic makes up at least 40% in weight of the total plastic used if a mix of post-consumer and post-industrial material is used,
- If recycled plastic consists solely of post-consumer material, the blending ratio shall be no less than 20% of weight,
- Ink refill cartridges should be replaceable,
- Packaging or stowage material is to be as simple as possible and designed to be recycled to reduce the environmental impact upon disposal, and
- If plastic is used for product packaging or stowage, recycled or plant-based plastics shall be used as much as possible.

Procurement occurs through a competitive bidding process and procurement requires that each ministry tracks the amount of goods and services it procures. Each ministry reports results to the Ministry of Environment, including the amount of eco-friendly goods and services procured and the ratio of eco-friendly goods to the total amount of goods and services procured. As of 2013, there were 101 companies carrying Eco Mark certification for their ballpoint pens. The total number of ballpoint pens purchased was 2 205 000, of which 2 189 000 met GPP criteria, with 99.4% of ballpoint pens meeting sustainability criteria.

Based on data collected in 2013, mitigation of 16.8t of CO_2 resulted from the switch to purchasing green ballpoint pens since the early 2000s. In 2013, there was a 6.1t reduction in plastic consumption compared to 2000, due to the GPP criteria. The ballpoint pen market rapidly increased the supply of "green" pens to meet the criteria with a market penetration of 13.0% of the ballpoint pen market in 2000 to 33.8% in 2013, more than doubling in size. GPP activities were regarded as the chief driver in the greening of the ballpoint market (GPNM, 2017).

5.4 Green Public Procurement

Green public procurement (GPP) is a policy tool that involves the procurement of 'green products', such as bioplastics, by state entities. This can be considered a steppingstone towards Sustainable Public Procurement (SPP) where public authorities attempt to balance economic, social and environmental needs when procuring goods, services or works. Governments and public institutions can participate directly in markets as consumers, and this participation offers the state an opportunity to increase demand for certain types of goods and services. Given the size of the state as a consumer, this increase in demand can be substantial and serve to ignite small or new markets. The size of government as a consumer means that GPP can stimulate the

market for sustainable products and can serve as a driver of demand for green products and bio-based products.

GPP is one of the pillars of sustainable public procurement, which includes economic, social and environmental responsibility (OECD, 2015). This policy lever allows government authorities and public institutions to account for environmental costs and benefits when procuring goods and services. GPP is typically linked with other environmental policy instruments, such as standards and ecolabels.

GPP has grown in prevalence around the world, where almost all OECD countries have developed strategies or policies to support GPP. The European Commission for example has introduced a public sector directive which encourages member states to engage in green procurement through including eco-label criteria in public tender offers and by taking life-cycle costs into account (European Commission, 2018; OECD, 2015).

5.4.1 Variants and components

Countries have different public procurement regulations and variations in the centralization of their respective purchasing frameworks:

- Targeted group: GPP can be applicable at the national, subnational, or local government levels. In most countries where GPP is mandatory, green procurement is compulsory at the national state level and voluntary at the local and subnational levels. Some countries extend procurement focus to include private sector businesses and the public.
- Governance: GPP can be mandatory or voluntary with the state deciding on the level of governance.
- Extent of green procurement: Due to the variations in the definition of “green products”, GPP can include a broad range of goods and services. Europe and the United States of America have guidelines which directly cover GPP of bio-based products. As indicated in the previous section, China bases its GPP on a range of designated product categories and number of products, and the guidelines include over 70 product categories and 100 000 individual products.
- Stage of the value chain: In the context of plastics, procurement criteria can address different aspects of the plastics value chain. For instance, procurement can be used to avoid the consumption of traditional plastic products and incentivize the consumption of sustainable products which are purpose-designed for re-use and recycling.
- Synergies with social and political considerations: GPP which is aligned with departmental, subnational policies. GPP which incorporates the skills development requirements, strategic environmental sustainability strategies of various departments and the inclusivity for previously disadvantaged groups, as with the BBEE score requirements in South Africa.

5.4.2 *Effectiveness and challenges*

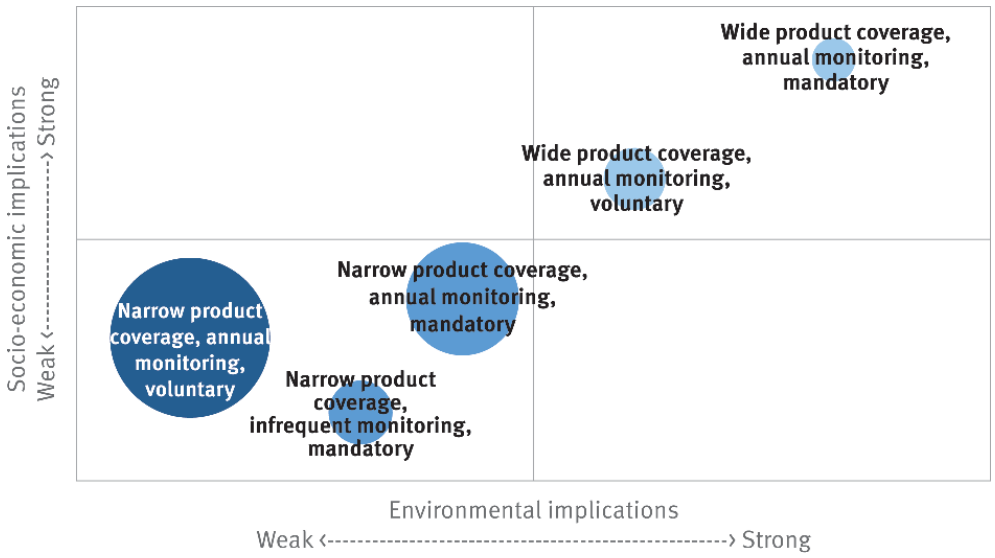

Figure 13: Comparison of GPP policy variants.
(NB: The size of the bubble indicates the prevalence of usage).

The key driver to the effectiveness of GPP is a comprehensive standards and labelling framework which provides public authorities with guidelines on the various products to consider in procurement processes. GPP has been highly effective in driving the market for low-carbon products as government institutions are a significant consumer and government institutions can provide preferential treatment to smaller producers and environmentally friendly products (Ministry of the Environment, Japan, 2015; OECD, 2015).

The challenge in the uptake of GPP has been:

- A lack of information and data on the real environmental impact of products, product opportunities and a lack of knowledge of environmental and climate risk of traditional products.
- Competing priorities such as local procurement, small business support, and environmental sustainability.
- A lack of standardized procedures on how to include environmental impact into procurement processes.
- Shortage of monitoring and evaluation frameworks and information and a lack of transparency to track the progress of GPP.
- A lack of co-operation between government authorities and institutions and conflicting policies.
- Lack of capacity at the subnational and local government levels to implement GPP.
- Financial constraints to purchase green products which are typically more expensive than traditional products.
- Difficulties in finding suppliers when preparing calls for tenders and shortages in green products.

5.4.3 *Country examples*

Within the sphere of GPP, countries approach sustainable procurement from different perspectives. The chief areas of difference arise with respect to whether GPP is mandatory, the extent of procurement which has to be sustainable, and which levels of government GPP applies to.

Table 7: Approaches to GPP.

Strong approach	Strong to moderate approach	Moderate to weak approach
Mandatory procurement for all government institutions (local and national) that is centrally coordinated and with wide product coverage. Reporting on progress in GPP occurs to a central government authority.	Mandatory procurement at the central government level with voluntary arrangements for other levels of government, with a limited designated product set. Tracking of progress occurs on a voluntary basis.	GPP occurs on a purely voluntary basis for all levels of government with a narrow product focus.

5.4.3.1 Strong leaders in Asia: Japan and South Korea

Japan introduced GPP practices in the 1990s, to support the national green purchasing activities the non-profit organization Green Purchasing Network was established. In 2001, the Act on Promotion of Procurement of Eco-friendly Goods and Services by the State and other Entities was introduced to expand the market for environmentally friendly products. The act is mandatory for all government agencies across a wide variety of product categories, state agencies set their own voluntary GPP targets and report to the Ministry of Environment. The law stipulates the green contracting requirements for government agencies and institutions Japan has environmental labelling NGO/NPOs which assist government in providing information about the certification criteria and products. Central government, local government, NGO/NPOs and suppliers cooperate with each other to promote GPP (Ministry of the Environment, Japan, 2015).

South Korea's GPP was introduced in tandem with the Korea Eco-label. The Act on Encouragement of Purchase of Green Products was introduced in 2005, after the Act on Promotion of Procurement of Eco-friendly Goods and Services. South Korea's GPP aimed at leveraging the state to drive demand for green products. GPP has grown significantly in South Korea. Total public expenditure in green purchases tripled between 2005 and 2012 from KRW 254 billion in 2004 to KRW 2.2 trillion in 2014 (UNEP, 2017). The success of GPP in South Korea has been largely driven by the Korea Eco-label and the Green Products Information System (GPIS), an online platform which assist government entities in reporting and monitoring the GPP process. 60% of national green procurement data is automatically reported through GPIS, reducing the administrative burden for government, and making GPP processes easier (OECD, 2015; United Nations Environment Programme, 2017).

Box 6: Multi-level GPP leadership in Italy.

In Italy, green procurement has been used as a tool to stimulate demand for bioplastics at both the national level and at the regional/city level. At the national level, the state has placed requirements for bioplastics in large scale catering events. Further, Milan, for example, had green procurement requirements for the EXPO 2015 event (Imbert et al., 2017). Municipal authorities have started to develop specific procurement measures, where in Turin for example, school catering contracts are designed to prioritise reusable and refillable packaging. The city was estimated to save 157 tons of plastic per year on average (OECD, 2019). In the Italian case, green procurement has been regarded as a key driver of the market for bioplastics.

5.4.3.2 Ambitious but governance challenges: Thailand

During 2005, the Thai Government has adopted strategies, plans and policies geared towards sustainable development (UNEP, 2017). In 2008, the government introduced two Green Procurement Promotion Plans to mainstream GPP and increase government spending on sustainable products and services (GPNM, 2017). In the 2nd Green Public Procurement Promotion Plan (2013-2016), the target groups were expanded to local authorities, private-sector businesses, and the public. GPP in Thailand is decentralized, the law encourages procurement of environmentally friendly products however GPP is conducted on a voluntary basis. As part of its GPP initiatives, the Thai government has formulated targets and metrics for GPP in terms of training workshops and seminars, and among other GPP initiatives and other critical elements of green public procurement programming. Since 2013, the scope of target groups was increased to include procurement by local authorities, private-sector businesses, and the public. With respect to governance, GPP remains voluntary for the state at all levels of governance.

While up to December 2015, more than 25 000 tons of CO_2 reductions have been achieved due to GPP in Thailand, major barriers to further scaling up and effectiveness of GPP have been noted due to the policy design and implementation (UNEP, 2017). Given that GPP occurs and is monitored on a voluntary basis, the ability of GPP to drive new sustainability market has been regarded as less effective than if GPP was mandatory. On average, only 40% of targeted implementing agencies have enacted GPP policies in procurement and the lack of monitoring makes tracking progress difficult (UNEP, 2017). Standards and ecolabels ease procurement decisions, and the lack of a sufficient number of labelled products has prevented greater GPP in Thailand, particularly due to labelled goods not being available throughout the country. Related to this, stringent procurement criteria that sets out criteria for procurement in Thailand are not matched by products which provide the same level of information in product labels or specification documents. This mismatch creates confusion for procurement in practice, as to whether the procured products meet the intended standards. Since procurement in the public sector in Thailand is coordinated in a disaggregated manner, without centralized platforms, each implementing agency has to set up systems to track sustainability purchases which increases time and staffing costs for GPP. Finally, awareness and training has not been uniformly applied across implementing agencies in Thailand, resulting in a lack of technical knowledge among procurement staff in certain agencies, reducing the likelihood of sustainable purchases.

5.5 Social Awareness

Social awareness and education are important components of increasing demand for plastic alternatives and to convey accurate information to consumers about the harms of plastic consumption. Typically, most policies which serve to increase demand for sustainable alternatives are accompanied by some form of social awareness and education. This can take the form of stakeholder consultations prior to designing and implementing a policy, where this information is conveyed to consumers; through dedicated awareness campaigns; and through school curricula. Social awareness of low-carbon and/or bio-based products can drive demand for these products as consumers are made aware of the harmful environmental impact of traditional products and how environmentally friendly alternatives contribute towards environmental and social suitability (Saha and Kuruppuge, 2016).

Given that consumers are accustomed to habitual consumption, successfully altering consumption behaviour requires consistent reinforcement through appropriate channels to reach all consumers. This reinforcement has to be targeted across multiple dimensions including targeting consumers with different incomes, ages,

levels of education, geography and cultures. Social awareness strategies can include a wide range of activities designed to persuade and educate. Longstanding changes in consumer behaviour and cultural attitudes are best achieved through regular and engaging messaging, where the choice rests with the consumer and not through once off and/or standalone campaigns (Divyapriyadharshini et al., 2019; Saha and Kuruppuge, 2016). Social awareness campaigns can be driven by governments as in Canada's reusable bags campaigns or they can be driven by producers and retailers in the form of green marketing or sustainable branding.

5.5.1 Variants and components

Social awareness campaigns can include a range of mediums to educate and inform consumers of the impact of their purchasing activities, successful companies use a combination of mediums to ensure sufficient reach.

- Traditional media — television, radio, and newspapers.
- Online media — social media platforms, online news outlets, websites, blogs.
- Product labelling — eco-labels.
- Education incorporating eco-friendly content into school curricula.
- Promotional activities — providing consumers with access to information and greener alternatives through conferences, workshops, demonstrations.
- Awards, rewards, and other incentive programs which provide proof of product excellence and rewards for producers.
- Social nudging — positive reinforcement to consumers through small incentives or through in-store signs and messaging, for example.
- Social proof — People are likely to copy the actions and undertake the social behaviour of people they admire and respect, social proofing can use experts, celebrities, and influencers to promote, endorse and recommend bio-based products to their audiences.

Social awareness should be used in combination with other policy interventions and strategies to assist in achieving the desired outcomes.

5.5.2 Effectiveness and challenges

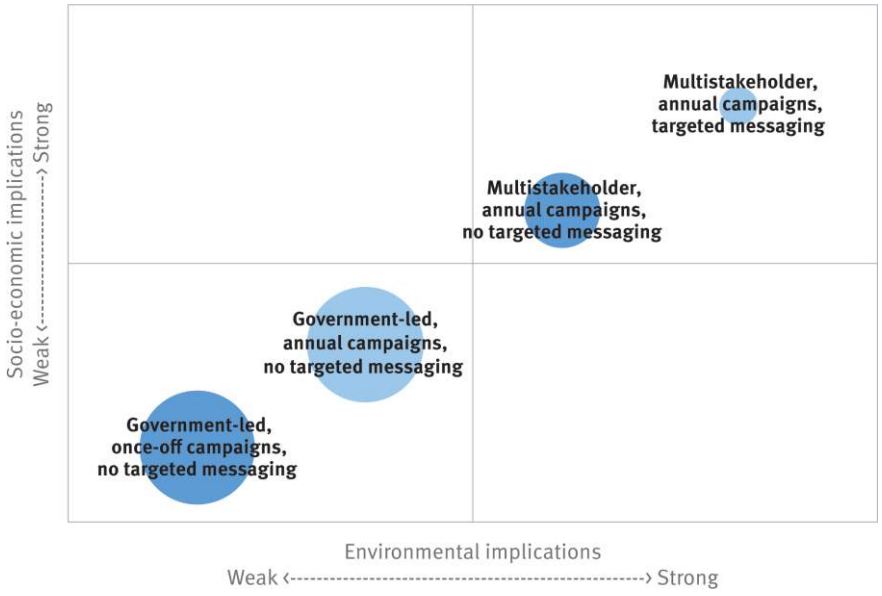

Figure 14: Comparison of social awareness policy options.
(NB: the size of the bubble indicates the prevalence of usage).

Social awareness can play an important role in changing consumer behaviour and stimulate the market for environmentally friendly products. Social awareness is only as good as its messaging campaigns, which inform and engage consumers, instead of ridiculing or shaming, have the most success in changing consumer patterns. Social awareness campaigns which take advantage of social proofing where celebrities, experts and influences are used to promote and endorse products play an important role in changing consumer behaviour and stimulating demand for bio-based products (Awan and Wamiq, 2016). In recent times the concept of a social nudge has become popular, which combines behavioural economics principles with sustainability. Social nudges refer to cues provided to consumers who are on the margin with respect to sustainable behaviour and consumption. Small measures in the form of clear messaging in stores, on products or through advertising can hold potential to alter consumption behaviour.

Creating social awareness to sustainable consumption is a challenging exercise as two key challenges surface from the literature. Firstly, awareness campaigns can create the drive for changes in consumption, however the results tend to be short-lived if the awareness intervention is transient. Natural human behaviour is to resume habitual behaviour, thus awareness raising has to be consistent. Another challenge arises from the diversity of populations that differ by culture, gender, income, education, and access to information among other demographics. Differences in demographics and equity mean that awareness messaging will be received differently by different people and tailoring a campaign which appeals to most consumers can be difficult (Awan and Wamiq, 2016). Interventions may be tailored to the desired target group to be effective.

5.5.3 Country examples

The extent to which social awareness and education campaigns occur vary by country. Key differences in approaches arise in terms of the duration of awareness and education interventions, the target groups, the number of stakeholders involved in raising awareness, and the mix of interventions.

Table 8: Approaches to social awareness.

Strong approach	Strong to moderate approach	Moderate to weak approach
Social awareness involves alliances of stakeholders where awareness consists of comprehensive and targeted awareness and education campaigns that are long term, and informed by surveys of consumers.	The state drives awareness campaigns with once-off campaigns collaborating with certain stakeholders (e.g. the domestic plastics industry).	Social awareness occurs on an inconsistent and generalised basis and applied in an ad hoc fashion by different stakeholders without coordination. Targeted awareness and education do not feature.

5.5.3.1 Go Green campaigns: Malaysia

Since 2012, the Malaysian government has prioritized social awareness through awareness campaigns. The government in partnership with NGOs has introduced Go Green campaigns to try to encourage green behaviour and sustainable consumption. Campaigns such as the No Plastic Bag Day, 3Rs (Reduce, Reuse and Recycle) and environmental education have been organized by NGOs and government. The campaigns have had an impact on the public however the impact has not been the same for society (Masoumeh et al., 2015). Analysis of the perceptions and changes to behaviour indicate a higher likelihood of changed behaviour for females, married individuals, higher income, higher education, and urban residence in response to the

campaigns. Further, families with young children were found to adopt energy efficient technology and energy conservation practices. Women were more influenced to perform green activates than men and people with higher incomes were more likely to perform green behaviour than people with lower incomes (Masoumeh et al., 2015).

Box 7: Social nudges through nominal levies in Toronto, Canada.

Social nudges are intended to typically be small, non-coercive, highly visible, repetitive, and symbolic interventions intended to sway consumer thoughts and resulting behaviour. These interventions are meant to serve as a reminder to consumers about options, rather than to result in punitive costs to the consumer (Rivers et al., 2017) numerous jurisdictions have sought to curb disposable bag use by implementing a levy or fee at the point of purchase. These levies are typically small and symbolic (around $0.05 per bag). With respect to the impact of such interventions on behaviour, some studies indicate nominal levies can decrease plastic bag usage by up to 50% or more in certain contexts. After a growing waste problem with landfills reaching full capacity, the City of Toronto passed a $0.05 levy on each disposable bag given to customers, from June 2009. The new charge was advertised with signage in stores and appeared on customer receipts, along with a four-week advertising campaign preceding the charge.

Regular audits and reviews were conducted to monitor the effectiveness of the policy in changing consumer behaviour. Based on data collected from household waste audits, disposable bag use declined by 53% between 2008 and 2012 in the city, which equated to 242 million less bags consumed per year (Rivers et al., 2017) numerous jurisdictions have sought to curb disposable bag use by implementing a levy or fee at the point of purchase. These levies are typically small and symbolic (around $0.05 per bag). Results from 2013 also indicated that 72% of households reported using reusable bags more frequently and 59% of households reported using fewer plastic bags. The impact was found to be strongest among consumers that already used reusable bags. While the results were encouraging the social nudge on plastic bags was subsequently removed in 2013 due to a change in the mayor of the city and a change in political approach.

5.5.3.2 Leveraging celebrities: Japan

In 2014, Japan launched a nationwide campaign to fight climate change named the Fun to Share campaign. The aim of the campaign was to encourage people to live everyday life in a manner that helps the country realize the benefit of a low-carbon society. The campaign had the support of local government, economic and industrial organizations and celebrities pledged to support Fun to Share. A 2016 government survey shows that the interest in climate change had declined among people between the ages 18 and 26 by 15%. Young people in Japan are more concerned with economic growth. New efforts to capture young people's attention have begun where government is studying the benefits of a sharing economy, the government is also looking to incorporate popstars and mascots in future campaigns to attract young people to participate in the country's efforts (Ministry of the Environment, Japan, 2014; Schlossberg, 2016).

6. Policy Insights for South Africa

From the analysis of the demand-side policy measures, key insights can be drawn to develop the South African bioplastics market from the demand side. In this section, each of the demand-side policy measures are evaluated for South Africa by reviewing the extent to which the given policy measure is implemented in South Africa and potential steps to use the policy tools to stimulate demand for bioplastics. An accompanying socioeconomic impact assessment (SEIAS) draws out key implementation measures, benefits, risks, and challenges.

6.1 Bans and Taxes

South Africa currently has a ban on plastic bags which are less than 0.3 millimetres thick and a levy on the manufacturing of thicker bags. The tax was introduced at 3c in 2004 and was ramped to 12c in 2017. During the 2020 budget speech the levy was increased from 12c per bag to 25c per bag from April 2020 (Business Insider, 2020). The levy is paid at the manufacturing stage by plastic bag manufacturers. South Africa's levy applies to consumers through supermarkets and other shopping outlets, where retailers decide on the extent to which they pass on the cost to consumers. South Africa's tax rate has been criticized for being too low to influence behaviour, where consumers have become accustomed to paying for plastic bags (Donnely, 2019; United Nations Environment Programme, 2018b).

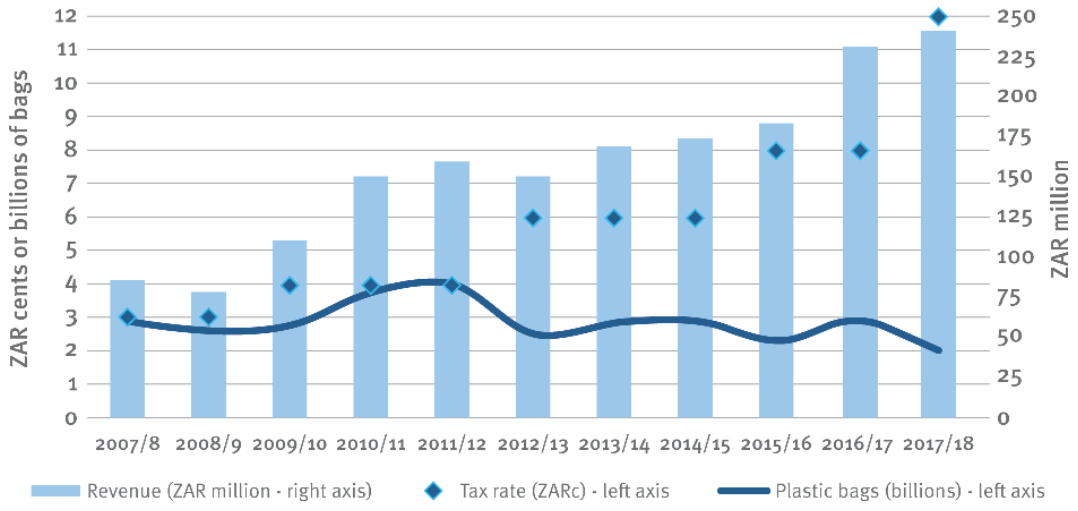

Figure 15: Impact of the plastic bag levy in South Africa.

(Source: Montmasson-Clair & Chigumira, 2020, based on data from SARS, Series on revenue collection, environmental taxes, downloaded from https://www.sars.gov.za in October 2019).

During the South African Plastics Pact Breakfast, which was hosted in November 2023, Minister Barbara Creecy, of the South African Ministry for Forestry, Fisheries and the Environment, indicated that unnecessary and problematic plastics were identified by the SA Plastics Pact. She further indicated that the Pact commits to ensure that 100% of all plastic packaging would be reusable, recyclable, or compostable. Thus, ensuring that 70% of plastic packaging would be effectively recycled. Additionally, plastic packaging would be informed by a 30% average post-consumer recycled content.

The consideration of further punitive measures on plastics is seen as a response to the increasing pressure to mitigate carbon leakages into the environment. Further, DFFE's actions come after mounting pressure from consumer campaigns on single-use plastics and the transition towards zero plastic by major food and

beverage manufacturers, retailers and restaurants. Several major South African retailers, such as Woolworths and Pick n Pay, have targeted single use plastics and plastic bags through a progressive phase out. The plastics industry has also committed to increasing plastic recycling and landfill diversion, where Plastics SA has introduced an initiative to eliminate plastic waste in landfills by 2020. The industry body hopes to work with government in developing markets and providing infrastructure to achieve 'zero plastic to landfill' (Business Tech, n.d.; Moodley, 2014).

Table 9 and Table 10 propose several implementation measures, benefits, costs, and risks on the socio-economic impact assessment for plastic ban and taxes and fees, respectively. The extent of uptake of proposed measures and related costs have to be considered by the respective line function Ministries, noting the anticipated risks, prior to implementation.

Table 9: Socio-Economic Impact Assessment for plastic ban.

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
Government	*DFFE* conducts stakeholder engagements and secures buy-in about a ban and specifies which products fall within and are exempted. Based on engagements and research a formal policy stance and framework is formulated. **The dtic** formulates incentives for plastic producers to switch production to new and sustainable plastic products.	*DFFE* delivers on mandate to mitigate the impact of manufacturing practices on the environment through policy on limiting egregious plastics. **The dtic** leverages industrial policy to promote sustainable alternative plastics to provide consumers with alternatives. This expands sustainable production sectors and creates new capabilities and skills.	*DFFE* may need to consider investment into resources in market research and engagements to test the effectiveness of a ban on certain plastics and formulate a framework which sets out banned plastics and exempted plastics. This will also have to account for how the banned plastics are consumed and the impact on value chains as a result. **The dtic** may need to mobilise resources for incentives through Treasury to support alternative bio-based plastic products to substitute for banned plastics. *Treasury* could face declining tax revenues from plastic producers that cease production due to heavy investment in banned plastics.	*DFFE:* A lack of enforcement results in illegal use of banned plastics with no material impact on demand for bioplastics and continued environmental impact of harmful plastics. Potential backlash from the market or consumers results in the failure of the ban. **The dtic:** incentives do not deliver the growth anticipated due to failures on enforcement of the ban. Should alternatives not be accessible geographically or price competitive, certain consumer groups ignore the ban.

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
Plastic Producers	Depending on the stage of the value chain, producers modify production to new plastic products in line with the ban. Upstream polymer providers increase the bio-based content in polymers.	Exposure to punitive legislation, such as carbon taxes, declines due to sustainable adjustments to production. This also provides producers with business continuity and certainty.	Declining revenues and demand given the ban on production of certain plastics. Potential employment losses among producer that are unable to adapt to new market conditions.	Incumbent producers risk losing market share absent any modification to production. Adaptive producers do not achieve desired growth and demand given poor enforcement of the ban and illegal consumption.
Retailers	Retailers adjust procurement practices to stock only sustainable plastics.	Retailers benefit from an improved brand image of sustainability in operations. Exposure to punitive legislation such as carbon taxes also declines.	Retailers adjust procurement to only stock legal plastics. Retailers could face higher costs depending on the availability of sustainable plastics.	Rise in input costs given higher costs of production of bioplastics.
End consumers	Consumers adjust consumption choices to new sustainable plastics given the lack of egregious plastic products.	Eases sustainability consumption decisions.	Reduced choices if no sustainable alternatives available.	Alternative plastics are costly leaving consumers with little alternatives.

Table 10: Socio-Economic Impact Assessment on taxes and fees.

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
Government	*Treasury* reviews existing plastic levy framework and evaluates whether it is effective. *DFFE* engages with Treasury to review existing plastic levy framework and conducts research on the willingness to pay of consumers. This informs a new potentially higher levy on plastic products such as single-use plastics	*DFFE* benefits through greater mitigation impact through reduced use of harmful plastics and increased use of sustainable plastics. **The dtic** leverages industrial policy to promote sustainable alternative plastics to provide consumers with alternatives. This expands sustainable production sectors and creates new capabilities and skills.	*Treasury* faces potentially lower net tax revenues from plastic levies given the extent to which demand shifts to sustainable alternatives. *DFFE* may need to invest in staffing and resources in market research and engagements to test the effectiveness of a ban on certain plastics and	*DFFE:* A lack of enforcement results in illegal use of banned plastics with no material impact on demand for bioplastics and continued environmental impact of egregious plastics. Potential backlash from the market or consumers results in the failure of the ban. **The dtic:** Incentives do not deliver the

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
	and plastic bags, along with clear specification and exemptions. **The dtic** formulates incentives for plastic producers to switch production to new and sustainable plastic products that are not impacted by the levy.		formulate a framework which sets out banned plastics and exempted plastics. This will also have to account for how the banned plastics are consumed and the impact on value chains as a result. **The dtic** may be required to mobilize resources for incentives through Treasury to support alternative bio-based plastic products to substitute for banned plastics. *Treasury* could face declining tax revenues from plastic producers that cease production due to heavy investment in banned plastics.	growth anticipated due to failures on enforcement of the ban. Should alternatives not be accessible geographically or price competitive, certain consumer groups ignore the ban.
Plastic Producers	Depending on the stage of the value chain, producers modify production to new plastic products in line with the levy. Upstream polymer providers increase the bio-based content in polymers.	Exposure to punitive legislation such as carbon taxes declines due to sustainable adjustments to production. This also provides producers with business continuity and certainty.	Declining revenues and demand given the higher cost of certain plastics. Potential employment losses among producers that are unable to adapt to new market conditions.	Incumbent producers risk losing market share absent any modification to production. Adaptive producers do not achieve desired growth and demand given poor enforcement of the ban and illegal consumption.
Retailers	Retailers adjust procurement practices and systems to stock only sustainable plastics and account for the higher levy in financial plans.	Retailers benefit from an improved brand image of sustainability in operations. Exposure to punitive legislation such as carbon taxes also declines.	Retailers adjust procurement to only stock exempt plastics. Retailers could face higher costs depending on the availability of sustainable plastics.	Rise in input costs given higher costs of production of bioplastics.

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
End consumers	Based on new levies consumers adjust consumption choices to new sustainable products given the higher cost of traditional plastics.			Raising costs for consumers, with regressive social impact on low-income households, where cost-effective alternatives are not available.

Possible policy amendments to ban plastics and/or increasing the plastic levy are important tools to divert demand to new and sustainable bioplastic industries. Given the review of the international literature, it is imperative that the following steps are taken if bans and taxes are further pursued.

- ***Extensive public consultation*.** In countries and states such as Rwanda, California, and Ireland, where bans and taxes were effective in reducing traditional plastic consumption and diverting consumption to sustainable alternatives, stakeholder buy-in was actively pursued and sought throughout the policy design and implementation process. This engagement serves to notify stakeholders of policy intentions and identify potential political economy tensions such that they may be mitigated. A key tension, for example, relates to the employment impacts that a ban has on certain plastic producers. These risks need to be identified early on such that policies and plans can consider the impacts and mitigate against them. Securing the buy-in of key stakeholders also provides momentum to the policy and ensures that unwanted behaviour does not occur.

- ***Ensuring the availability of cost-effective alternatives.*** Access to alternative materials for their intended usage, such as paper bags or bio-based bags, are vital if consumers are to divert from the use of plastic bags. The appropriate supply-side interventions to stimulate biomaterials production such as incentives and other policy measures are required. In Rwanda, for example, incentives to modify production away from traditional plastics through capital grants allowed producers to continue supplying new products that were able to meet new sustainability standards.

- ***Sufficient disincentives.*** For punitive policy measures to be effective, the cost imposed on consumers must be a sufficient deterrent. With respect to taxes, the accurate determination of a price to result in a change demand is key. In Ireland and Portugal, the setting of a plastic tax was preceded by a representative survey of consumers and the determination of the price that they were willing to pay for plastic bags. Policymakers then set the rate sufficiently higher than this average price to adequately shift demand away from the type of plastic that was identified as harmful. This type of process is integral for the determination of a levy and should be part of the policy process in South Africa when considering future plastic levies.

- ***Effective enforcement.*** The enforcement of policy is a crucial cornerstone to stimulating demand for bioplastics through bans and taxes. Thorough enforcement not only prevents unwanted consumption behaviour but also serves to change the culture of consumption among the intended target group. In Rwanda, thorough enforcement through regular inspections within the economy and at borders was effective in reducing traditional plastic prevalence and litter. When contrasted with countries where enforcement was not prioritised, such as in Bangladesh, the emergence of black markets for undesirable plastics emerged combined with continued use of

banned plastics. The enforcement of fines and possible prison sentences can also serve as a deterrent to unwanted consumer behaviour.

6.2 Standards and Labels

Ecolabels currently do exist in South Africa and tend to have a sectoral focus. The EcoProduct label, for example, is a South African label which focuses on building products and systems, focusing on the construction and interiors market. Table 11 provides a sample of common ecolabels in South Africa. Currently, there is no legislation or regulation surrounding ecolabels in South Africa, and ecolabels occur on a voluntary basis.

Table 11: Sample of ecolabels in the South African market.

Label name	Sectoral/thematic relevance	Origin
EU energy Label	White goods, light bulb packaging and cars	EU
Green Dot ecolabel	Recycling/packaging	EU
Energy Star ecolabel	Energy efficiency	US
Forest Stewardship Council (FSC) ecolabel	Sustainable forestry	EU
Green Globe ecolabel	Travel and tourism	United Nations Rio de Janeiro Earth Summit (1992)
Fairtrade ecolabel	Sustainable and equitable trade	Netherlands
Eco Standard/Eco Product ecolabel	Construction and interiors market	South Africa
Roundtable on Sustainable Biomaterials (RSB)	Aviation fuel	Switzerland

Ecolabel legislation and regulation is typically enforced as part of a holistic policy stance to ensure that the costs (e.g. search costs) associated with sustainable consumption in an economy are reduced. Ecolabels also allow for state procurement through GPP to occur more easily as procurement managers can easily identify products that meet sustainability criteria that they desire. In fact, as indicated in preceding sections, many countries first design and implement ecolabel legislation and regulation prior to embarking on GPP policies.

Table 12: Socio-Economic Impact Assessment on standards and ecolabels.

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
Government	**The dtic** and NCPC are provided with the mandate to drive ecolabels and formulates an ecolabel framework for	**The dtic** and NCPC lead on sustainable product development through formulating	**The dtic** and NCPC may be required to invest in resources in market research and engagements to test	**The dtic** and NCPC: consumers are not sufficiently aware of labels and what information they

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
	South Africa, acting as a regulator. This involves setting standards for ecolabels in the country and regular review of standard setters and granting approval.	an ecolabel framework. This increases sustainability focus in the economy through product availability. **The dtic** leverages industrial policy to promote sustainable alternative plastics that abide by ecolabel standards. This expands sustainable production sectors and creates new capabilities and skills.	the ecolabel framework. This will include the formulation of market standards for accreditation institutions. **The dtic** may need to mobilise resources for incentives through Treasury to support alternative bio-based plastic products to substitute for banned plastics that abide by ecolabel standards.	convey, altering current consumption minimally. **The dtic:** incentives do not deliver the growth anticipated due to failure of ecolabels to penetrate markets or due to a lack of consumer awareness about what ecolabels mean.
Plastic Producers	Producers that wish to gain market share in sustainable plastics apply for ecolabels on their products. Producers also advertise and make logos visible on products.	Exposure to punitive legislation such as carbon taxes declines due to sustainable adjustments to production. This also provides producers with business continuity and certainty. Producers can provide credible sustainability assurance to consumers including the state through GPP.	Sustainable producers wishing to access ecolabels will have to incur staffing and consultancy costs to engage with accreditation institutions to incorporate labels into their products.	Investments into introducing labels onto products are not realised due to a lack of market demand based on higher product prices or a lack of consumer awareness. Small and new firms may be unable to incur label these costs, excluding them from participation.
Retailers	Retailers incorporate ecolabels into their procurement and increase the number of ecolabel goods for end consumers. Retailers increase advertising efforts towards increasing the image of eco-labelled products.	Retailers benefit from an improved brand image of sustainability in operations. Exposure to punitive legislation such as carbon taxes also declines.	Retailers adjust procurement, re-orientating procurement towards products with ecolabels, potentially incurring higher costs.	Downstream consumer face higher prices for labelled goods.
End consumers	End consumers educate themselves on ecolabel products	Easier sustainability procurement	Potentially higher prices	N/A

Given that South Africa currently does not have an overarching ecolabel framework and regulation, leading departments such as **the dtic** and the NCPC should formulate clear guidelines and frameworks which guide the process of ecolabels in general, and for bioplastics in particular, in the country and provide direction to private

and public consumers. This policy direction can then provide third party accreditors and producers with specific direction on the development of ecolabel markets. Specific guidance should be provided on the following:

- The types of assessments that are accredited and desirable. This refers to whether complete LCA is required for labels or whether other types of sustainability assessments are acceptable.
- The types of ISO labels that are accepted. ISO distinguishes between Type 1, 2 and 3 labels, each with differing requisites. **The dtic** and NCPC should provide clear guidance on which labels are acceptable in consumer markets.
- Periodic review of labels. NCPC should set out the criteria for which ecolabels are reviewed and allowed to continue with periodic reviews to ensure consistency in accreditation.

6.3 Green Procurement

GPP has yet to achieve wide deployment in South Africa, and currently is implemented by certain municipalities and metros on a voluntary basis. The municipalities of Cape Town, eThekwini, Ekurhuleni, Nelson Mandela Bay, and Tshwane committed in 2002 at the World Conference on Sustainable Development to incorporate green procurement into procurement practices (SEA, 2012). Further in 2017, Agyepong and Nhamo indicated that the City of Cape Town and Ethekwini Municipality had incorporated green procurement principles into their procurement processes; and that the City of Cape Town and Nelson Mandela Bay Metropolitan Municipality were the only municipalities to have green procurement strategies.

Supply Chain Management in South Africa operates within a regulatory framework set by National Government and extended by provinces and local governments to specific policies, legislation, and regulations.

The legislation which impacts procurement includes the Public Finance Management Act (1999), Preferential Procurement Policy Framework Act (2000), Preferential Procurement Framework Regulations (2001) and National Treasury Regulations (2005). The Municipal Finance Management Act (MFMA) of 2003 governs the financial and supply chain management functions of Local Government.

Table 13: Socio-Economic Impact Assessment on green procurement.

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
Government	DFFE in combination with other departments such as *Treasury* and ***the dtic*** develop a national GPP framework and are provided with the mandate to make some element of GPP mandatory within government. This includes the development of common platforms	All government departments benefit from increasing sustainable procurement and providing a leading stance on sustainability in the economy. **The dtic** increases sustainable production in industry through	Procurement costs within national government increase due to the need for training and upskilling of procurement managers on GPP. In addition, state resources have to be mobilized to set up systems for GPP that include common	GPP systems fail to deliver increases in sustainable purchases due to difficulty in identifying suitable products or due to a lack of suppliers.

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
	through which suppliers and consumers can be linked. Treasury can leverage the central supplier database to focus on GPP specifically.	new producers targeting sustainable products and targeting the GPP market.	procurement platforms and databases of sustainable products.	
Plastic Producers	Producers engage with the relevant departments and provide an indication of the extent to which they can provide sustainable products to meet GPP standards.	Increased bioplastic supply through new firm market entry combined with existing producers modifying production to meet GPP criteria.	Producers incur investment costs into altering production to meet GPP criteria.	The costs of orienting production to meet GPP criteria are too high, resulting in a limited number of suppliers in the market.
Retailers	N/A	Increased supply market for bioplastics driven by state procurement	N/A	N/A
End consumer	N/A	Increased choice of bioplastic products through new markets	N/A	N/A

For GPP to work as a tool to increase the demand for sustainable products such as bioplastics, a comprehensive framework and plan should be developed that consists of the following key interventions.

- ***Mainstreaming GPP in national government.*** GPP should be incorporated into central government as a mandatory element in procurement and should be developed in conjunction with a credible system for ecolabels that aid in easing procurement decisions. This requires the necessary mandate to be formulated and enacted such that GPP is an imperative. Currently, there is no compulsory requirements captured within the current legislation that requires an entity to implement GPP. In countries where GPP has achieved successful results, such as in Japan, China, and South Korea; GPP has been driven by central government, which in turn was driven by a central GPP framework or policy.
- ***Centralised procurement.*** As evidenced in the cases of Thailand and South Korea, centralized systems allow procurement managers access to certified products, and allow managers to be linked to suppliers, reduces the administration costs in procurement when compared to disaggregated procurement systems. In South Africa, the PFMA prescribes decentralized procurement. For GPP to occur within this framework, each organization would have to invest in separate skills development, awareness training and manage the use of local suppliers to implement GPP (Naicker, 2018). The decentralization of procurement in South Africa means that additional resources are required to ensure GPP is executed across the public sector, which would slow down execution, and increase the costs for each implementing unit.

- ***Creation of centralized systems.*** Platforms to link public and private consumers in the economy with verified suppliers can reduce search costs and ease procurement for public and private sector consumers that wish to increase sustainable purchases. One example is Japan's Green Purchasing Network which consists of approximately 2 000 member organizations from businesses, local governments, and NGOs and houses and updates a database of eco-products and GPP guidelines on its website. This will require the necessary back-end support and funding, which can be sourced from the state (through levies for example) and the plastics industry.

6.4 Social Awareness

Social awareness and education in South Africa, occur by different stakeholders with differing methods of raising awareness. DFFE currently has a few support programmes that target awareness-raising around sustainability. Examples include *National Marine Week*, *Clean–Up and Recycle Week*, and *Good Green Deeds*. The National Marine Week is a DFFE-led awareness campaign that takes place annually and is intended to highlight the importance of the marine environment and its role to the country. The 2020 theme was related to sustainability and innovation. Clean–Up and Recycle Week that DFFE participates in with other stakeholders such as the domestic plastic industry. Here, DFFE engages with communities through awareness-raising activities. Finally, the Good Green Deeds programme creates awareness on reducing litter and dumping, minimising waste, and encouraging waste entrepreneurship. Many stakeholders such as private firms and industry bodies also create awareness around sustainable plastic use. Within retail, firms, such as Pick 'n Pay and Woolworths, have adopted policies against sing-use plastic. Within the plastics value chain, firms such as Safripol also create awareness through advertisements. Industry bodies such as PetCo and Plastics SA also engage in awareness through publications and involvement in alliances with other plastics stakeholders.

South Africa has been criticized for a lack of alliances and unified voice from all stakeholders with respect to sustainable plastics use. The lack of efforts in raising awareness through stakeholder interactions and public awareness campaigns around the plastic bag levy in SA for example has been criticized and this is an area which requires attention not only to impart information regarding the harms of plastic but also to increase demand for bioplastic alternatives (UNEP, 2018). More recently stakeholders related to the plastic value chain have united under the South African Initiative to End Plastic Pollution in the Environment which was formed in 2019 with the overall aim of reducing plastic pollution. The alliance includes several private firms across value chains (e.g. polymer producers, converters, fast food retailers), producer responsibility organizations, state organizations such as DFFE and **the dtic,** and the United Nations Environment Programme (Hanekom, 2020). Within the alliance various focal areas have been developed which include the development of the bioplastics economy in South Africa, and the raising of awareness and education. The alliance plans to raise awareness and education through various channels which include information booklets, pamphlets, websites, mobile apps and clean-up events. The awareness campaigns aim to build networks within the state, among communities, consumers, and industry. This recent alliance is a positive move for gaining traction for bioplastics as well as for raising awareness around sustainable plastic use. Since the alliance is newly formed, it remains to be seen how effective the alliance will be in achieving its goals.

With respect to education, while awareness to pollution is taught as part of the national curriculum, a recent evaluation of primary and secondary education has revealed key gaps that need to be addressed within education on climate awareness (Dalu et al., 2020). There is an increased need for learners to participate in cleaning up schools and for schools to limit plastic consumption. A key barrier found in the study was that learners from poorer backgrounds use plastics for storage purposes for their school equipment, and that no substitutes were available, having implications for limiting plastic use. Related to the curriculum, the study

found that a greater emphasis on climate change, the impact of plastics and the circular economy were needed.

Table 14: Socio-Economic Impact Assessment on social awareness and education.

Stakeholder	Proposed implementation measures	Benefits	Costs	Risks
Government	National Government to mobilize resources to large scale awareness campaigns that occur frequently and that identify groups by their differences, tailoring messaging to them. Demographics to account for include age, income, education, gender, and location. Department of Basic Education (DBE) should ensure that sustainability and plastic awareness is part of curriculum and that teachers are adequately trained to impart education to learners.	Departments, like DFFE, deliver on their mandates and add to their existing awareness-raising portfolio. If targeted correctly, awareness-raising should alter behaviour. DBE increases access to education that will be tailored to sustainable futures.	Investment costs and resources devoted to awareness-raising across DBE.	If awareness-raising is not targeted and consistent, state resources do not deliver the intended behavioural change. A lack of targeted education and awareness results in consumers persisting in carbon-intensive and unsustainable consumption practices, failing to create demand for sustainable products in the future.
Learners	N/A	Enhanced skills and knowledge with future emissions reductions from educated future generation.	N/A	N/A
Plastic Producers	As part of already-established alliances, private firms should mobilize resources for greater awareness raising and education.	Increased demand for sustainable alternatives	Producers face reduced demand for fossil-derived plastics, impacting on revenues, investment, and employment.	If awareness-raising is not targeted and consistent, state resources do not deliver the intended behavioural change.
Consumers	Receptivity to consumer sustainability awareness and education messages	Increased knowledge and awareness around sustainable consumption		

In addition, as a potential regulator of ecolabels, **the dtic** and NCPC should partner with ecolabel regulators

in other countries to ensure mutual acceptance of labels and to incorporate learnings from other jurisdictions. The formulation of ecolabel legislation and regulation in the country can then ease sustainable purchases at various levels in the economy and enable larger demand stimulus such as GPP at the national level. Further, there is a symbiotic relationship between ecolabels and GPP in that the formulation and implementation of GPP can also increase the number of ecolabel products given the rise in demand for such products through GPP.

7. Conclusion

South Africa's carbon intensity in production is high given the reliance on coal-based electricity and polymer production through Eskom and Sasol, respectively. Encouragingly, there are numerous efforts to mitigate emissions within industry through the use of carbon pricing, investigating feedstock substitution, and a number of research collaboratives, pooling together private firms, researchers and government departments.

Biomaterials certainly stand to allow for reduced carbon emissions and impacts throughout the value chain, and bioplastics, in particular, emerge as a worthy candidate for plastics of the future. Like all sustainable technologies, production methods and products, at the early stages of development, these sustainable solutions require support to be initiated and to grow over time. From a supply perspective there is currently a lot of support and resources being devoted to developing bioplastics in the country. However, for a market to properly function and grow, attention needs to be shed on the demand side of the market developing channels through which bioplastics can initially combine with, and eventually substitute for, traditional fossil-based plastics.

This report has sought to investigate the literature around demand-side policies that can be used to stimulate the demand for bioplastics and the relevance such policies have to the South African policy space. The basket of policy measures considered consists of penalty-based and incentive-based tools which should be used in combination as part of an overall approach and framework. These policy tools have precedent in their ability to develop the demand side of the bioplastics market. Current bioplastic production and interest in South Africa has begun to flourish but there remains some way for the market to develop. The demand-side policies should be harmonized with existing supply-side policies and presented as an overall solution to plastic production, consumption, and post-consumption stages. When considering policies to stimulate demand, it is important to learn from the lessons gained in other countries to ensure avoiding the unintended costs of certain policies and build mitigation measures within policy frameworks to ensure optimal outcomes.

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Appendix i: List of Contacts.

Organisation	Area	Contact person	Role
Building Energy	Feedstock	Matteo Brambilla	Managing Director Africa
Coca Cola	Biopolymers	Casper Durandt	Director: Sustainable packaging and climate change
Council for Scientific and Industrial Research	Biopolymers	Avashnee Chetty	Research Group leader: Polymers and composites
Council for Scientific and Industrial Research	Biopolymers	Sudhakar Muniyasamy	Senior Researcher: Polymer and Composite
Department of Forestry, Fisheries and the Environment (DFFE)	Sustainable Development	Devina Naidoo	Senior Policy Advisor
Ecopack	Sustainable packaging	Lauren Clack	Director
Lignotech	Feedstock	Dharani Moodley	Sales Manager
OptimusBio	Green chemicals	Raj Lalloo	Chief Technology Officer
Plastics SA	Biopolymers	Jacques Lightfoot	Sustainability Manager
South African National Energy Development Institute (The Working for Energy programme)	Biomass to Energy	David Mahuma	General Manager
SAPPI Biotech	Biomaterials production	Louis Kruyshaar	Executive Vice President
SunChem SA	Feedstock	Samantha Hampton	Project Manager: Solaris
Red Cup Village	Biodegradable Cup manufacturer	Luvuyo Ndiki	CEO
University of South Africa	Biomass expert	Tirivaviri Augustine Mamvura	Senior Lecturer
VTT Technical Research Centre	Biomaterials research	Marko Nokkala	Senior Sales Manager

Appendix ii: List of validation-workshop attendees.

Organization	Name	Role
ABSA	Aveshen Moodley	Vice President: Sustainability
AFRD Georgia	Kakha Nadiradze	President
African Circular Economy Network	Chris Whyte	Director
Agri Urb	Wolfe Braude	Director: Research & Knowledge Management
AIDC	Bruce Baigrie	Climate Justice Liason
Aquinox Developers	Bo Manqele	Director
Blue Crane Green Energy	Brian Barnard	Director
Catholic Parliamentary Liaison Office	Lovedonia Mkansi	Environment & nergy Project Coordinator
Chemical & Allied Industries Association	Mlu Ganto	Head of Regulatory Affairs
City of Johannesburg	Maria da Silva	Assistant Director: Policy Regulation and Development
COPCO/ Kompost-it	Emma Algotsson	Director
Council for Scientific and Industrial Research	Prabashni Lekha	Senior Researcher
Council for Scientific and Industrial Research	Saloshnee Naidoo	Research Engineer
Council for Scientific and Industrial Research	Bruce Sithole	Chief Scientist & Director
Council for Scientific and Industrial Research	Vincent Ojijo	Research Group Leader-Advanced Polymer Composites
Council for Scientific and Industrial Research	Ravini Moodley	Technology Transfer and Innovation Management
Council for Scientific and Industrial Research	Mohammed Balogun	Senior research scientist
Council for Scientific and Industrial Research	Maya Jacob John	Principal Researcher
Council for Scientific and Industrial Research	Sudhakar Muniyasamy	Senior Researcher
Dai Europe	Robert Nyakuwa	M&E Advisor
Dave Wright Consulting	David Wright	Consultant
Department of Environmental Affairs and Development Planning	Ron Mukanya	Sustainability Head
Department of Economic Development and Tourism	Celeste Dias	Deputy Director Economic Policy and planning

Organization	Name	Role
Mpumalanga		
Department of Forestry, Fisheries and the Environment	Mulalo Tshikotshi	Control Environmental Officer
Department of Forestry, Fisheries and the Environment	Leanne Richards	Deputy Director
Department of Forestry, Fisheries and the Environment	Nape Mothapo	Intern
Department of Forestry, Fisheries and the Environment	Anam Ngoma	Project Administrator
Department of Planning, Monitoring and Evaluation	Nomzamo Ngwabe	Research Assistant
Department of Planning, Monitoring and Evaluation	Rudzani Mashangu	Outcome Manager: Environment
Department of Public Enterprises	Mohlala Tabudi	Senior Financial Analyst
Department of Science and Innovation	Mahlori Mashimbye	Director Chemicals and Related Industries
Department of Science and Innovation	Nthabeleng Makhetha	DD
Department of Science and Innovation	Khanyisile Malunga	Intern: Industry and Environment
Department of Trade, Industry and Competition	Karishma Ramcharan	Director: Chemicals
Dept of Economic Development, Tourism & Environmental Affairs	Mbuyiselo Sani	Chief Director: Economic Research & Planning
DNA Economics	Tlale Matseke	Consultant
Embassy of Finland in Pretoria	Jenni Kiilholma	Agricultural Counsellor
Energy Systems Research Group	Joseph Masenda	Research analyst
Engineering News	Schalk Burger	Journalist
Enviromall	John Fox	Sales Director
Ernst and Young	Tebogo Maphala	Audit Supervisor
eThala Management Services	Pita (Jabulani L) Mbatha	Group COO
eThekwini Municipality	Ravesha Govender	Programme Manager (Manufacturing)
eThekwini Municipality	Anasuyah Pather	Programme Manager
European delegation	Ariane Labat	Counsellor
Exxito Sustainability Ventures	Lebohang Raliapeng	Principal

Organization	Name	Role
EY	Daniel Biyekele	Associate
Footsteps Foundation	Karin Badenhorst	Founder
Fund Social Good NPC	Desigan Pillay	Managing Director
GCPPC	Azubike Michael Nwachukwu	Director
Glenheim Venture Capital	Richard von Seidel	Chief Investment Officer
Government of the Western Cape	Ronald Mukanya	Project Manager
GreenCape	Kirsten Barnes	Circular Economy Analyst
Industrial Development Corporoation	Nathan Fredericks	Analyst
Institute for Economic Justice	Julia Taylor	Researcher and Climate Policy Lead
Institute for Economic Justice	Katrina Lehmann-Grube	Climate Justice Researcher
Independent	Malesela Tlhotse	Student
Independent	Renee Grawitzky	Researcher/communications
Independent Researcher	Myriam Velia	
Industrial Development Corporation	Mkhetwa Maluleke	Senior Industry Development Manager
Institute for Economic Justice (IEJ)	Carilee Osborne	Researcher
Interlinks Traceability Services	Gwynne Foster	Traceability Facilitator
International Labour Organization	Siyanda Siko	PAGE Coordinator
International Labour Organization	Matilda Dahlquist	Technical Officer: Just Transition and Sustainable Enterprises
International Labour Organization	Tahmina Mahmud	PAGE Focal Point
International Labour Organization	Jens Dyring Christensen	Senior Specialist: Sustainable Enterprises
Itochu Plastics PTE LTD	Felix Wang	General Manager (Accounts/ Finance & Admin)
Jupilog Consulting	Barrie Harvey	Research Associate
Kwazulu-Natal	Ndidzulafhi Nenngwekhulu	Assistant Director
Mining Dialogues 360	Tracey Cooper	Executive Director
Mvello-PLA SA	Darrell Caister	Project Director
National Agricultural Marketing Council	Thabile Nkunjana	Economist
National Treasury	Natalie Reenen	Economist

Organization	Name	Role
National Treasury	Dimakatso Mkwanazi	Junior Economist
National Treasury	Cassandra Dunstan	Economist
National Treasury	Asanda Ntunta	Economist
National Treasury	Kuhle Mxakaza	Economist
NCRF	Michael Lawrence	Executive Director
Nelson Mandela University	Hope Baloyi	Assistant Lecturer
Norwegian Embassy in Pretoria	Alf Friiso	Counsellor
PAMSA	Julie Borland	Research and Development
Plastix 911	Annabe Pretorius	Owner
Redflank	Janice Greaver	Management Consultant
Ruhi Consulting Ltd	Terence Singh	Director
SA Canegrowers	Muhammad Kadwa	Industrial Affairs Manager
SA Rebuilders	Maryam Amra Jordaan	Co-founder
SAFDA	Marilyn Govender	Diversification
Safripol	Avashnee Chetty	Sustainability Manager
Sappi Biotech	Matt Spence	VP Biomaterials
South African Reserve Bank	Letlotlo Khoathane	Risk Analyst
Swiss Economic Coorporation	Shakespear Mudombi	Programme Officer
South African Bureau of Standards	Thero Malumane	Senior Standards writer
South African Petroleum Industry Association	Kevin Baart	Head: Strategic Projects
South African Plastic Recycling Organization	Phil Sereme	General Manager
Stainbank Bros	Graeme Stainbank	Managing Director
Standard Bank	Sheila Kombe	Project Manager
The Department of Trade, Industry and Competition	Hawie Viljoen	Chief Director: Competitiveness Improvement Investments
The Department of Trade, Industry and Competition	Christopher Wood	Director: International Operations
The Moss Group	Rob van Hille	Principal Consultant
TIKZN	Queen Mkhize	Project Manager
Trade and Industrial Policy Strategies	Liako Mofo	Senior Economist
Trade and Industrial Policy	Kelello Mashiane	Researcher

Organization	Name	Role
Strategies		
Trade and Industrial Policy Strategies	Itumeleng Mokoena	Intern
Trade and Industrial Policy Strategies	Mbofholowo Tsedu	Economist
Trade and Industrial Policy Strategies	Elize Hattingh	Sustainable Growth Researcher
Trade and Industrial Policy Strategies	Sandra Makumbirofa	Economist
Trade and Industrial Policy Strategies	Gillian Chigumira	Economist
Trade and Industrial Policy Strategies	Ntombi Matonana	Intern
Trade and Industrial Policy Strategies	Nokwanda Maseko	Economist
Trade and Industrial Policy Strategies	Saul Levin	Executive Director
Trade and Industrial Policy Strategies	Tsholo Setati	Intern
Trade and Industrial Policy Strategies	Lesego Moshikaro	Economist
UCL Energy Institute	Elusiyan Eludoyin	Research Fellow
University of Johannesburg	Patience Mamathaba	Strategic Tutor
University of KwaZulu Natal	Annegret Stark	Research Chair
University of KwaZulu Natal	Kushveena Gokul	Student
UN Industrial Development Organization	Abu Saieed	Green Industry Expert
United Nations Framework Convention on Climate Change	Cecilia Njenga	Director: Intergovernmental Process and Collective Progress
University of Pretoria	David Walwyn	Professor
University of Pretoria	Margaret Chitiga	Professor
University of the Western Cape	Lizette Grobler	Postdoctoral Fellow
University of the Western Cape	Takunda Chitaka	Postdoctoral Research Fellow
Veolia	Chris Braybrooke	General Manager
Water Research Commission	Bonani Madikizela	Chief Director of Research in Aquatic Ecosystems
Western Cape Government	Deejay Jay	Project Leader: Green Economy
Western Cape Government	Ismail Wambi	Environmental Officer
World Wildlife Fund	James Reeler	Bioenergy Project Manager

Organization	Name	Role
World Wildlife Fund	Lorren de Kock	Project Manager: Circular Plastics
World Wildlife Fund	Tjasa Bole-Rentel	Bioenergy Programme Manager
World Wildlife Fund	Farai Chireshe	Bioenergy Analyst
World Wildlife Fund	Zaynab Sadan	Project Officer: Circular Plastics
World Wildlife Fund	Reinhardt Arp	Environmental Economist
World Wildlife Fund	Mamaputle Boikanyo	

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