Worldwide Review of Current Restrictions on Single-use Plastics and their Replacement by Alternative Materials in Relation to the Commonwealth Litter Programme (CLiP) in Belize

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Executive Summary

1 Background and Objectives

Eunomia Research & Consulting Ltd (Eunomia) was commissioned by the Centre for Environment, Fisheries and Aquaculture (Cefas) under the Commonwealth Marine Litter Programme (CLiP) to deliver of a desktop study to support CLiP activities and recommendations in Belize between May and September 2019.

CLiP's work supports a number of developing countries across the Commonwealth to develop national litter action plans focusing on plastics entering the oceans, by sharing expertise and finding solutions to the environmental and socio-economic problems caused by litter in the marine environment. This study supports this objective by providing:

1. A worldwide review of currently implemented bans/restrictions by countries on single use plastics and/or polystyrene, their implementation and subsequent efficiency including the economic, environmental, policy and legal implications, including any recommendations for future bans.

2. A worldwide review of alternative materials now used to replace currently banned items/materials, their economic, social and environmental impacts, success of their replacement as well as a pro-cons assessment between materials. As part of this review, the ability of countries with varying levels of waste management to sustainably process these alternative materials after use was also considered, with focus on Belize's solid waste management systems.

2 Methodology

Against this background, Eunomia reviewed the implementation of three key forms of restrictions on single-use plastic litter globally: bans, levies, and deposit return systems. For each, a selection of case studies was further developed to identify best practice in the implementation of these measures, as well as areas for improvement and lessons learned from other countries that faced challenges in implementing them. This informed a series of key recommendations related to the successful implementation of restrictions on single use plastic litter that was presented at the National Workshop for Marine Litter and Waste Management in Belize on the 11th and 12th of July 2019.

In the second phase of work, Eunomia developed a long list of single use plastic items commonly found in terrestrial and marine litter, identifying the key alternatives that are currently available for each of these. Single-use non-plastic items, multi-use (or reusable) items, and alternative plastic items were included in this assessment. SUPs and their alternatives were shortlisted for review based on their relevance to Belize's proposed restrictions, as well as the availability of data on the relative merits of each one. The assessment considered environmental and socio-economic impacts (in the production, use and disposal phase) related to the shortlisted SUPs and their alternatives, providing a summary of the pros and cons of each.

Finally, the findings of the preceding reviews were synthesised in the context of Belize's current solid waste management system, providing a view on both the present and future considerations that are relevant to the country.

The primary research method used throughout the study was a desk-based strategic review of the available literature including accessible academic studies, institutional reports, and media articles, supplemented by Eunomia's considerable expertise in policy design to address the issues posed by single use plastic items in waste and litter, and the alternatives to these items.

Input on the context for and progress towards the development of Belize's own restriction on SUPs was provided by the Cefas steering group and the Belizean Department of Environment. Information regarding Belize's litter composition and solid waste management processes was gathered from CLiP's ongoing work in Belize.

3 Results

3.1 Key Messages for Implementation of SUP Restrictions

The rapid global adoption of regulatory/binding instruments relating to SUP product restriction has resulted in a growing range of deployments in recent years. Despite this increase in the uptake of policy instruments which aim to regulate SUP products, there is a knowledge gap surrounding their precise impacts. This is often because there has been limited effort to understand the baseline situation prior to implementation, with inadequate subsequent evaluation. However, it is still possible to draw out the guiding principles in establishing such policy measures and the relative performance of each of these.

3.1.1 Bans

- Bans are a common intervention aiming to reduce the use of, and pollution from, SUP products in countries around the world.
- There is a widespread evidence-gap on the effectiveness of bans as a policy instrument. There are significant differences in their impacts which can be correlated to a number of variables including implementation and enforcement.
- There is no scope for raising tax revenues through bans, with the exception of financial penalties for offending organisations. However, there are significant costs of the ban arising through its implementation and enforcement. These can be direct costs such as policing and indirect costs such as the loss of jobs.
- The implications of bans should thus be given careful consideration to minimise the risk of unintended consequences. These can incur additional financial burdens and disproportionately impact certain groups within society. There is a knowledge gap in this area, and it is difficult to discern whether there are additional burdens on some groups or whether it is only perceived that this could be the case.
- As certain SUP products are banned, national waste management processes must be able to effectively manage their replacements. This may require further regulatory guidance, standards, or infrastructure, such as facilities for industrial composting or anaerobic digestion. Equally, if interventions help to reduce demand (including demand for single-use non-plastic alternatives), there is less of a strain (and associated cost) placed on waste management systems.

- There are a number of design principles which increase the likelihood of a positive outcome: phased enforcement, public awareness campaigns, availability of alternatives and international cooperation.

3.1.2 Levies

- Levies are a legally-binding economic instrument which raise funds that can be spent on waste management programmes, or other causes. These are designed to nudge consumer behaviours in a certain direction, away from the consumption of problem products. There is a much stronger base of evidence for their effectiveness compared to bans, which can be explained in part by their frequent implementation in developed nations, but arguably more significantly, in that they generate data alongside revenue.
- An important further point is that a levy will align the interests of the retailer with those of the Government in seeking to reduce consumption. Taking single-use coffee cups as an example, these are surprisingly expensive, so a charge that encourages customers to bring their own will mean the retailer saves money for each disposable cup they are not required to 'give away'. In some places, smaller retailers are able to keep the proceeds of the charge, which would be additional to the saving from the avoided provision of a disposable cup. This means that the greater the reduction, the greater the benefit to the retailer (plus the consumer should ultimately see a reduction in the price of the coffee as cost of the 'free' disposable cup provided would have been covered by the overall cost. By contrast, where certain SUP items are banned, the apparent single-use alternatives, such as biodegradable or compostable cups are often more expensive, meaning that the ban would lead to a negative financial impact for the retailer.
- Levies are a step towards internalising the cost of damage caused by pollution, moving the economic costs associated with environmental damage to consumers.
- There are still issues around the enforcement of levies, and they require effective governance systems to ensure nation-wide compliance, albeit as explained above, compliance should be higher than for a ban as the incentives for retailers are aligned. Furthermore, the fact that levies raise money (as opposed to bans) means that a proportion of the money raised could be ring-fenced for enforcement.

3.1.3 Deposit Return Systems (DRS)

- The majority of these globally have been implemented in developed nations, and are able to demonstrate positive outcomes in increasing capture rates of targeted SUP products while decreasing littering rates.
- There is considerable flexibility in terms of scheme design, meaning that an optimal design for Belize could readily be identified.
- DRS can be implemented relatively quickly, meaning that their benefits with regard to reducing litter and increasing collection rates can be accessed over a short period of time. Schemes can be put in place to complement existing waste management process, or in their absence – standing as their own intervention.

3.2 Key Messages for Alternatives to SUPs

The relative merits of SUP alternatives were assessed for the items in Table 1 below.

Table 1: Shortlisted SUP Items and Alternatives for Review

SUP Item Category	Description	Alternatives Reviewed		
		SUNP	MU	AP
Food containers for transport	Clamshells, food containers, and soup containers	Cardboard Bagasse	Reusable plastic	PLA
Beverage containers for transport	Plastic beverage bottles and beverage bottle lids, beverage cartons, water and other beverage pouches	Metal cans Glass	Refillable plastic	Bio-based PET
Food and beverage containers for immediate consumption	Plates, bowls, cups, lids, tumblers - both for hot and cold beverages	Cardboard/ paper Banana skins	Reusable china Reusable plastic	PLA
Eating and drinking utensils	Cutlery, stirrers, drinking straws	Wood Paper	Reusable metal	PLA
Lightweight Carrier bags.	Lightweight plastic carrier bags (e.g. those provided at grocery stores to carry shopping)	Paper	Cotton Reusable plastic	PLA/ PBAT

A summary of the key findings of the review is provided below:

1. The relative merits of the alternatives reviewed can vary according to the assumptions regarding their production, use and end of life disposal. Significantly, the assumptions regarding end of life management can be critical in influencing the outcomes of life cycle analyses.
2. Life cycle analyses of the environmental impacts of various items do not, however, account for the potential for and impacts of littering of such items. This omission means that LCAs (notwithstanding the various assumptions that might be applied) should not be the sole basis for decision making when seeking to prevent litter.
3. Multi-use (MU) alternatives typically perform well compared to other alternatives, especially where they are used many times over. Of significant relevance in the context of this study is that MU items not only reduce waste but significant reduce the potential for the generation of litter. MU items that are easily recyclable at the end of life provide the greatest benefits.
4. While MU items can be more costly than single-use alternatives on a per item basis, they can be cheaper when considered on a per use basis due to the large number of times an MU item can be reused relative to a single use one.
5. With regards to single use bioplastic alternatives, LCA studies indicate that these tend to be more resource intensive than single use conventional plastic in the production phase. In addition, biodegradable plastics are not suitable for recycling and, if not

littered, will end up in landfill. Once in landfill, it is impossible to ensure that they degrade entirely, due to the mixture of aerobic and anaerobic processes that waste is subject to in landfill. If they do degrade, this results in the release of significant methane emissions, resulting in negative environmental impacts. In addition, single use biobased/ biodegradable plastics are as prone to being littered as conventional plastics, and are unlikely to degrade in the natural environment as they will have been designed to degrade within a specific treatment process. Purely fibre based alternatives like paper and bagasse are likely to be preferable from this point of view, as these items are as likely to end up in litter, but are more likely to degrade if they do.

3.3 Summary of Findings in Belize's Context

1. With regards to instruments to restrict SUP litter, in Belize's context, a ban is likely to be challenging to implement given the role of the import/ export market and the costs associated with implementing and enforcing bans more generally.
    a. Levies on SUP items might prove relatively feasible to implement. This is because the point of application and enforcement of levies is limited to retailers and consumers of SUP items, impacting the import market through reduced demand for products as opposed to restricting supply of these products. Levies have the added advantage of being able to raise revenue, which can be used in a variety of ways to offset the costs of implementation.
    b. Expanding the DRS in Belize to apply to plastic beverage containers, including water pouches, represents a "quick-win" from the perspective of tackling two key sources of litter in Belize. Given its familiarity with the concept of DRS and the existing scheme, uptake of an expanded DRS in Belize is likely to be high.
2. Adopting multi-use alternatives in the place of single use plastic items is associated with the greatest benefits in the context of preventing waste and reducing litter in Belize. Focussing on recyclable multi-use products, such as metal, glass, and plastic reusables, reduces impacts further.

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1 Introduction

Eunomia Research and Consulting Ltd (Eunomia) is pleased to provide the Centre for Environment, Fisheries and Aquaculture Science (Cefas) with this report on a *Worldwide Review of Current Restrictions by Countries on Single-Use Plastics and Their Replacement by Alternative Materials in Relation to the Commonwealth Litter Programme (CLiP) in Belize*.

This report documents the findings of a strategic review of restrictions on single-use plastics (SUPs) worldwide, and the success of replacement of a range of alternatives to key SUPs in preventing waste and litter.

The study also aims to support the development of the first phase of Belize's restrictions on SUPs by making recommendations regarding best practice in implementing such restrictions and the relative pros and cons of key alternatives to these SUP items. Many of these recommendations will also be applicable to the other countries in which CLiP is active.

In line with these objectives, this report includes the following elements:

1 A summary of the methodology used in this study (Section 2);

2 A strategic review of restrictions on SUPs globally (Section 3);

3 A review of the pros and cons of key alternatives to SUPs (Section 4); and

4 Key lessons from the review and their application in Belize's context (Section 5).

Note:

At the time of this study's commencement, it was understood that Belize's proposed restriction on SUPs would be enforced in the form of a ban to be implemented in April 2019, and would include provisions relating to plastic beverage bottles, water pouches and Styrofoam pellets[1]. As such, the global review of restrictions includes a focus on these items.

During the course of the project, it was made clear that the proposed ban in Belize was subject to significant revision, and the date for its implementation postponed indefinitely. These changes impacted the scope, timescales, and framework for enforcement of the policy. As a result, plastic bottles and water pouches are currently excluded from the proposed restriction, and while many styrofoam items are still prohibited, this is to be enacted via a system of restrictions and prohibitions. Styrofoam manufacture as a material is restricted – and requires a permit -- with specific single-use applications for the material, such as food containers, being prohibited.[1]

[1] Pre-production pellets, as opposed to those used in void fill for packaging.

2 Methodology

This study consists of two main components; the first is an illustrative review of restrictions on SUP products from countries around the world. The second is an assessment of the most relevant alternatives to key SUPs that are currently restricted globally, and consideration of the ability of Belize's waste management system to sustainably manage these. The overarching objective of these tasks is to support the development of policy to prevent litter (in both terrestrial and marine environments) and reduce the generation of waste.

The primary research method used in the study was desk-based review of the available literature. Input on the context for and progress towards the development of Belize's own restriction on SUPs was provided by the Cefas steering group and the Belizean Department of Environment.

2.1 Global Review of Restrictions on Single-use Plastics

A strategic review of existing literature and data on the implementation of restrictions on SUP items was undertaken in order to develop an overview of the prevalence of such instruments and the items to which they are applied. A key source of information was UNEP's Single-use Plastics Sustainability Roadmap (2018), which documents the actions introduced by both public and private sector actors to reduce the production and consumption of single-use plastic products. This was supplemented by Eunomia's prior expertise in restrictions on additional SUP items, as well as a review of readily available and accessible reports, academic literature, and media articles regarding additional bans implemented since the UNEP report was published.

An assessment of the available information was then carried out in order to identify key examples of global restrictions on SUPs that a) represent best practice and lessons to be learned in terms of their reported success and b) are the most interesting to assess further in light of the proposed measures to address this issue in Belize. This selection and the recommendations arising from an analysis of these were reviewed with the Cefas steering group and presented to stakeholders at the National Workshop for Marine Litter and Waste Management in Belize on the 11th and 12th of July 2019 (see Appendix 1 for slides used). The selection of the case studies for this assessment was based on:

- Available information. Many examples were excluded based on limited available information, or information from a single source without clear references. This was more often the case in developing nations. Included examples were those that had reliable information from multiple sources.
- Relevancy to Belize and the Commonwealth. The Commonwealth is an inherently diverse group of nations, which broadens the scope of relevant examples. There is a slight bias to include examples of developing nations as these are the focus of the Commonwealth Litter Programme (CLiP). Examples from the US and UK have been

included to demonstrate how interventions can be deployed in developed nations. Relevancy to Belize is more specific, and includes primarily smaller coastal (or island) states in particular.

- Targeted SUP products. Globally, policy instruments target different SUP products, from bags to nappies. Examples have been selected to reflect this range, indicating how different interventions have been adopted and deployed.
- Policy instruments deployed. The collection of examples includes bans, levies and deposit return schemes, which were identified as the prime examples of instruments currently in use to tackle SUP litter, and, in the case of bans and levies, restrict or reduce consumption of such items. These different interventions have relative strengths and weaknesses.
- Maturity of the scheme. While there has been a recent rise in the deployment of relevant policies, there are more established examples of interventions that have been in place for a decade or more. Including these examples gives a long-term perspective on how policies can develop.

2.2 Review of Alternatives to Single-use Plastic Items

This task involved the shortlisting of 2-5 of the most relevant available alternatives for key SUP items that are currently subject to restrictions, followed by an assessment of the success of their replacement (in terms of litter and waste prevention) and their relative socioeconomic and environmental impacts. SUP items considered here consisted of those that are currently subject to restriction in some form or another globally. Given that the nature, use, and alternatives to some of these items are largely similar (for example, straws, stirrers and cutlery), items were further grouped into categories where this was relevant. The longlist of SUP items, the categorisation of these, and the alternatives that were considered for each, are provided in Appendix 2.

In order to shortlist among these, firstly, SUP products which are included in Belize's proposed ban were selected in order to ensure relevancy of the findings. Additional items (plastic bottles and water pouches for example) were then selected on the basis of their prevalence in Belize's litter (based on a recent beach-litter composition study as part of the CLiP work in Belize[2]). Following these processes, the following SUP item categories were selected for further assessment:

- Lightweight Carrier bags;
- Food containers for transport (i.e. containing the food for some time before consumption);
- Beverage containers for transport (i.e. containing the beverage for some time before consumption);
- Eating and drinking utensils; and
- Food and beverage containers for immediate consumption;

For each of these, a range of alternatives across three key types (single-use non-plastic, multiple-use and alternative plastics) were proposed based on literature reviews, market research and discussion with Eunomia's experts. The aim of the proposed selection was to give an indication of the range of potential materials and their application to specific items, despite some remaining in early stages of development. A shortlist for further assessment was then finalised with Cefas based on alternatives that are currently commonly in use and easily available in other countries, as well as those that are interesting to consider from the perspective of Belize's proposed use of bio-based and biodegradable plastics as an alternative to SUPs.

The alternatives to the shortlisted SUP products, as selected by Cefas and primarily based on those that were originally understood to be included in Belize's ban, are then assessed for their relative merits in greater detail. A predominantly qualitative analysis based on the available literature has been conducted exploring the following variables:

- Environmental performance;
- Socio-economic implications; and
- The relative impacts on litter and waste prevention.

A qualitative assessment of these variables was considered as the most viable approach in providing insight into the relative pros and cons of alternatives that would be applicable in Belize and other Commonwealth countries. This is because quantitative studies of this nature are highly relevant to the specific markets in which they are carried out, with limited scope for transferability of results due to widespread differences in waste management systems, costs of alternatives, supply chains including labour markets, and so on.

The analysis of each item/ material included a review of institutional and academic literature on the subject, as well as discussion with Eunomia's experts. It is noted that several relevant studies have been funded by representatives of the plastic/ bioplastic industries and therefore might potentially be considered as not fully impartial. Effort was made to exclude studies from the review where this was found to be the case, or where the study method, assumptions and findings were otherwise found to be lacking in transparency and robustness.

2.3 Application of Findings in Belizean Context

The recommendations from the two tasks above were then tailored to Belize's specific context, using input from the Department of Environment and Cefas' ongoing work in the CLiP programme. This involved consideration of the current framework for SUP restrictions being proposed in Belize (legislation for which has been revised during the study), as well as an overview of the waste management system and the likely performance of various instruments to restrict SUPs and the impacts of alternatives to these on litter and waste in this context.

3 Global Review of Restrictions on Single-use Plastics

Globally, there is a significant trend for countries to adopt different legally-binding instruments relating to SUP products to reduce consumption (thereby seeking to prevent both waste and litter), increase recycling rates, improve waste management processes and promote alternatives. This has been catalysed by a surge in public concern over the impacts of plastic pollution on marine and terrestrial environments.[3]

Governments have reacted with a wave of policy interventions, targeting different SUP items.[4] These can include, though are not limited to, plastic bags, straws, utensils, expanded polystyrene (EPS) products and food containers. The range of instruments that have been deployed is wide, including, among others, bans, recycling targets, levies and taxes, and awareness campaigns. UNEP has found that, as of 2018, 127 countries have adopted some form of legislation to regulate plastic bags and/or other SUP products.[5] These have been deployed at an accelerating rate around the world, spurred by growing scientific evidence and public concern on the impacts of plastic waste and pollution.[6]

While the uptake of related policies has been growing, the evidence of the effectiveness of these interventions remains sparse. Therefore, there are significant uncertainties regarding the implications of many policies, arising from a lack of quantitative evidence and variables around their context and implementation.[7]

Although the majority of legally-binding instruments relating to restricting consumption of SUP products and the litter arising therefrom have not been comprehensively reviewed, some interventions give more indications of effectiveness than others. With this in mind, this study focuses on three frequently applied policy instruments which will be introduced in subsequent sections; bans, levies and deposit return systems (DRS). It is noted that apart from DRS, other forms of extended producer responsibility (EPR) were excluded given that the aim of such systems is to internalise the costs of end of life management of products to their producers, as opposed to restricting the consumption of, and thereby litter from, SUP items. DRS was included as there is a strong litter-prevention effect associated with this measure. The following selection of examples has been collated to reflect the diversity of these three intervention types, their contexts and implications.

3.1 Global Examples of SUPs Bans

Bans are one of the most commonly used policy instruments around the world, where the import, manufacture, distribution and/or use of certain SUP products is legally prohibited. There are myriad examples of different approaches to bans, where they are implemented in the supply chain and the item(s) that they cover. They can be implemented at national and sub-national (regional/ state/ city) levels.

An analysis by UNEP has suggested that bans are utilised more commonly in the Global South, in particular in Africa, where several countries have adopted total bans on SUP products with a focus on plastic bags. Similarly, the European Union has more recently committed to a union-wide ban on plastic cutlery, cotton buds, straws and stirrers by 2021.[8]

While bans are politically ambitious, the costs, preparations and strength of governance required to comprehensively implement them are substantial. Where these are not sufficient, bans can be hindered or postponed, undermining public engagement and uptake.[9]

Table 2 provides several examples of bans from around the world in various stages of implementation and scope. The majority of these have been selected as good practice examples, though the inclusion of some, such as Zimbabwe's, are intended to demonstrate areas for improvement. Based on these examples, there are a number of general principles in the design of a ban that increase the likelihood of a positive impact:[7]

- **A phased approach to introduction and subsequent enforcement of bans is more effective.** A transition period between the announcement, introduction and the enforcement, allows businesses and consumers to prepare and adapt. It also reduces the risk of backlashes, which can include legal challenges. Industry consultation during the design and planning of the ban can also prevent backlash and costly delays at the time of implementation. Introducing a levy to reduce consumption of a specific item, while an effective instrument in its own right, could also be a first step in moving towards an ultimate ban.

- **Public awareness campaigns are a valuable tool in engaging consumers in the process.** This increases knowledge of what the ban will entail, the rationale for its implementation, how to prepare and what alternatives are available.

- **Ensuring that viable, cost-effective alternatives exist and are widely available.** Multiple-use products are an ideal replacement, and where single-use non-plastic (SUNP) products are encouraged their impacts should have been fully evaluated in advance. In order to encourage waste prevention, alongside a ban on SUPs, it would be fully appropriate to apply a levy to the SUNP alternatives.

- **Regional/ international co-operation.** Where possible, creating unified and consistent policies helps to create clear market signals which are more easily enforceable. This may limit the impacts of excessive producer costs, cross-border fraud, freeriding and smuggling that could arise if regional policies are not cohesive.

Table 2: Global Ban Examples

Location	Items covered	Date Implemented	Enforcement	Comments
Antigua and Barbuda	Plastic bags, utensils and polystyrene	2016	Reportedly well enforced, including consultation with stakeholders, transitional period to implementation d, incentives for a range of alternatives and awareness programmes[10]	The ban initially covered import and manufacturing, and was extended to cover sales 6 months later. A ~15% drop in the proportion of plastic waste going to landfill was recorded due to the ban and accompanying measures. The ban was preceded by public consultations and awareness raising campaigns.
Costa Rica	Plastics bags, straws, stirrers, food containers, bottles, EPS[2] and utensils	2018 to 2021	Initial stages are enforced, though not fully implemented yet	Implemented alongside Costa Rica's 2021 climate neutrality target, the country is implementing the ban in different stages from 2018 to 2021. This is supported by public awareness campaigns of new laws and regulations.

[2] The Independent (2019), *Costa Rica to completely ban polystyrene due to environmental impact*, 18 July 2019, https://www.independent.co.uk/environment/costa-rica-polystyrene-styrofoam-ban-environment-microplastic-law-a9011531.html

Location	Items covered	Date Implemented	Enforcement	Comments
India (regional)	Regional bans for various SUPs, national ban for all SUPs tbc in 2022.	2017 to 2022	Ranges from weak to comprehensive	India has several different bans at state level, which cover different items and are enforced to different extents. The range of ban efficiencies is a reflection on the importance of governance.
Jamaica	Plastic bags and EPS foam containers	2019	n/a	The ban is enshrined in national law, though will not be enforced until 2020 at least. This period is designed to smooth the transition to alternatives, though figures on the adoption rate of these are not currently published.
Kenya	Plastic bags	2017	Well enforced	Kenya's plastic bag ban was one of the world's first, implemented to tackle the nation's consumption of 24 million plastic bags per month. The ban is strictly enforced across the country, with only some marginal use continuing in border regions due to smuggling.[11]
New York, USA	EPS foam containers	July 1st 2019	n/a	New York first tried to implement a ban in 2013, but met with legal challenges.[3] The ban was re-introduced in January 2019, with a 6-month grace

[3] These challenges, posed by the Restaurant Action Alliance (spearheaded by the Dart Container Corporation) between 2013 and 2017, mostly focussed on evidence regarding the City's ability to recycle EPS in an "economically feasible and environmentally sound way". Details can be reviewed at https://www.politico.com/states/new-york/city-hall/story/2018/06/08/court-rules-in-favor-of-nyc-on-foam-food-container-ban-459836

Location	Items covered	Date Implemented	Enforcement	Comments
				period. Primarily enforced by the Department of Sanitation, through a stepped fine system.
San Francisco, USA	EPS foam containers	2006	Well enforced	First implemented in 2006, the scope of the ban was increased in 2017. This now covers around 98% of establishments, resulting in a 41% decrease in EPS foam litter from 2007 to 2009.[12]
Taiwan	SUP products	2019 - 2030	n/a	Taiwan has proposed a stepped ban, from July 2019 to 2030. Initially just public sector services will be covered by the ban, eventually moving on to cover all SUP products.
Vanuatu	Plastic bags, bottles, straws, utensils, EPS foam containers and nappies	2018 to 2020	Completed stages are well enforced	The ban is one of the world's strictest, indicative of Vanuatu's commitment as co-Chair of the Commonwealth Clean Oceans Alliance. The bans enforcement through financial penalties has resulted in national compliance for the first stages.
Zimbabwe	EPS foam containers	2017	Only enforced in the capital	The ban was implemented in 2017 after a short notice period. This was subsequently lifted due to backlash from businesses. The ban has since been reintroduced, but only enforced in the capital.[13]

3.1.1 Implementation of bans

Banning products which are heavily integrated into economies and cultures can have complex and unforeseen consequences, exacerbated by inadequate preparations. The examples of Costa Rica and Zimbabwe are useful in contrasting how preparations can be utilised to prepare businesses and citizens.

Costa Rica's ban is stepped over a four-year period, from 2018 to 2021, gradually covering a greater number of items and sectors of the economy.[14] The first stage, which has now been implemented, applies only to public sector institutions such as schools, health centres and prisons. The ban has been designed to complement other strategies in the country, such as the transition towards carbon neutrality and the Sustainable Development Goals. Therefore, careful consideration has been given to the implications of the ban, which is hoped to benefit not only the environment but also the economy and impoverished sections of society which tend to be disproportionately impacted by poor waste management.[15]

The national commitment is supported by an online portal, 'Zona Libre de Plástico' (Plastic Free Zone)[16], through which citizens and businesses can explore alternatives for common SUP items such as plastic bags, bottles and straws. Suggested alternatives include those made of natural materials (paper, bamboo, etc.), biodegradable plastics and reusables (metal and plastic). The portal also hosts the #YoMeComprometo ('I promise') campaign, to engage the public to reduce plastic consumption.

Contrastingly, Zimbabwe's ban was initially implemented in 2012 in response to rising criticism of the country's heavily polluted waterways and urban areas. This was delayed in order to explore alternatives and ease the likely burden on industry. In 2017, the ban was reintroduced for immediate enforcement, but this resulted in significant backlash from manufacturers and food vendors who were given no notice, and were not consulted, resulting in the ban being temporarily lifted and a reprieve of a few months granted to businesses. Since the ban was re-introduced, financial penalties ranging from of US$30 to US$5,000 have been imposed to deter against breaches of the law.[17] However, Zimbabwe's Environmental Management Agency (EMA) has so far only been able to enforce compliance within the capital city's markets.[18]

These differing approaches to implementing bans are indicative of the importance of careful design and planning, while engaging citizens and businesses in the process.

3.1.2 Implications of bans

When enforced, bans can lead to unforeseen consequences in the economy and society. Two interesting examples are Kenya and Vanuatu. Both nations are developing country members of the Commonwealth, and have implemented bans on particular SUP products.

Kenya implemented one of the world's first and most comprehensive bans on single-use plastic bags in 2017. The ban covered the importation, manufacture, distribution and use of bags, meaning that even people in possession of a plastic bag are breaking the law. The ban was implemented as a result of the country's considerable consumption and improper disposal of bags, and their resultant widespread pollution. The ban is enforced through a partnership between the National Environmental Management Authority and the National Police Force. Since the ban's implementation, around 1,150 producers and sellers of plastic bags have been arrested, and face financial penalties and potential imprisonment.[18]

The ban is also stated to have had an impact on the frequency with which plastic bags are found in the stomachs of slaughtered animals. Some abattoirs have noted that the frequency has decreased from around 30% to 10%.[19]

The ban was opposed by the Kenyan Association of Manufacturers, which represents plastic-producing companies accounting for 3% of the country's workforce.[20] The ban was also met with a petition against its enforcement, though this was dismissed by the Kenyan High Court in June 2018.[21] The ban was upheld on the basis that the benefits outweighed the harm, and that it was in the overall interest of the general public.

The Kenyan ban's continued and stringent enforcement has resulted in high compliance rates, with very few single-use bags being used in the country. However, the ban has seen a rise in smuggling activities and the development of a black market for plastic bags.[11] Kenya borders five countries, though there is a particular problem near the borders of Uganda and Tanzania.[22] Towns near the porous borders are reported to have a relatively active trade in plastic bags, though the ban has been well-enforced across the rest of the country. Failure to consider the availability and accessibility of alternatives from the outset has been cited as the primary driver of this outcome in Kenya. Consequently, the use of woven synthetic fibre bags has become widespread in Kenya, with some exemptions from the ban now having been granted for plastic films to wrap meat and other fresh foods. Made of polypropelene, the bags are therefore also plastic, though their nature as a reusable product has not adversely affected the litter prevention performance of the ban. An 80% overall reduction in the consumption of plastic bags from the ban's implementation in 2017 till earlier this year is estimated.[23]

While the development of a black market for plastic bags in Kenya was one unforeseen consequence of a ban on single-use plastic bags, the ban on certain SUPs in Vanuatu has resulted in others. Vanuatu's ban was first introduced in 2018, covering a number of SUP products such as plastic bags and EPS foam containers. Consumers and businesses were given six months' notice, before the introduction of the ban and penalties, which range between US$175 and US$900.[24]

The initial ban has since been bolstered by proposals to include other SUP products such as nappies, plastic cutlery, polystyrene cups, drink stirrers and certain types of food packaging. These bans will be enforced from December 1st 2019. Banning nappies should have a positive effect on the environment, as their multilayer, composite structure (including a combination of plastic and absorbent chemicals) means they are a complex waste to process. However, a central critique of banning disposable nappies is the disproportionate social impact on women (due to the burden of the additional effort and time required when using reusable alternatives).[25] By coupling such a ban with education and awareness campaigns, the negative impacts can be reduced. Without these, the ban's impact could conflict with development strategies in Vanuatu such as the National Gender Equality Policy.[26]

An additional consideration for the impact of Vanuatu's SUP ban is regarding local and small manufacturers. Traditional biodegradable woven baskets made of pandanus are manufactured in rural areas of the country. It has been reported that these local alternatives struggle to compete with mass-manufactured reusable alternatives (for example, from China) that are flooding the market to meet increased demand following the ban. [27]

The social and economic implications of bans are therefore multifaceted and often unpredictable. The examples of Kenya and Vanuatu highlight differing instances of this, and the importance of adapting to mitigate against negative impacts as they arise.

3.2 Bans and levies

An introduction to bans is given in Section 3.2. Here, it is now explained how bans can be coupled with an additional policy instrument; levies. Levies are a charge placed on certain products, which can be consumer facing or higher in the supply chain.

The combination of bans and levies is a policy instrument that has been favoured by several countries, in which the ban covers the most damaging SUP product while the levy is placed on the single-use alternative, and reduces consumption (and thereby waste and litter generation). Levies can target both problematic plastic and non-plastic items, incentivising behaviour changes to reduce consumption. In terms of the waste hierarchy, this is a more favourable approach as it encourages waste prevention as opposed to bans that shift consumption (and waste generation) to different materials.

Outright bans may not lead to a reduction in consumption (and any associated litter generation) if single-use alternatives are provided freely (and in some cases, subsidised). When such alternatives are coupled with a levy, greater emphasis is placed on shifting away from the single-use culture that is embedded in societies across the globe. Encouraging consumers to adopt reusable products reduces the environmental burden of single-use products (both plastic and non-plastic) and the costs associated with their disposal.

Levies/ charges, on the other hand, can raise funds which can be ring-fenced for particular kinds of spending though this is not always the case. Proceeds can also remain with the retailer, such as the grocery store or café, at which the charge is applied. In addition, it is noted that the point of application of such levies/ taxes (e.g. at point of manufacture/ sale/

purchase) also impacts the effectiveness of this instrument. Levies can also be an effective instrument in reducing consumption when used independently of bans.

The examples in Table 3 outline how bans and levies have been introduced to varying degrees of success.

Table 3: Global Levies Examples

Location	Items covered	Date implemented	Enforcement	Comments
Botswana	Plastic bags	2007	Suspended	First implemented in 2007, a government tax was placed on all plastic bags and retailers could decide the extent to which to pass on the charge to consumers. The result was not considered to be efficient, so a ban was introduced instead in 2018 which was then suspended.
China	Plastic bags	2008	Weakly enforced	Bags less than 25 microns thick were banned, while thicker bags had a charge placed on them.
New Zealand	Plastic bags	2019	n/a	The ban will cover bags up to 70 microns thick and a levy will be placed on those which are thicker. Compostable bags are included in the ban.
Wales	Plastic bags	2011	Well enforced	Single-use bags made of plastic or paper, 'carrier bags', can only be provided by retailers for a fee.

3.2.1 Implementation of levies

Botswana and China have used levies to reduce the consumption of SUPs to varying degrees of success, both of which were implemented in different ways.

China implemented a combination of ban and levy on plastic bags in 2008. Bags less than 25 microns thick were banned, and thicker bags had a levy placed on them. This has reduced plastic bag consumption in supermarkets between 60% and 80%.[28] However, the ban has been weakly enforced amongst smaller retailers and in food markets.

In 2018, an evaluation of the ban's enforcement surveyed 1,101 retailers, of which 979 supplied plastic bags. It was found that most of these were providing plastic bags, and only 17% were charging as stipulated in national law.[28] Most retailers who complied with the law were larger supermarkets. 78% of surveyed retailers used bags that were technically illegal (thinner than 25 microns). Only 9.1% of the retailers in the survey were fully compliant with national law.

A lack of enforcement of the ban has resulted in low levels of compliance.. These have been comprehensively enforced, and have resulted in positive outcomes including raising funds for positive causes and reducing consumption.

Botswana implemented a levy on retailers of plastic bags in 2007, though retailers were able to decide if and how much of this charge they would pass on to consumers. This resulted in a 50% decline in the consumption of plastic bags within 18 months, which was partly attributed to the consistently high prices of bags in the country.[29] While the levies reduced consumption, plastic bag pollution continued to cause a problem for the country, which introduced a complete ban on plastic bags in June 2018, to be implemented in November 2018.[30] The ban was extended to cover importation, manufacturing, trading and possession of plastic bags. The ban's enforcement was proposed to be based on an initial warning, which would be followed by financial penalties and even imprisonment for repeat offenders.
However, shortly after the ban's implementation in early November 2018, the government postponed the ban indefinitely after mounting pressure from the manufacturing industry. The ban has remained suspended since. It is likely that the ban's short warning period and limited engagement in the design phase is the cause of this delay.

3.2.2 Implications of levies

In Wales, mandatory consumer-facing charges on single-use plastic and paper bags have been in place since 2011. The money raised is collected by the retailer, and passed to good causes. There is a preference for environmental causes in Wales.

The levy resulted in a 71% reduction in single-use plastic bag consumption between 2011 and 2014, while consumer support for the charge increased from 61% to 74% between 2011 and 2015.[31] It also estimated that from 2011 to 2014, the five pence charge raised between £17 million and £22 million for good causes. Where levies are enforced, there is clear scope for funds to be raised while deterring consumption.

3.3 EPR - Deposit Return Systems

Deposit return systems (DRS) are well-established policy tools through which incentives are provided for products to be returned to collection points after use. Schemes are a form of extended producer responsibility (EPR), the costs of which can be shouldered by producers/consumers. A DRS is not strictly a form of restriction on SUPs, but has been included here due to its potential impact on the littering of SUPs. As a policy instrument, DRS can be introduced to meet the following objectives:[32]

1. Increase the quantity of target materials captured for recycling (capture rate);
2. Improve the quality of material captured, to allow for higher value recycling;
3. Encourage wider behaviour change around materials (for example, in managing litter); and
4. Deliver economic and social benefits.

UNEP's global review of SUP bans and restriction found that 63 of the 192 countries reviewed had some form of extended producer responsibility (EPR) related to SUPs, including take-back schemes, deposit refund, and waste collection and takeback guarantees for SUPs.[5] Europe had the highest concentration of such schemes. Globally, schemes varied in their scope, with some focusing on particular items and others covering a range.

In this review, we placed emphasis on deposit return systems as the key form of EPR related to tackling litter (a key objective of CLiP). This is because a key aim of EPR in most other forms tends to be covering the costs of waste management (and, less often, litter) and therefore does not deal directly with the issues of litter reduction.

In DRS on the other hand, deposits are the primary mechanism to encourage consumers to return their items (most commonly beverage containers, but sometimes packaging more widely) to recycling points. These deposits vary between US$0.05 and $0.30 per item. Items which are included in schemes are categorised based on material (primarily plastic, metal and glass) and volume.

Where effectively implemented, DRS are a proven method for increasing collection rates of single-use products and reducing littering rates.

Palau established a programme under the Palau Recycling Act, where a $0.10 deposit is charged for every glass, metal and plastic container which is imported into the country. Consumers can return the containers after use for a $0.05 refund.[32] The other $0.05 of the deposit is used to fund the country's recycling programme. However, to be most effective and efficient, a DRS should provide a full refund to consumers – as is the case with most schemes around the world - and the scheme should not be used to fund the recycling of materials outside the scope of the DRS. The costs of recycling such items should be covered by the producers of those items.

3.4 Key Messages

The rapid global adoption of regulatory/binding instruments relating to SUP product restriction has resulted in a growing range of deployments. Those selected in this work are based on available information, relevancy to Belize and the Commonwealth, the SUP products targeted, policy instruments deployed and the maturity of the schemes. This gives examples of good practice, and others that might be considered suboptimal.

Although the uptake of policy instruments which aim to regulate SUP products has been growing in recent years, there is a knowledge gap surrounding their precise impacts. This is often because there has been limited effort to understand the baseline situation prior to implementation, with inadequate subsequent evaluation. However, it is still possible to draw out the guiding principles in establishing such policy measures and the relative performance of each of these.

Extended Producer Responsibility (EPR) schemes have not been discussed in this review. Their omission is due to their focus to date on producers covering the costs of managing the waste, rather than to reduce the consumption or reduce the littering of products, albeit this will be the case in a few years for certain SUP items in Europe where the litter clean-up costs will have to be covered by producers.

3.4.1 Bans

- Bans are a common intervention aiming to reduce the use of, and pollution from, SUP products in countries around the world.

- There is a widespread evidence-gap on the effectiveness of bans as a policy instrument. There are significant differences in their impacts which can be correlated to a number of variables including implementation and enforcement.

- There is no scope for raising tax revenues through bans, with the exception of financial penalties for offending organisations. However, there are significant costs of the ban arising through its implementation and enforcement. These can be direct costs such as policing and indirect costs such as the loss of jobs.

- The implications of bans should thus be given careful consideration to minimise the risk of unintended consequences. These can incur additional financial burdens and disproportionately impact certain groups within society. There is a knowledge gap in this area, and it is difficult to discern whether there are additional burdens on some groups or whether it is only perceived that this could be the case.

- As certain SUP products are banned, national waste management processes must be able to effectively manage their replacements. This may require further regulatory guidance, standards, or infrastructure, such as facilities for industrial composting or anaerobic digestion. Equally, if interventions help to reduce demand (including demand for single-use non-plastic alternatives), there is less of a strain (and associated cost) placed on waste management systems.

- There are a number of design principles which increase the likelihood of a positive outcome: phased enforcement, public awareness campaigns, availability of alternatives and international cooperation.

3.4.2 Levies

- Levies are a legally-binding economic instrument which raise funds that can be spent on waste management programmes, or other causes. These are designed to nudge consumer behaviours in a certain direction, away from the consumption of problem products. There is a much stronger base of evidence for their effectiveness compared to bans, which can be explained in part by their frequent implementation in developed nations, but arguably more significantly, in that they generate data alongside revenue.

- An important further point is that a levy will align the interests of the retailer with those of the Government in seeking to reduce consumption. Taking single-use coffee cups as an example, these are surprisingly expensive, so a charge that encourages customers to bring their own will mean the retailer saves money for each disposable cup they are not required to 'give away'. In some places, smaller retailers are able to keep the proceeds of the charge, which would be additional to the saving from the avoided provision of a disposable cup. This means that the greater the reduction, the greater the benefit to the retailer (plus the consumer should ultimately see a reduction in the price of the coffee as cost of the 'free' disposable cup provided would have been covered by the overall cost. By contrast, where certain SUP items are banned, the apparent single-use alternatives, such as biodegradable or compostable cups are often more expensive, meaning that the ban would lead to a negative financial impact for the retailer.

- Levies are a step towards internalising the cost of damage caused by pollution, moving the economic costs associated with environmental damage to those who consume the product.[33]

- There are still issues around the enforcement of levies, and they require effective governance systems to ensure nation-wide compliance, albeit as explained above, compliance should be higher than for a ban as the incentives for retailers are aligned. Furthermore, the fact that levies raise money (as opposed to bans) means that a proportion of the money raised could be ring-fenced for enforcement.

3.4.3 Deposit Return Schemes

- The majority of these globally have been implemented in developed nations, and are able to demonstrate positive outcomes in increasing capture rates of targeted SUP products while decreasing littering rates.

- There is considerable flexibility in terms of scheme design, meaning that an optimal design for Belize could readily be identified.

- DRS can be implemented relatively quickly, meaning that their benefits with regard to reducing litter and increasing collection rates can be accessed over a short period of time. Schemes can be put in place to complement existing waste management process, or in their absence – standing as their own intervention.

4 Review of Alternatives to Single-use Plastics

As outlined in Section 2.2, this task reviews the relative merits of shortlisted alternatives to key SUP items, based on environmental performance, economic implications and social implications. While the core goal of this study is to prevent litter, there are numerous other potential co-benefits which can be accessed by adopting alternative products, such as potentially reducing emissions and costs of waste management. The outcomes of the review feed into recommendations regarding the pros and cons of alternatives that countries may choose to support alongside the implementation of restrictions on conventional SUP products. These recommendations are contingent on a large number of contextual factors which must be borne in mind when applying them.

Given the wide range of alternatives to SUP products, and the key variations in their use patterns, we have categorised these as single-use non-plastic (SUNP), multiple-use (MU), and alternative plastic (AP) items. The products and materials within each category have relative strengths and weaknesses, which are often dependent on the context of their use and end of life management. Each of these categories of alternatives are further discussed in Section 4.1. Section 4.2 then goes on to describe the key variables assessed in the course of the review, with Sections 4.3 - 4.7 outlining the findings of the review for each category of SUP items assessed.

A summary of the SUP item categories and key alternatives that were shortlisted and have been assessed in this study is provided in Table 4 below.

Table 4: Summary of SUP Alternatives Reviewed

SUP Item Category	Description	Alternatives Reviewed		
		SUNP	**MU**	**AP**
Lightweight Carrier bags.	Lightweight plastic carrier bags (e.g. those provided at grocery stores to carry shopping)	Paper	Cotton	PLA/ PBAT
Food containers for transport	Clamshells, food containers, and soup containers	Cardboard Bagasse	Reusable plastic	PLA
Beverage containers for transport	Plastic beverage bottles and beverage bottle lids, beverage cartons, water and other beverage pouches	Metal cans Glass	Refillable plastic	Bio-based PET
Eating and drinking utensils	Cutlery, stirrers, drinking straws	Wood Paper	Reusable metal	PLA
Food and beverage containers for immediate consumption	Plates, bowls, cups, lids, tumblers - both for hot and cold beverages	Cardboard/ paper Banana skins	Reusable china Reusable plastic	PLA

4.1 Alternatives Reviewed

4.1.1 Single-use Non-Plastic Products

Single-use non-plastic (SUNP) products refer to a range of items which are made from non-plastic materials though are still designed to be used in the same way as conventional SUP products (i.e. to be disposed of after one use). Products may include bottles, cups, cutlery, food dishes and packaging. The materials used include, though are not limited to, wood, cardboard, paper, bamboo, metal and glass.

It is noted that a direct switch from SUP to SUNP items in the absence of any further incentive to change consumer behaviour is likely to have little to no impact on the issues of litter and waste generation. However, depending on the specific material chosen for a particular application, SUNP items may be easier to recycle if collected in formal waste management systems (e.g. aluminium cans). Similarly, some materials may be associated with fewer negative impacts if landfilled or littered (e.g. paper bags).

4.1.2 Multiple Use Alternatives

Multiple use (MU) products are those that are designed to be used time and time again and can be made from any material. Examples include, but are not limited to, water bottles, food containers, reusable coffee cups, "Bags for Life" and metal straws. There has been a recent surge in the use of these products in the UK, as public awareness has grown and policy interventions have nudged consumers away from SUP products.[34]

Generally speaking, MU products are made to a higher quality than single-use products, which increases the environmental impact of their manufacture. Their performance relative to SUP products in this respect therefore improves the more these items are reused. A key advantage of MU items is that, because of their reusable nature, they tend not to be discarded carelessly as litter, nor are they disposed of after just one use.[4] This has significant implications for waste and litter prevention, as well as the avoidance of the negative environmental impacts associated with these relative to SUPs.

MU alternatives can be owned by the consumer, who would therefore take responsibility for cleaning the product, or can be part of a deposit-return scheme. When the product is part of a DRS (such as a city-wide coffee cup scheme), infrastructure is required to collect, clean and distribute products.

4.1.3 Alternative plastics

There are a number of materials which technically and functionally perform as plastics, though are distinguished based on their source material (bio-based as opposed to fossil-based) or biodegradability. The term 'bioplastic' is often used to cover bio-based and biodegradable

[4] It's important to note in this regard that LCA studies comparing reusables with disposable items do not (and indeed are unable to) account for impacts associated with littering at end of life.

plastics. However, this term is confusing as it covers a range of different types of material, even fossil-based material. For clarity, the term can be split into the following three groups of plastic:

- Biodegradable bio-based;
- Biodegradable fossil-based; and
- Non-biodegradable bio-based.

Figure 1 shows an overview of plastic types, the origin of their material and the biodegradability.

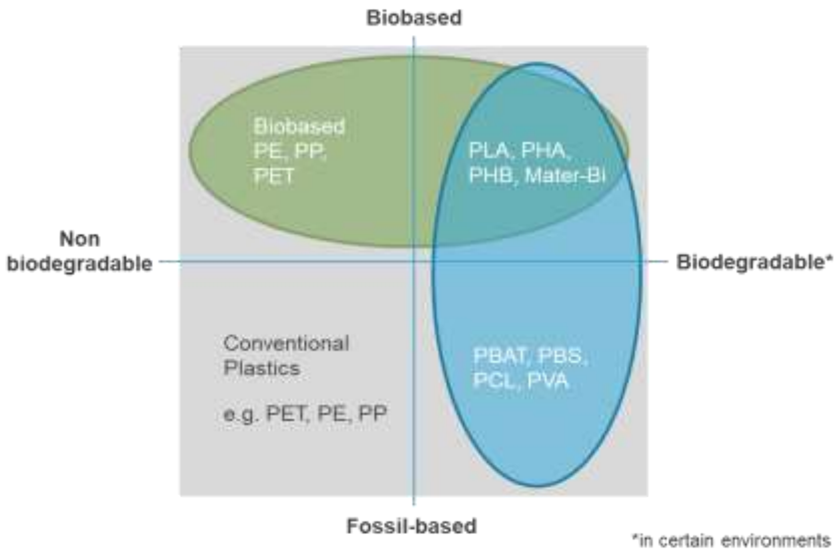


Figure 1: Overview of plastic types

Raw materials for bio-based plastics come from forestry, agriculture, residues, bio-waste and other sources. This includes timber, cassava, plant oils, fructose, maize, sugar cane/beet, corn, potato, wheat and algae. Currently, 0.016 % of global agricultural areas are used to grow bio-based and biodegradable plastic feedstocks.[35]

4.1.3.1 Bio-based Plastics

Bio-based plastics are plastic materials which are derived from plant-based sources, as described above. Plastics which are 'bio-based' may have mixed proportions of fossil and plant-based materials, rather than being entirely plant-based. Bio-based plastics include PLA (polylactic acid), PHAs (polyhydroxyalkanoate), starch blends and bio-PBS(A) (polybutylene succinate).

Bio-based plastics can be further categorised as drop-in or novel plastics. 'Drop-in' bio-based plastics are so called because of their ability to be exchanged directly with their fossil-based counterpart (e.g. bio-PET). On the other hand, there are completely novel bio-based plastics with a chemical structure like no other, for example PLA and PEF (polyethylenefuranoate).

While bio-based plastics are derived (primarily in-part) from plant-based sources, the chemical process creates polymers that can be identical to conventional plastics. This means that just because plastics are bio-based, does not mean that they are biodegradable. For example, as shown in Figure 1, bio-based PET does not biodegrade.

4.1.3.2 Biodegradable Plastics

Biodegradable plastic can be defined as "A degradable material in which the degradation results from the action of microorganisms and ultimately the material is converted to water, carbon dioxide and/or methane and a new cell biomass."

Some biodegradable plastics may biodegrade very quickly in one environment but not in others. It is therefore very important to define timeframe and environment when talking about biodegradation. The term 'biodegradable' has little or no meaning without a clear specification of the exact environmental conditions that this process is expected to occur in.

The rate of decomposition is affected by the presence of bacteria, fungi and oxygen, hence a 'biodegradable' material may decompose in industrial composting conditions, but not (or at a considerably slower rate) in landfills, on land or in the marine environment.

4.1.3.3 Compostable Plastics

'Composting' is defined by the European Commission as enhanced biodegradation under managed conditions, predominantly characterised by forced aeration (in the presence of oxygen) and natural heat production resulting from the biological activity taking place inside the material. The term 'compostable plastic' refers to a material that can biodegrade in an industrial composting facility but not necessarily in a home composting environment, in the ocean or in any other natural environments. These will be made from bio-based plastics.

Industrial composting and anaerobic degradation are the only environments that have been subject to international standards for biodegradation, in the form of the European Standard EN 13432 for plastic packaging and EN 14995 for other plastic items. This is primarily because a test can be developed that simulates *some* industrial composting and AD facilities. However, there is scepticism towards these standards and the methods used to determine the requirements as some have argued that it is not possible to recreate these environments. Industrial composting and AD processes vary from place to place.

4.1.3.4 End-of-life Considerations for Alternative Plastics

Certain bio-based materials can produce common fossil plastic types like PE, PP and PET, which are fully recyclable. These drop-in bio-based plastics are easier to process in existing manufacturing and recycling systems as they are identical to their fossil-based counterparts. Newer bio-based plastics, such as PLA, cannot be recycled together with conventional plastics as existing sorting plants are set to accept fossil-based plastics and do not have separate streams for the newer bio-based plastics. Depending on the sorting technology in place, PLA will therefore either get sorted out of the recycling stream and go to incineration or landfill, or head for recycling. If it does end up entering the recycling process, PLA will cause interference by contaminating the rest of the fossil-based material resulting in lower quality of recyclate, or rejection of the entire load.

There is a range of problems tied to the use of biodegradable and compostable items in the waste management systems that do include organic treatment. If mixed in with food waste, this is most likely sent to treatment plants for biogas production or to industrial composting. As contamination levels are often high, due to incorrect sorting and the use of bags to collect food waste, a pre-treatment process is usually in place to remove all contaminations before the food waste enters both biogas plants and industrial composting plants. Regardless of what material the bag is made of, or whether a product is biodegradable or compostable, or made from fossil resources, the objects will be removed in the pre-treatment process.

In this pre-treatment process the bags are ripped open and shredded and the removal of the entire bag, and other contaminants, is challenging. Some particles will follow the process and mix in with the final product (digestate or compost). Leftover plastics that are not removed can cause mechanical trouble to the equipment used in the plant, but also to the equipment used in agriculture when using the digestate or compost. Microplastics have become a severe challenge and there is a high risk that food waste bags and contaminations will give rise to microplastics in the digestate. Some plastics are biodegradable, and will degrade over time.

The recognised standard for the biodegradability of packaging products, EN 13432, covers their degradability in industrial treatment plants, both industrial composting and biogas plants. Although some products are certified as compostable as per EN 13432, it is not guaranteed that they will degrade in all composting and biogas plants as the treatment period does not match the criteria of the test method. The test conditions used for certification of biodegradability of packaging products are not comparable to real life conditions in most plants. The pre-treatment process in place at these industrial plants will also remove waste bags and other contaminations to the food waste, including biodegradable and compostable products.

4.2 Key Variables Reviewed

4.2.1 Environmental Performance

When assessing the environmental performance of various alternatives relative to the SUPs they seek to replace, the following key impacts are considered:

- GHG emissions, other externalities, and land/ water use associated with the production of items;
- GHG emissions, other externalities and land/water use associated with the management of waste arising from these items; and
- The impacts of litter associated with these items (in both marine and terrestrial environments).

These impacts are dependent on a range of additional variables, such as transport costs, washing costs (for reusable items), carbon intensity of the energy mix in different markets, etc.

Life cycle assessments of the environmental impact of SUPs and their alternatives have largely been carried out in the context of developed country markets (for example, within the EU, USA, Australia and Canada), with several of these being funded by the plastics industry themselves. The applicability of the findings of these studies to other country/ market contexts, as well as potential conflicts of interest in the findings of the literature reviewed, must therefore be treated with caution.

4.2.2 Socio-economic Implications

The economic impacts of a switch away from SUPs to other alternatives vary in terms of overall costs to producers, retailers and consumers. In addition, the cost associated with managing waste derived from the various alternatives must be considered, as well as the damage costs associated with the externalities (including litter) they generate.

An assessment of these impacts depends on a number of market-specific variables including the unit cost and availability of different alternatives in different markets, their durability/ functionality and therefore extent of their life in use, any additional costs associated with reusables (such as refill/ washing schemes), the distributional impact of the costs depending on the purchasing power of various income groups in society, and so on. The findings in this review are therefore relative to the markets in which the research has been conducted, and cannot be directly extrapolated to other country contexts.

In addition to the distributional impacts mentioned above, impacts associated with employment (both associated with manufacturing as well as end of life management of alternatives) are explored – this will be particularly important in countries with a large labour force in which employment is a significant driver of policies. Here, additional consideration must be given to the point of manufacture of the various alternatives to SUPs – for example, in markets that largely import SUPs as opposed to manufacturing them locally, the impact of a switch away from these products on the local employment market will not be significant.

4.3 Lightweight Carrier Bags

4.3.1 Summary of Assessment

As shown in Table 6 below, of the alternatives reviewed, reusable bags are the most preferred alternative due to their limited potential for becoming litter, and the reduced impacts associated with end of life management. Reusable bags made of plastic (either polyethylene [PE] or polypropylene [PP]) perform favourably compared to cotton ones, due to their lower environmental impacts in the production phase, greater functionality and lower economic cost.

Neither paper nor bio-based plastic bags represent an advantage in respect of preventing litter, though paper alternatives are highly degradable and therefore are likely to have a limited impact if they do end up as litter. Bio-based plastic bags, on the other hand, are likely to degrade only under certain industrial conditions. This, coupled with their resource intensity in the production phase (relative to conventional plastics) and their GHG impacts in landfill (due to methane emissions) make them a less favourable choice in the absence of investment in end of life management.

Finally, given the economic advantage conventional plastic bags have over the alternatives assessed below (in terms of purchasing cost), reusable plastic bags (such as bags of life in the UK) present the best option from both an economic and environmental perspective on a per use basis.

Table 5: Summary of Carrier Bag Alternatives Assessed

Material	Item Type	Advantages	Disadvantages
LDPE/ HDPE	Single-use plastic	• Economically preferable • Least environmental impact in production phase	• Negative impacts at end of life significant in landfill, incineration; and not practical for recycling • Highest littering potential and impacts of litter
Paper	Single-use non-plastic	• More expensive than SUP • Environmental impacts in production phase higher relative to SUP (use of recycled paper improves this performance)	• High potential for litter though degradable • Lower impacts at end of life relative to SUP(as widely recyclable)
Cotton	Multiple-use	• Most expensive on item basis, though economy improves with an increasing number of reuses • Highest environmental impact in production phase	• Less widely recyclable than paper • Least potential for littering
Reusable PE/ PP	Multiple-use	• More expensive than SUP on a per item basis, though cheaper on a per use basis • Environmental impacts in production phase higher relative to SUP, though performance improves with higher number of reuses	• Less widely recyclable than paper • Least potential for littering

PLA (including PLA/PBAT)	Single-use alternative plastic	• More expensive than SUP • Higher environmental impact at production phase relative to SUP	• Negative impacts at end of life significant (particularly in landfill) • High littering potential and potential impacts of litter

4.3.2 Alternatives Selected for Assessment

Globally, the use of plastic carrier bags is estimated to be around 0.5 billion to 1 trillion per annum.[36] The majority of these bags are single-use products, which are then discarded, landfilled or incinerated. The definition of a single-use carrier bag as used in this work is the same as that adopted by the European Commission:

"carrier bags, with or without handle, made of plastic, which are supplied to consumers at the point of sale of goods or products…with a wall thickness below 50 microns". [37]

These bags are commonly made from polyethylene, a plastic which can be used in high- or low-density forms.[38] High density polyethylene (HDPE) is used for the majority of carrier bags, while low density polyethylene (LDPE) is lighter and can be used in films and wrapping. The scale of production of plastic carrier bags means that their relative environmental impact per bag at the production stage is small. However, the tendency of these bags to be littered, and their lasting negative impacts in the natural environment has been widely recognised leading to a number of measures such as bans and taxes/levies/charges to tackle the issue. [5] While it is technically possible to recycle polyethylene in many of its forms, it does not typically occur for reasons of cost due to the limited amount (by mass) of material relative to the surface area, which will often be contaminated. Therefore, there are limited efforts to increase capture rates, exacerbating the effect of single-use plastic bag consumption and littering.

In the subsequent sections, the relative pros and cons (economic, environmental and social) of some key alternatives to SUP carrier bags are assessed based on the available literature.

1. **Multi-use cotton bags (also known as 'tote' bags):** These are reusable alternatives to single-use polyethylene bags. While cotton bags are not made from fossil-based materials like conventional plastics, there is a significant amount of embodied carbon in the growing of cotton and manufacturing processes. There are also issues around the use of agro-chemicals and freshwater usage. They are generally smaller than the largest plastic bags in use, with a lower carrying capacity. However, they rarely end up in litter and are highly reusable.

Figure 2: Example of a cotton carrier bag

2. **Single-use paper bags:** Single-use bags made of kraft or unbleached paper are available with and without handles and in a variety of sizes and thicknesses depending on their application. They tend to be less durable than conventional plastic carrier bags and incur greater carbon impacts in the production phase, though the increased use of recycled paper in their manufacture and high degradability improve their environmental performance. They are more likely to be recycled and will biodegrade entirely if littered.

Figure 3: Example of a single-use paper bag

3. **Reusable plastic bags (PE/ PP), woven or non-woven):** Resuable plastic bags can be made of a range of materials, including thick gauged or 'heavy-duty' LDPE, and woven or non-woven polypropylene fibre. In all cases, these tend to be thicker and heavier than conventional single use plastic bags, and are therefore more durable, allowing them to be reused multiple times. These are often offered as alternatives to banned single use plastic bags, though usually sold with a consumer levy or charge in order to incentivise reuse and prevent littering.

Figure 4: Example of reusable plastic bag (woven PP), copyright Bag for Life UK

Figure 5: Example of reusable plastic bag (LDPE), copyright Bag for Life UK

4. **Single-use bioplastic bags (PLA, generally starch based biopolymer):** Biodegradable plastic bags are often made of bio-based polylactic acid (PLA), the feedstock for which can be a variety of starches (e.g. corn and potato). This material is often produced as a mixture including fossil-based PBAT (polybutyrate adipate terephthalate) for carrier bags, due to the similar properties it bears to LDPE. Such bags are single-use, and tend to be less resistant than conventional LDPE bags. Their compostability/ biodegradability is widely debated.

Figure 6: Example of a PLA carrier bag. Copyright: Vegware

4.3.3 Assessment of Environmental Performance

A large number of life cycle assessment (LCA) studies have been carried out to assess the environmental performance of different carrier bags. LCA provides a standardised methodology for quantifying environmental impacts of providing, using and disposing of a product or providing a service throughout its life cycle, taking into account the resources necessary to produce, use and dispose the product, and also the potential emissions (or avoided emissions, in the case of recycling/ reuse) that may occur during these stages.

LCA is therefore a valuable tool in the objective assessment of these alternatives, which have a number of different impact areas including emissions (kg CO_2e/ global warming potential), land use, water use and toxicity amongst others. It is worth noting that generally LCA studies select a number of environmental impact categories to explore, which are deemed most relevant to the objectives of the study, rather than to provide a comprehensive assessment of all impacts. While LCAs are a useful tool, there is a need for them to be contextually relevant in terms of the study location (and associated distribution/ waste management systems) and date of study (within the last decade as recycling rates and technologies have improved considerably).

Despite the consistent application of the LCA methodology therefore, the findings of the carrier bag LCA studies reviewed here are limited in both scope and application. This is due to the use of a wide range of assumptions regarding the production, use, and, most prominently, disposal, of carrier bags in each of the studies. In particular, the studies fail to account for the environmental impacts of litter, which are often significant and long-lasting, though difficult to quantify. This is an important limitation, given that the aim of this task is to assess the relative impacts of single-use plastic carrier bag alternatives on litter and waste prevention.

For example, a recent study by the Danish Environmental Protection Agency[39] found that conventional single-use LDPE carrier bags for groceries are the most environmentally friendly option in the Danish context, outperforming paper, cotton and biopolymer (starch-based) alternatives particularly in respect of impacts associated with production emissions and resource use. In all cases, a higher number of reuses of the carrier bags studied improved their environmental performance, though the potential for reuse was noted to be limited for the paper and biopolymer alternatives. Of the reusable bags assessed, it was found that a cotton bag outperforms conventional single use plastic bags on climate change impacts after roughly 52 uses, compared to the reusable plastic bag (PP, woven/ non-woven) which is preferable after only 5-8 uses. The study assumed, however, that the LDPE bags were neither littered, nor did they end up in landfill. These assumptions are not unreasonable in Denmark's context, but are clearly not representative of the majority of Commonwealth countries, where a relatively large number of such bags may end up in the wider environment.

A study by the UK Environment Agency[40] similarly found that single-use HDPE carrier bags outperformed cotton, bioplastic, and paper alternatives in the production phase, and that the number of reuses of each item was the key to improving environmental performance (estimated across 9 key indicators). The study concluded that cotton bags struggle to compete with conventional HDPE carrier bags even when reused widely. Paper bags showed better performance, albeit still requiring 4-5 reuses before they can compete with conventional bags (unlikely given the limited durability of paper bags). Starch-polyester carrier bags performed the worst in seven out of the nine impact categories considered, in part due to the high impacts of raw material production and high emissions of methane when such bags are landfilled. With regards to the reusable plastic bags, the study concluded that:

The LDPE bag has to be used five times to reduce its GWP to below that of the conventional HPDE bag. When used five times, its impacts were lower in eight of nine of the impact categories…

The non-woven PP bag had to be used fourteen times to reduce its GWP to below that of the conventional bag. With this level of reuse it was also superior to the conventional HDPE bag in five of the nine categories…When recycling was considered global warming potential and abiotic depletion impacts were reduced similar to the HDPE bag.

This finding is significant, especially considering that the likelihood of the bags being littered and impacts in this scenario were not considered – this would likely improve the performance of reusable plastic bags even further .

Similar results were found in a study of Carrefour's key carrier bag alternatives in France (excluding cotton bags) that later fed into an impact assessment for a levy on carrier bags in Scotland[41]. However, the Carrefour study additionally compared the alternatives in terms of overall litter risk, by developing qualitative indicators (high, medium, low) of the volumes consumed of each type of bag, and the potential for these to be littered, windswept (and thereby littered) and to subsequently remain in the environment as litter. Using this rudimentary approach, the authors concluded that paper bags were associated with lower litter risk than both compostable and conventional plastic alternatives, mainly due to their lack of persistence in the wider environment after becoming litter. As mentioned, cotton bags were not assessed.

The aforementioned Scottish Impact Assessment further found that the overall conclusion from the Carrefour study indicated that reusable plastic bags ('bags for life') are more sustainable than all types of lightweight carrier bags (plastic, paper, or degradable) if used four times or more (see columns 4 and 5 in table above), offering the greatest environmental benefits over the full life cycle of any bags used.

A study by Uslu et al. in Spain[42] sought to refine this approach further, carrying out a probability analysis using the same indicators as in the Carrefour study in addition to the number of bags required to meet the functional unit of the study, surface area, weight, price and biodegradability of the materials applied to the bag. The results of the risk analysis were then compared to the LCA results of the other environmental impacts associated with paper and biodegradable bags. Cotton bags were not included in the study. It was found that

"…the littering potential [LP] calculated resulted in nearly the opposite ranking of the conventional LCIA results. The conventional LCIA results gave preference to LDPE and HDPE bags, while the LP indicator identified these types of bags as having the highest probability of contributing to marine littering problem."

It is noted however, that when comparing between the paper and biodegradable plastic bags, the authors applied the same degradability criteria to both these alternatives, in the absence of clear data on degradability of bioplastic bags. A lack of subsequent sensitivity analysis on this assumption precludes a robust comparison of these two alternatives.

The review therefore concludes that conventional single-use plastic bags outperform the cotton, paper and biopolymer alternatives in the production phase.

In the end of life phase, however, plastics and biopolymers both perform poorly if landfilled, with the latter responsible for large methane gas emissions if they biodegrade.

In incineration, paper, cotton and biopolymer alternatives perform better than plastic bags due to the lack of fossil-based carbon in these, though in the case of PLA/PBAT compounds that do contain a proportion of fossil-based polymer, their performance is reduced.

If recycled, the performance of all the alternatives improves, though the likelihood and feasibility of recycling is highest for the paper alternatives, with both the conventional and biopolymer plastic alternatives highly prone to littering and associated impacts. Biopolymer alternatives in particular were found to be rarely recycled/ composted, disrupting the recycling process if wrongly sorted with other conventional plastics, and separated out of the organic fraction prior to composting in Denmark.

The potential for littering was highest for the single-use items – conventional plastics, bioplastics, and paper. Reusable plastic bags were associated with a much lower litter risk, reducing their overall impacts. Of these, the impacts of single use plastics were deemed to be the greatest due to their lack of degradability. The degradability of bioplastics in the natural environment is debated, with studies concluding that these do not to degrade if not collected and composted in specific heat and moisture conditions that tend not to be achieved in the natural environment.

Finally, a higher number of reuses increased the environmental performance of alternatives across the board, though both paper and biopolymer alternatives were found to be less reusable than conventional plastic bags, with cotton providing the most reusable alternative. Multi-use plastic bags were found to be more favourable than cotton bags in terms of overall environmental impacts.

4.3.4 Assessment of Socio-Economic Implications

The economic implications of a switch away from single-use plastic carrier bags are highly relative to the markets in which they occur, and the mechanisms underlying such a switch. In the review below, these impacts are considered in broad terms, focussing on production, retail, consumption, and waste/ litter management.

4.3.4.1 Production impacts

The impacts of such a switch on employment and profit in the production phase depends heavily on the extent to which plastic bags and their alternatives are manufactured domestically as opposed to being imported. In addition, the cost of labour and the labour intensity of such manufacturing operations must be considered. Previous work in the EU and Norway has suggested that the manufacture of plastic bags is likely to be more labour intensive (and associated with greater employment costs) than paper and cotton alternatives on a per tonne basis. Given the lightweight nature of plastic bags in comparison to these alternatives however, the labour intensity on a per item basis is likely to be lower for plastic bags. This suggests that there is likely to be a short-term loss of employment associated with a switch away from single-use plastic carrier bags, which could be exacerbated if the consumption of other single-use alternatives is also restricted. It is worth noting that in several cases, it has been reported that mass-manufactured carrier bag alternatives (particularly cotton and paper bags from Asian markets) can crowd out locally manufactured alternatives that are comparatively expensive (See the example of Vanuatu in Section 3.1.2). Such welfare trade-offs between local employment and costs must be considered.

4.3.4.2 Retail/ consumption impacts

In the majority of cases, single-use plastic carrier bags are the cheapest alternative for retailers, and are provided to consumers free of cost (albeit they are not free to the retailer and the cost will thus be covered through the price of good paid by the customer to the retailer). In comparison, cotton alternatives are likely to be the most expensive on a per item basis, and therefore very challenging for retailers to provide free of charge. In the case of reusable plastic, biopolymer and paper alternatives, these are still significantly more expensive (as much as ten times more so) than conventional plastic carrier bags, though in the case of biopolymer bags, unit costs are declining due to economies of scale as they become more widely produced. It is noted that the additional costs of reusable plastic bags to retailers are likely to be more than offset by the reduced frequency with which they would have to be provided. For this reason, a ban on conventional plastic bags, with alternative bioplastic bags permitted, would lead to negative economic impacts for retailers (and ultimately consumers) if they felt compelled to 'give them away' without an explicit charge.

Table 6 below compares the cost of different alternatives to single-use carrier bags in the EU market as estimated in the EU Carrier Bag Impact Assessment[43].

Table 6: Unit Costs of Carrier Bag Alternatives to Retailers (EU, 2011)

Bag Type	Unit Cost (per 1,000 bags)[31]
Single-use Non-Biodegradable Plastic Carrier Bag	€8.31*
Single-use Biodegradable Plastic Carrier Bag	€82.87*
Single-use Paper Bag with Handles	€97.58*
LDPE 'Bag for Life'	€17.87*
Woven PP	€452.73**
Jute	€1,161.62***
Cotton	€1,111.25*

Notes

* Costs taken from http://www.polybags.co.uk/

** Data taken from AEA Study for the Welsh Government[32]

*** Costs taken from http://www.midpac.co.uk/jute-bags/natural-jute-bags

Source: Eunomia for the European Commission (2012)

It is noted therefore that in the case of these single-use alternatives (biopolymer/ paper), the transfer of the costs of the bags from retailers to consumers is therefore likely to be necessary in order to avoid excessive cost burden on smaller businesses in particular. It would be preferable to legislate for this rather than leave it to the discretion of individual retailers.[44] In this scenario, cotton bags are potentially more cost effective for the consumer in the long run due to their high reusability relative to paper, biopolymer and single-use plastic alternatives. The most cost-effective alternative in this regard is likely to be multi-use plastic bags.

4.3.4.3 Waste management/ litter impacts

The cost of waste management of single-use plastic carrier bags and other bags will depend upon the waste management route taken, and the unit cost of each route, with considerable variation from country to country. This includes consideration of the collection costs associated with the relevant waste service provided, as well as the extent to which waste is exported for treatment (and the relevant transport costs).

Similarly, the cost of litter is highly variable depending on the costs associated with both the managed fraction of litter (i.e. the litter that is subsequently picked up and managed by municipal authorities) as well as the unmanaged fraction (i.e. that which remains in the wider environment). For managed litter, it is possible to make an estimate of cost based on:

1. A labour component, for the individual sweeping/picking up litter, or driving a mechanical sweeper;
2. A cost for the vehicle/plant expenditure and other operational costs; and
3. The cost of disposal of the litter collected.

However, the cost of the unmanaged proportion of litter is more uncertain, firstly because the extent of this issue is often unknown (i.e. the total tonnage of plastic bag litter that is not cleaned up is not known), and secondly because the extent of the impact is often uncertain. Previous studies have attempted to estimate this based on the reported extent of disamenity consumers experience due to litter in various environments, though this estimate still cannot account for the wider impacts of plastic litter on the environment.

Both the costs of waste management and litter management are likely to be higher for the single-use carrier bag alternatives assessed here, due to the higher volumes of waste and litter generated relative to the reusable cotton alternative. Of the single-use alternatives, bio-based and conventional plastic bags are likely to be the most costly to manage at the end of life.

4.4 Food containers for transport

4.4.1 Summary of Assessment

As shown in Table 6 below, of the alternatives reviewed, reusable plastic food containers are the most preferred alternative due to their limited potential for becoming litter, and the reduced impacts associated with end of life management. However, mobilising these alternatives may require additional efforts in terms of establishing bring your own container schemes, or providing mobile washing units to encourage their use in on-the-go contexts.

Neither fibre-based (bagasse/paperboard) nor bio-based plastic containers represent an advantage in respect of preventing litter, though paper alternatives are highly degradable and therefore are likely to have a limited impact if they do end up as litter. This is likely to be similar for bagasse containers so long as they are not manufactured with PLA lining. PLA food containers, on the other hand, are likely to degrade only under certain industrial conditions. This, coupled with their resource intensity in the production phase (relative to conventional plastics) and their GHG impacts in landfill (due to methane emissions) make them a less favourable choice in the absence of investment in end of life management.

Finally, reusable plastic containers were also found to have an economic advantage over their single use counterparts, assuming they are regularly reused. This also relies on the further assumption that single use plastic containers are not reused, which is true of EPS containers, as well as PE-lined paper ones, but not necessarily so for rigid plastic containers.

Table 7 Summary of Food Containers for Transport Assessed

Material	Item Type	Advantages	Disadvantages
Rigid plastic/ Plastic-lined/ EPS	Single-use plastic	• Economically preferable • Highly functional in multiple applications	• Negative impacts at end of life significant in landfill, incineration and not practical for recycling • Highest littering potential and impacts of litter
Bagasse	Single-use non-plastic	• Relatively inexpensive compared to other single use alternatives • Less complicated to manage at the end of life than PLA and compostable. Biodegradable in pure forms	• High transport costs because of production concentrated in sugar-cane growing countries • The impact of end of life management will depend on whether the material is combined with other materials (e.g. PLA lining) in production

Material	Item Type	Advantages	Disadvantages
Paper/ Card	Single-use non-plastic	• More expensive than SUP • Environmental impacts in production phase higher relative to SUP (use of recycled paper improves this performance)	• High potential for litter though degradable • Lower impacts at end of life relative to SUP (widely recyclable)
Reusable Plastic	Multiple-use	• Most preferable alternative across the majority of environmental indicators (related to production and waste management phase) • Economically more favourable than single use alternatives when reused a greater number of times • Least potential for litter	• High water use and retailer costs associated with washing products before they can be reused
PLA	Single-use alternative plastic	• More expensive than conventional SUP • Higher environmental impact at production phase relative to other single use alternatives	• Negative impacts at end of life significant (particularly in landfill) • High littering potential and impacts of litter

4.4.2 Alternatives Selected for Assessment

Food containers for transport include takeaway food packaging such as boxes, clamshells and bowls made of rigid plastic, EPS foam and polyethylene-lined card.

The category excludes plates, trays, cups, and other plastic food packaging that are filled at the point of sale for immediate consumption. The differentiating characteristic between these two categories is the need for greater functionality (particularly in terms of airtightness, waterproofness and durability) in the case of food packaging for transport. Plastic cups with lids (such as takeaway coffee cups) have also been included for analysis here, due to their tendency to be consumed on the go rather than immediately.

Market reports estimate that together, roughly 6.5 million tonnes of these two categories of single use plastic food packaging (i.e. food containers and cups for both immediate consumption and transport) will be placed on the market globally in 2019.[45]

The low value, durability and light weight of these items make them both commonly used, as well problematic if littered in the wider environment. Litter associated with such items is common, as indicated by their regular identification in the top ten items (by count) found in beach, river and land litter surveys around the world. EPS foam cups, food packs and trays have similarly been identified as key category of items found in Belizean litter.[46]

Even if disposed of correctly, high amounts of food contamination for such items make them prone to high reject rates and are thus a barrier to their recycling into high quality, high value materials. When collected, these items therefore tend to end up in landfill or incineration, if not in litter.

1. **Single-use Bagasse Containers:** Bagasse is a fibre-based packaging material, manufactured from sugarcane pulp residues instead of wood that is conventionally used in paper and card manufacture. The fibres derived from the crushing of sugarcane to extract the juice are well-suited to the manufacture of paper and card packaging as they can be converted into bio-based materials that can be compostable, depending on the blend of the end-material, under various conditions. Utilising sugarcane residues in this way also prevents burning of such by-products as waste from the sugar industry.

   For every 10 tonnes of crushed sugarcane, nearly three tonnes of bagasse is produced by the sugar industry. Since bagasse is a by-product of the sugar cane industry, the quantity of bagasse produced by each country depends on the amount of sugarcane it produces, with countires like India and China currently dominiating this market. However, the cultiavtaion of sugarcane is spread across more than 90 countries, with the crop's abundance making the use of its by-product for packaging production feasible on a worldwide scale in the future. [47]

Figure 7: Example of single-use bagasse Food Container

2. **Single-use Paper/ Card Containers:** Single use food containers made of paperboard or card are a common alternative to plastic takeaway food containers, though their applications are limited due to their reduced barrier properties and durability when compared to plastic containers. Such containers are often lined with polyethelene film to address this issue, though this negatively impacts both the recyclabiltiy and degradability of card packaging products.

Figure 8: Example of single-use paperboard/ card food container

3. **Reusable plastic Containers:** For at-home consumption of take-away meals, reusable containers can be used. These are already widely used and accepted in environmentally focused establishments across Europe, rather than SUP containers which are used by the majority. Consumers can either purchase standardised containers, taking these to the relevant takeaway outlet when they go to pick up their meal (they then wash it at home ready for the next visit), or they can bring their own containers to fill up and take away. For home delivery of food, which is becoming more popular, reusable containers can similarly be supplied for a small fee which can be refunded when the container is returned to the store/ returned on the next delivery.

   Where consumers are visiting take-away outlets and want to eat out 'on-the-go', the potential for utilising reusable containers is diminished, but could be achieved if reusable approaches were more established (a container could be provided for a refundable deposit and returned to the same or other participating outlets).

Figure 9: Example of reusable plastic containers

4. **PLA Containers:** The use of single-use food containers made of bio-based polylactic acid (PLA), the feedstock for which can be a variety of starches (e.g. corn and potato), is increasing globally as a replacement for conventional single use plastic containers. However, though often advertised as compostable/ biodegradable products, this is often in reference to industrial conditions which are not always met in commercial facilities and the wider environment. In addition, these items are often confused with conventional plastics, and disposed of incorrectly, causing problems for conventional plastic recycling where it does take place.

Figure 10: Example of single-use PLA food container

4.4.3 Assessment of Environmental Performance

Studies on the environmental performance of alternatives to SUP food and beverage containers tend to vary in their scope (i.e. the types of containers considered and the relevant applications for these) and assumptions. As outlined in Section 4.3.3, the methodology and findings of these studies should therefore not be extrapolated to other contexts, though they do provide a useful indication of the relative merits of the selected alternatives.

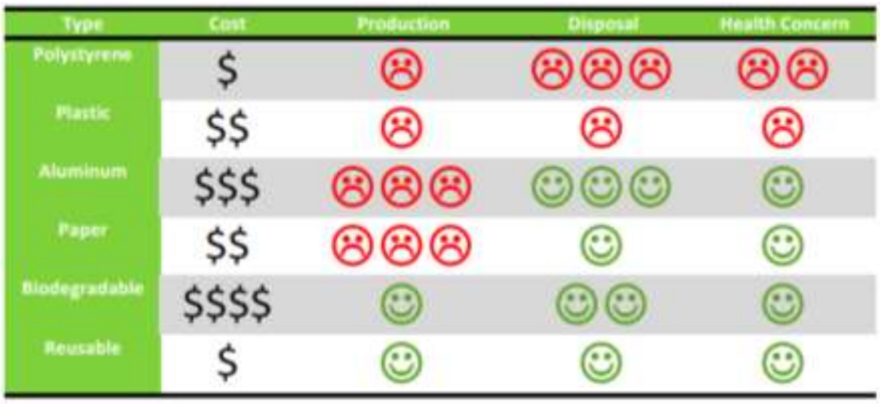
A study for the Norwegian Environment Agency[48] considered the environmental impact of switching from single use plastic food containers to reusable card alternatives with a mineral oil layer in place of the conventional polyethylene lining. Environmental impacts considered included the GHG emissions associated with the production, washing (in the case of reusables) and end of life management of the items, as well as the likely amount of waste and litter that would be generated if all SUP food containers were replaced by all mineral-oil coated card.

It was found that a larger amount (by mass) of waste and litter was associated with the card alternatives – though this was explained in part by the fact that the card alternatives are heavier on average per item than the SUP ones (particularly when compared to EPS containers). In addition, the card alternatives were associated with less impact when littered, due to their degradability (though this was not assessed quantitatively).

In addition, it was found that the overall GHG impacts associated with the card alternatives was lower than that associated with SUP containers, though the land and water use in the production phase was marginally higher for the card alternatives.

The same study also considered the relative merits of reusable plastic cups relative to conventional SUP cups (including PE-lined paper cups), finding that across all environmental parameters except water use (for washing), reusable plastic was preferable to single use plastic.

In a separate study to assess the pros and cons of food containers for transport in Vancouver[49], polystyrene, single use plastic, aluminium, paper, bagasse (biodegradable) and non-aluminium reusable alternatives were reviewed across a range of key indicators, with the findings of this review summarised on a qualitative scale of very bad (three red faces) to very good (three green faces), reproduced in in Figure 11 below.



Type	Cost	Production	Disposal	Health Concern
Polystyrene	$	☹	☹☹☹	☹☹
Plastic	$$	☹	☹	☹
Aluminum	$$$	☹☹☹	☺☺☺	☺
Paper	$$	☹☹☹	☺	☺
Biodegradable	$$$$	☺	☺☺	☺
Reusable	$	☺	☺	☺

Figure 11: Summary of On the Go Food Containers Assessed in Green 2 Go Report

These results led to the following recommendations, in the context of Vancouver's existing waste management systems and consumer market:

• *We encourage restaurants to provide incentives to customers that bring their own reusable containers.*

• *We recommend restaurants to consider switching to compostable containers even if it means asking customers to incorporate the additional costs.*

• The use of plastics is not recommended as their recycling rates are considerably low and the production impact is high, but if necessary restaurants should purchase plastic with resin codes 1 or 2

• Even though Styrofoam containers are currently the cheapest available option, there is no responsible way to dispose of food soiled polystyrene containers in Vancouver. Styrofoam carries prolific and persistent end-of-life management issues so we strongly discourage their use and suggest their substitution by materials that can be effectively degraded or composted.

Regarding the findings related to bagasse in particular, it is worth noting that the study caveats the environmental performance of this material with two key points:

1. The end of life environmental impacts of this material will depend largely on the disposal route it is associated with; and
2. Bagasse is commercially manufactured in a limited number of countries worldwide, necessitating consideration of the transport and energy costs associated with their use internationally.

Regarding the first point, many of the concerns the authors list mirror those raised in respect of the PLA alternatives reviewed for carrier bags in Section 4.3.3. The environmental impacts associated with PLA food containers are logically likely to be similar to those identified for PLA carrier bags. When considering bagasse however, it is noted that it does not resemble conventional plastic (see Figure 7), and is therefore less likely to be confused for plastic and cause disruption in the plastic recycling process than PLA.

Regarding the environmental impacts associated with transporting materials globally, it can be argued that the manufacture of many conventional plastic packaging items is currently concentrated in a handful of countries (China for example) with similar impacts related to transport emissions expected for these items as well (albeit to a lower extent as plastic is lighter to transport per unit relative to bagasse). However, the development of markets and associated economies of scale in the manufacture of bagasse products could help to mitigate against these externalities and make them more competitive with conventional SUP food containers and packaging more generally.

Finally, when considering the environmental impacts of bagasse food containers relative to reusable plastic ones specifically, a study carried out at the University of California, Berkeley is relevant, having compared the impacts of GHG contributions, energy consumption, material waste, and water consumption associated with bagasse and reusable polypropylene clamshells.[50] As was the case in the Vancouver study, it was found that the reusable plastic clamshells performed better than the compostable alternatives on all indicators, except for water use (given the need to wash reusable containers for reuse). The author concluded that the reusable clamshell required 14 reuses before one clamshell generated the GHG emissions, energy, and material waste of one compostable takeout clamshell used once. Consequently, a consumer that used 15 compostable takeout clamshells would have a greater overall environmental impact in these three categories than a consumer that uses a reusable clamshell 15 times. On average, the reusable clamshells were found to be used 43 times before breakage.

4.4.4 Assessment of Socio-Economic Implications

4.4.4.1 Production Impacts

As can be seen from Figure 11 in the preceding section, of the alternatives to SUP food containers for transport that were assessed in Vancouver, reusable plastic alternatives are likely to present the least expensive option in terms of financial costs, though the assumptions and elements of this financial analysis are not made clear in the study.[49]

When comparing the costs of PLA and bagasse food containers with conventional SUP food containers, a study by the FAO found that:

The vast majority of bio-based food packaging products are relatively expensive compared to fossil-based alternatives (Molenveld et al., 2015). Unfortunately, no precise statistics on the cost comparison between fossil-based compared with bio-based materials for food packaging is available, a few studies give an indication that bio-based materials made from residues is between 3 to 5 times more expensive compared with fossil-based materials for packaging (Economic Planning Systems Inc, 2012; Rodenburg, 2016; Van Dijk, 2016). The main drivers of the cost for producing bio-based materials include: Cost of mobilizing biomass residues, Cost for technological innovations required, Lack of economies-of-scale. [47]

Additionally, In Norway, a switch to the reusable plastic cups as well as the card food containers were estimated to be associated with an increase in employment figures (associated with both production as well as end of life management), though this increase was marginal in the case of the card containers. [48]

4.4.4.2 Retail/ Consumption Costs

In Norway, reusable plastic cups were found to outperform single use plastic alternatives in terms of both consumer costs as well as the costs associated with waste management at the end of life. In terms of retailer costs, it is noted that reusable food service items, including cups were found to have additional costs associated with staff time, water rates, water heating and detergents in order to wash items prior to reuse. While similar washing costs are incurred by individual consumers (in the case of bring your own reusable schemes), the savings from reduced expenditure on SUP items were found to be significant, given the millions of uses per annum of these products. These savings occur despite relatively minor increases in washing costs for consumers.[48]

In contrast, the same study found that single use paperboard/ card food containers were more expensive in terms of consumer costs relative to conventional single use plastic alternatives. This cost was offset somewhat by the lower waste management costs associated with card alternatives, though not entirely.

4.4.4.3 Waste Management/ Litter Impacts

Where the costs of waste management associated with the alternatives reviewed here were examined in the literature, this has been outlined in the preceding sections. In particular, the PLA alternatives are likely to be associated with high costs of end of life management if they are to be correctly collected and disposed of. Paperboard and card alternatives, as well as bagasse alternatives are comparatively cheaper to manage at the end of life, with the reusable plastic alternatives providing the cheapest option due to the low volumes of waste generated (assuming products re reused as intended).

Finally, costs associated with litter from food containers for transport were not assessed in the majority of studies reviewed here, though given the similarities in materials assessed and the nature of use of food containers for transport, these are likely to be similar to the findings for carrier bags assessed in Section 4.3.4. The key finding in this regard is that reusable alternatives are associated with a significantly lower potential for littering, and therefore the impacts associated with littering, when compared to single use products of any material.

4.5 Beverage containers for transport

4.5.1 Summary of Assessment

Table 87 outlines the advantages and disadvantages of different options for containers which can transport beverages. The category refers to products which allow beverages to be safely transported and stored, and includes single-use plastics such as PET bottles and beverage cartons, aluminium cans, glass bottles, reusable bottles and biobased PET bottles. All of the single-use products carry a similar risk of being littered, though incur varying risks once they are littered. For replacing single-use water bottles and pouches, reusable bottles are the preferred option with significant potential to reduce consumption of single-use products. However, their viability is dependent upon a sufficient network of potable water refill stations. The extent to which this is possible in Belize is therefore a central variable.

For single-use aluminium and glass options, the risk of littering remains high. Glass in particular poses a risk in terrestrial environments due to shattering. Both materials have higher energy requirements in their sourcing of raw materials and production. If they are not recycled, there is a significant increase in emissions compared to single-use plastics. Therefore, end-of-life management and recycling rates are key variables. Glass products can be used in DRS, which greatly improve their environmental performance.

Biobased PET is not considered to be a serious alternative to single-use plastics. Currently, commercial options for biobased PET start at around 20% biobased content and incur higher costs. There are complications with regard to recycling and contamination. The risk of littering remains high, the material is not biodegradable and there are only particular plant-based sources which cause a net decrease in the energy used to produce products.

Table 8: Summary of Beverage Containers for Transport Assessed

Material	Item Type	Advantages	Disadvantages
Plastic (PET bottles, LDPE pouches, HDPE lids)	Single-use plastic	• Economically preferable • Least environmental impact in production phase	• Negative impacts at end of life significant in landfill, incineration and not practical for recycling • High littering potential and impacts of litter
Beverage cartons	Single-use product (contains plastic and non-plastic materials)	• Widely available and economically preferable • Potential for storing long-life beverages	• Composite materials make them complex to recycle • Littering potential present; impacts of litter slightly reduced owing to smaller plastic content

Material	Item Type	Advantages	Disadvantages
Aluminium cans	Single-use non-plastic	• Lightweight and highly recyclable • Economically viable recycling process	• Littering potential is high (though slightly offset due to recyclable value). Impacts reduced as metal relatively less problematic than plastic in the environment • Energy intensive production process • Extracting raw material is a high impact process
Glass bottles	Single-use non-plastic	• Lower impacts at end of life relative to SUP (widely recyclable) • Potentially reusable as a product within a DRS	• More expensive than SUP items • High potential for litter, although impacts reduced owing to glass being relatively inert in the environment • Energy intensive production process • Environmental impacts in production phase higher relative to SUP items
Reusable bottles	Multiple-use	• Least potential for littering • Potential for giving a net economic saving after a certain number of uses • Has potential to be the least environmentally impactful option	• Most expensive item, though economy improves with an increasing number of reuses • High environmental impact in production phase
Biobased PET	Single-use alternative plastic	• Can be sourced from multiple plant-based materials • When particular materials are used, emissions during production are lower	• Negative impacts at end of life significant (particularly in landfill) • High littering potential and impacts of litter • Complications with recycling • Not commercially available with 100% biobased PET • More expensive than conventional SUP item

4.5.2 Alternatives Selected for Assessment

The category of products termed 'single-use plastic beverage containers for transport' refers to plastic beverage bottles and beverage bottle lids, beverage cartons, water and other beverage pouches, i.e. all SUP products which are not for immediate consumption (such as a cup). The category accounts for vast quantities of plastic consumption globally, consumption of plastic bottles alone being estimated at 480 billion per year.[51] This figure equates to around 1,000,000 plastic bottles used per minute and is projected to rise to over 580 billion by 2023. Each PET bottle uses 162g of oil to produce, and will take up to 450 years to degrade in the environment.[52]

The items in this category are made from different types of plastic, based on their properties and prices. Generally, plastics are used as they are lightweight, cost-effective and convenient. The type of plastic used to make each item are as follows:

- Beverage bottles: PET [53]
- Bottle lids/ caps: HDPE [54]
- Beverage cartons: LDPE (21%), paperboard (75%), aluminium (4%) [55]
- Water pouches: LDPE [56]

While all of these materials can technically be recycled, there are significant infrastructure requirements for doing so and variable economic cases. The case is further complicated by the fact that many of the items are consumed on-the-go and material streams derived from on-the-go disposal often have high levels of contamination besides contamination associated with the liquid contents themselves. This means that capture rates are normally lower than household waste streams.

In the subsequent sections, the relative pros and cons (economic, environmental and social) of some key alternatives to SUP carrier bags are assessed based on the available literature. The alternatives assessed are characterised as follows:

1. **Aluminium cans**: These are single-use cans made from aluminium which are a well-established means for packaging beverages. They can be conveniently transported and stored, and can be economically recycled. Recycling of aluminium is a process that is so well established that an estimated 75% of all aluminium ever made remains in circulation today.[57] The production of aluminium is an energy-intensive process, during which alumina is smelted to pure aluminium metal. Alumina is derived from bauxite, which is primarily mined in Australia, China, Guinea and Brazil.[58] The vast scales of mining activities result in significant impacts in the areas of land and water use. Cans are often consumed on-the-go, and therefore littering remains an issue.

Figure 12: Example of aluminium cans

2. **Glass bottles**: Glass bottles can be single or multi-use items, made in many different shapes and sizes. Glass can be readily recycled, and dependent on infrastructure, it can be recycled as glass or down-cycled as an aggregate for use in cement or surfaces such as asphalt. There is also potential for glass bottles to be re-used, as they can be easily cleaned. As a result, glass bottles are a common item to be included in a refill-based (multi-trip) as well as recycling-based (single-trip) DRS. When consumed as a single-use product, the risk of littering remains high. While glass is an inert material and presents a relatively low risk in marine environments, shattered glass is a persistent issue in terrestrial environments to both humans and animals.

Figure 13: Example of a clear glass bottle

3. **Refillable plastic**: Refillable plastic bottles are a multiple-use product which can be cleaned and used again. Polypropylene (PP) is a common polymer used in the manufacture of reusable products, which can be easily moulded and coloured. They are generally used to replace single-use water bottles (and potentially pouches) rather than carbonated beverages. In the UK alone, 7.7 billion single-use plastic water bottles are used, the carbon footprint of which is around 500 times greater than tap water.[52] Therefore, reusable bottles have significant potential in reducing the environmental impact compared to single-use alternatives, and are also less likely to be littered.

Figure 14: Reusable PP bottle

4. **Biobased PET**: As discussed in section 4.1, there is a range of biobased polymers with different properties and biodegradability. Biobased PET is a material than is often combined with conventional PET to produce products which are essentially identical to fully conventional PET products. This means they are easily mouldable and transportable, though are not biodegradable. Therefore, there are limited advantages of biobased PET over conventional PET, the primary one being that less fossil-fuels are used during production. With regard to littering, there is no evidence that biobased PET is a positive alternative. There are concerns about public awareness of bioplastics, and that it may increase littering as assumptions are made regarding its biodegradability.

Figure 15: Example of Biobased PET bottles

4.5.3 Assessment of Environmental Performance

The alternatives characterised above have varied environmental impacts in terms of their production, use and disposal. These findings are subject to the limitations of the LCA approach, as discussed in Section 4.3.3.

A recent 2016 LCA study explored the relative environmental impacts of aluminium and glass packaging for beer in portions of 500ml or less.[59] The study focused on greenhouse gas emissions and fresh water use in the production phase only, and therefore excludes consideration of impacts associated with end of life management. While aluminium is more energy intensive to produce, it is lighter to transport and therefore uses less energy during that stage of its life, meaning that there are both positive and negative drivers associated with its GHG impacts. The LCA suggested that glass ultimately results in fewer greenhouse gas emissions, as the production of virgin aluminium was so energy-intensive. This finding would be significantly impacted if the use of recycled aluminium content in cans manufactured today was taken into account. Water depletion was also explored in the study, in which aluminium was found to be around four times more impactful. The study also highlights the potentially narrow scope of LCAs, in the selection of environmental impacts. Findings were likely to be heavily affected by the study not accounting for recycled content in either material. Aluminium in particular generally has a high recycled content which considerably reduces the energy associated with its production. Additionally, end of life treatment options are not accounted for, such as recycling. Recycling would likely have influenced conclusions considerably.

Similarly, another 2016 study explored PET and glass bottles as packaging options for water, with a scope of cradle to consumer within Turkey.[60] This includes the manufacture of products and their transport to the customer. It was assumed that all waste would be sent to landfill, which is more comparable to the context of Belize than examples from within the EU.

When considered in this context, the study suggests that glass has greater environmental impacts than PET. Glass production is a more energy intensive process than PET and the material itself is heavier, so requires more energy to transport. The study considered the following impact areas: human health (climate change, ozone layer depletion, carcinogenic effects, respiratory effects, and ionization), ecosystem quality (impact on species diversity, acidification, eco-toxicity, eutrophication, and land use) and resource consumption (depletion of raw materials and energy resources) for the production of the different materials. Glass was considered to have a higher impact than PET in every category when landfilled. While the study gives more insight into how different materials incur impacts in different areas, it also shows how the often-limited scope of LCAs can influence outcomes. For instance, if recyclability and reusability had been considered in the assessment, outcomes would likely be more favourable for glass. Similarly, the impacts of litter (which are likely to be significant) were not included in the assessment.

An arguably more comprehensive example of an LCA from Simon et al. (2016) explored multiple packaging types and waste collection methods in Hungary.[61] The study explored aluminium, PET, cartons and glass containers of 0.33l and 0.5l capacities. The study considered three categories of environmental impact: human toxicity potential, smog (ethane) and GHG emissions. The recyclability of each product was also considered, with glass and aluminium being considered as 'good' while PET and cartons considered 'average'. The study showed that a significant proportion of the environmental impacts can arise from the collection and end of life treatment destinations for each packaging type. The study found that glass and aluminium were the least impactful materials when recycled. PET has a greater impact due to restricted recyclability as a result of contamination, resulting in quality and hygiene issues.

Three types of packaging are considered in another study which explored soft drink packaging options: glass bottles, aluminium cans and PET bottles.[62] The study explored impacts from resource extraction through to end-of-life management and recycling. The study focused on Brazil, and examined the following environmental impact categories: consumption of resources, use of water, GHG emissions and waste production. The study suggested that glass was the worst packaging option in terms of environmental impact, while aluminium and PET were better options under certain end of life treatments options.

An LCA study by Chen et al. (2016) explored how biobased PET compares to conventional fossil-based PET plastic, with a scope that covered cradle to factory gate (therefore not considering consumer and post-consumer stages).[63] The study looked at biobased PET from several sources including wood pellets, corn starch, wheat straw and switchgrass. The study assumed that 'biobased PET bottles' are manufactured from 100% biobased PET, which, however, is rarely seen in any commercial context. Biobased PET bottles may contain as little as 20% biobased PET, with the majority being fossil-based PET material. The study explored 12 scenarios for biobased PET production for impacts in the following areas: climate change, acidification, eutrophication, human toxicity, ozone depletion and others. The study suggests that woody-biomass bottles have the lowest global warming potential, though fossil-based alternatives have less of an impact in terms of ecotoxicity and ozone depletion. Again, the variation within environmental impact categories is highlighted. The study's focus on cradle to factory gate, however, overlooks differences that arise from differences in end-of-life management of biobased and fossil-based plastics.

The environmental performances of all materials improve when they are recycled. Aluminium cans generally have the highest capture rate of the alternative materials, as recycling aluminium is a cost-effective alternative to manufacturing from raw material.[57] Equally, aluminium can be remanufactured multiple times without degrading its quality. Recycling glass and biobased PET also improves their environmental performance. For MU alternatives, such as a refillable bottle, the more times they are used the lesser their environmental impact is per use. None of the studies explored the impact of littering, though it is considered that the majority of impacts in this regard will derive from single-use items.

4.5.4 Assessment of Socio-Economic Implications

The economic impacts of adopting alternatives to single-use plastic beverage bottles and beverage bottle lids, beverage cartons, water and other beverage pouches are dependent on a range of factors, likely to be specific to the market in which the change occurs. Equally, the policy instruments/ mechanisms which encourage such a switch will have an influence on the economic impact. The categories considered in this review include production, retail, consumption and waste/litter management.

4.5.4.1 Production impacts

The context in which the beverage bottles, lids, cartons and pouches are manufactured in will have significant influences on the socio-economic implications of adopting alternatives. The intensity of labour involved in the manufacture is a key variable here, and therefore adopting alternatives incurs a risk that there is a loss of jobs. Previous work Eunomia has conducted for the Norwegian Environment Agency has modelled the number of jobs created or lost by replacing SUP bottles with SUNP and MU alternatives.[48] Adopting SUNP alternatives was estimated to create a small number of additional jobs, while the widespread adoption of MU alternatives resulted in a small number of job losses.

Although estimating exact job losses is beyond the scope of this study, there is a PET bottle injection moulding facility in Belize[64], and therefore it is likely that adopting alternatives would lead to short term job losses. The extent to which these are offset by the development of facilities to manufacture alternatives would depend on government support and the costs of importing similar products.

4.5.4.2 Retail/ consumption impacts

The products being explored in this section, single use plastic PET bottles, cartons and water pouches, are generally the cheapest options for their respective uses. They have well-established supply chains, are recognised by consumers and can also offer additional benefits, such as cartons being able to safely store long-life milk. Therefore, the adoption of alternatives would likely incur additional costs, and potentially complexity for retailers and consumers.

Modelling work Eunomia conducted for the Norwegian Environment Agency suggested that adoption of SUNPs in the place of SUPs would result in a higher retail turnover, due to the higher cost of SUNP alternatives, though the adoption of MU in the place of SUPs would lead to a long-term lower annual turnover for retailers.[48] For the consumer, potential savings were modelled through the adoption of MU alternatives, and additional costs for SUNPs. This taking into account additional costs for MU alternatives such as washing.

4.5.4.3 Waste management/ litter impacts

The proposed single-use alternatives examined here can all technically be recycled, as can the PET bottles and cartons that they would replace. The waste management infrastructure and systems necessary to recycle these materials are the limiting factor here. Therefore, single-use alternatives will carry a similar risk of being littered as the current products unless capture rates are increased. There are differences in littering impacts though, such as the risk of littered glass shattering in terrestrial environments. For biobased PET, there is limited scope for commercially viable recycling due to complications of quality, percentage content and contamination. Currently, there are no facilities for this in Belize, therefore waste would be managed sub-optimally unless investment in new infrastructure was made.

It is likely that the widespread adoption and use of multiple-use alternatives will lead to the most significant impact on waste management and litter. MU water bottles (either PP plastic, glass or metal) have potential to reduce demand for pouches and PET water bottles, both highlighted as key problem items.[48] Adoption of MU water bottles is an important step, though widely available free potable water is required in order to maximise the reduction of these types of SUP products.[65] Where there is significant uptake of MU alternatives, there are large potential reductions in the quantity of waste sent for disposal. This reduces the costs associated with waste management.

4.6 Eating and Drinking Utensils

As highlighted in Table 98 below, different eating and drinking utensils have advantages and disadvantages to their use. Single-use plastic utensils, predominantly made from PPE and polystyrene, are fossil-based products which cause significant issues when littered. This is mainly due to the resilient nature of the plastics, taking several hundred years to breakdown. Wooden utensils (cutlery and stirrers) offer an advantage here, as they are biodegradable in industrial conditions and the environment. There is an additional cost to these items, and their environmental performance is dependent on the source of the material. There are standards which can verify the processes through which the wood is harvested.

Multiple-use alternatives again offer clear advantages over single-use products. They can be easily cleaned and owned by outlets or consumers. Metal is an inherently energy-intensive material to produce, in terms of extracting the raw material, refining and smelting. Therefore, any metal utensil has a use threshold, which must be passed in order for there to be a net saving to be made in terms of embodied energy and carbon. Multiple-use products have a vastly reduced risk of being littered and in instances when they are, they are an inert material that poses a limited risk in low concentrations.

Alternative plastics, in this case PLA, are increasingly used in some parts of the world. They are biodegradable only in industrial conditions and otherwise pose a similar risk to conventional plastics in terms of being littered. They are produced from plant-based materials, though are relatively energy-intensive to produce and more expensive to buy.

4.6.1 Summary of Assessment

Table 9: Summary of Eating and Drinking Utensils Assessed

Material	Item Type	Advantages	Disadvantages
Plastic utensils (PP and polystyrene)	Single-use plastic	• Lowest cost per unit • Least environmental impact in production phase	• Negative impacts at end of life significant in landfill, incineration and not practical for recycling • High littering potential and impacts of litter
Wooden cutlery and stirrers	Single-use non-plastic	• Lower emissions over entire life cycle • Can be produced from renewable resources • Reduced impact of littering as fully biodegradable	• Environmental credentials dependent on type of wood used in production • Extracting raw material can have a high impact • Higher cost than SUP cutlery

Material	Item Type	Advantages	Disadvantages
Paper straws	Single-use non-plastic	• Lower impacts at end of life relative to SUP • Littering impacts decreased as fully biodegradable	• More expensive than SUP • Energy intensive production process • Environmental impacts in production phase higher relative to SUP
PLA cutlery	Single-use alternative plastic	• Reduced use of fossil fuels in production • Sourced from renewable materials • Biodegradable in industrial conditions	• Highest cost per item • Examples of incorrect disposal due to plastic-like appearance • Highest environmental impact in production phase
Reusable metal utensils	Multiple-use	• Least potential for littering • Potential for giving a net economic saving after a certain number of uses • Has potential to be the least environmentally impactful option	• More expensive items, though economy improves with an increasing number of reuses • High environmental impact in production phase

4.6.2 Alternatives Selected for Assessment

Alternatives to SUP eating and drinking utensils explored in the subsequent sections of this report include cutlery, stirrers and drinking straws. Global consumption of these utensils is an extremely complex figure to estimate, compounded by a shortfall of accurate and reliable data.[66] In the UK alone, it is estimated that ~18 billion straws are consumed per year, though such estimates are subject to considerable certainty, and range from 5 to 40 billion straws consumed annually in the UK in the literature. These figures are associated with increasing uncertainty when extrapolated globally.[7] One estimate is that global consumption could be as high as 0.5 billion straws per day, equating to 182.5bn items a year.[67] The impacts of this vast consumption are numerous, with plastic utensils being considered by the Ocean Conservancy as some of the deadliest items to sea turtles, marine birds and mammals.[68] Recognition of these impacts and the often unnecessary consumption of such items has been a driving force behind the EU's recently proposed ban, which will cover plastic straws, cutlery and stirrers and will be enforced by 2021.[8]

Plastic utensils are made from different types of plastic. Straws are primarily made from polypropylene (PP), while cutlery and stirrers are made from either PP or polystyrene. There are a number of alternatives which can take the place of these SUP products. The alternatives covered in this study are wooden cutlery and stirrers, paper straws and PLA (biobased and biodegradable plastic) cutlery, as well as reusable metal items.

1. **Wooden cutlery and stirrers**: Wooden utensils are produced in a manufacturing process which stamps utensil shapes out of a roll of wood. The wood is taken directly from the log, which is rotated at speed over an extremely sharp blade, peeling off thin layers. The utensils are designed as single-use products, and are fully compostable in industrial facilities or even the environment. There are some key variables which influence the 'sustainability' of wooden utensils, in particular, how (if at all) the wood used to manufacture the products is certified. In the UK, the Forest Stewardship Council (FSC) is one of the most well-recognised certifications, verifying that the wood has come from a sustainability managed plantation, and is therefore a renewable resource.[69]

Figure 16: Example of wooden cutlery

2. **Paper straws**: paper straws, much like their plastic counterparts, are single-use products. Similarly to wooden utensils, the environmental credentials of paper straws follow directly on from the source of their raw material; wood. Where wood is sourced from sustainable plantations, the environmental impacts of paper straws are lessened. There has been a surge in demand for paper straws in Europe, which at first was mostly met by producers in Asia.[70] In the UK, a number of firms have started to produce paper straws which supports the environmental case further by reducing the associated transport emissions. Distances between manufacture and use have a significant impact on the environmental impact per straw. Paper straws are also fully biodegradable and compostable.

Figure 17: Example of paper straws

3. **PLA cutlery**: Polylactic acid (PLA) is a biobased material that is fully biodegradable in industrial composting conditions. PLA is introduced in Section **Error! Reference source not found.** as one of the most widely used biobased plastics. It is derived from plant-based sources such as corn starch, cassava, sugarcane or sugar beet.[71] PLA that is intended for

use with hot substances or foods (including cutlery) undergoes a crystallisation process to become crystallised (C)PLA. Although this is a technical difference, the term PLA is generally used across the industry to refer to either form. PLA is put through injection moulders to manufacture the desired product, in this case cutlery. Vegware, a large manufacturer of PLA products, has recently launched its range of recycled PLA products which have an improved environmental performance.[72]

Figure 18: Example of PLA cutlery

4. **Reusable metal utensils**: Reusable products have significant potential to minimise the environmental impacts compared to single-use alternatives. The number of uses is critical to this, and products will have a threshold of uses before they 'break-even' in terms of the impacts of their production. Metal utensils (primarily cutlery and straws) are an example of this, incurring significantly higher environmental impacts during their production than single-use products. Metal utensils are most often made from stainless-steel in an energy-intensive process. The production of steel (an iron alloy) in itself involves the removal of carbon from iron, as oxygen is blown through the molten metal at high temperatures.[73] Chromium is then added to the metal to make stainless steel. This final material must then be smelted into the desired product. This energy-intensive production necessitates that the utensils are used multiple times to bring them below the emissions associated with single-use products, per use.

Figure 19: Example of metal straws

4.6.3 Assessment of Environmental Performance

Conventional plastic products are well entrenched in terms of their production and use, therefore alternatives must offer advantages. This section will explore the environmental performances of conventional and alternative products. Life cycle analyses (LCAs) are a valuable tool in the assessment of products and materials, allowing a comparison to be made between the proposed alternatives and the conventional materials of PP and polystyrene, albeit with the caveats and limitations discussed in previous sections.

Adopting paper straws in the place of plastic straws is an increasingly common substitution in many countries. The 'Blue Planet II effect' has driven this further, which presented a shocking visualisation of plastic pollution in the oceans has been a major driver of this[74]. This was further compounded by a graphic viral video of a sea turtle having a plastic straw removed from its nostril by the Leatherback Trust. Straws, therefore, have been highlighted to the public as a problem item. While paper straws will more readily biodegrade in the environment, minimising the impact of marine litter, there are other environmental impacts which should still be taken into account. For instance, despite paper being sourced from potentially renewable sources, its manufacture is often more energy and resource intensive, compared to plastic.[75] While both plastic and paper straws can technically be recycled, this is rarely conducted at scale or in a commercially viable manner. A 2018 study on the embodied carbon of different straw types found that the CO_2e per straw was 1.48g for plastic and 1.36g for paper. [76] The study did not explore the impacts of land or water use during the production of straws, or littering impacts.

With regard to cutlery, a 2013 study by Brownlee et al. conducted a life cycle assessment on the impacts of plastic cutlery and one type of branded wooden cutlery, Aspenware.[77] The study was designed to explore which type of cutlery would be best suited for use on the University of British Colombia's campus, from environmental and economic angles. Plastic cutlery was found to be around 45% more carbon intensive per unit than wooden alternatives. However, the cost of plastic cutlery was found to be 43% less than wooden cutlery. In terms of end of life impact, wooden cutlery could be composted on site while plastic would be incinerated or landfilled. 76% of the wooden cutlery was correctly disposed of in composting bins. It is worth noting that the study mentions previous attempts to use PLA cutlery on site. This caused problems with waste management as the majority of PLA utensils were disposed of in residual rather than compost bins, and the PLA that was disposed of correctly in compost bins then often did not fully biodegrade.

Multiple-use straws, such as metal ones, have the potential to be used a large number of times. One analysis suggested that a stainless steel straw would need to be used 149 times in order to 'pay-off' the additional embodied carbon compared to a plastic straw. [76] The study estimated that the production and transportation of a stainless-steel straw results in 217g of embodied CO_2e. The cost per straw is also significantly higher, at $0.26 per unit, 87 times the amount of a plastic straw. This would suggest that it is easier to break even on the economics than the environmental impacts.

With regard to cutlery, stainless steel cutlery was found to be the optimal choice in a study by Tingley et al. (2011)[78]. While the production stage is the most impactful of single and multiple use products analysed, the lifespan of stainless-steel cutlery meant that it was the most sustainable option over its full life cycle. There are also options for recycling during end-of-life management. This study was subsequently supported by the conclusions of Plastic ZERO[79], who suggested that stainless steel cutlery was the optimal solution when it was assumed that utensils were used 600 times over the course of their life. It is also assumed that utensils are recycled at the end of their life cycle.

4.6.4 Assessment of Socio-Economic Implications

Socio-economic implications of adopting alternatives are an important area of consideration. All of the alternative products explored in this section incur higher costs than the conventional plastic products they would replace. This will have a knock-on effect for retailers and consumers. Some areas of literature do stress that there are a number of medical conditions which necessitate the use of straws. In these cases, the use of plastic straws should be permitted to avoid any disadvantage to the individual concerned, as recommended in the EU's proposed ban.[8] For metal cutlery, such utensils are frequently used in domestic settings in many parts of the world. Encouraging consumers to carry metal utensils with them for 'on-the-go' meals would require awareness raising and shifts behavioural shifts.

4.6.4.1 Production impacts

When modelling the changes associated with adopting SUNP and MU alternative straws in the place of SUPs, previous work Eunomia has conducted has suggested that there would be not be a discernible change in total job numbers.[48] It is worth noting that there are other straw alternatives which are not specifically explored in this study. For instance, re-usable bamboo straws can be easily produced without large scale production facilities and there case studies of this already happening in Belize.[80] While this has not been subjected to academic analysis, it is indicative of how job opportunities can develop in response to public demand and/ or policy interventions. The production of metal straws, as previously discussed, is an energy intensive process, and geographically limited to countries with steel smelting infrastructure. For nations which would not be able to produce products, additional emissions are accrued in their transportation. The same is applicable to other metal utensils such as cutlery, where the production is more energy-intensive but an extended use period can more than offset this.

4.6.4.2 Retail/ consumption impacts

As mentioned previously, the costs of all of the alternatives are higher than conventional plastics. One study which analysed the embodied carbon of different straw types also noted the costs of the different straws in the study.[76] Plastic straws were $0.003 per unit while paper straws were $0.04 per unit. This is around 13 times the cost of the conventional product, against which there is a likely benchmark set. While there is an increased cost associated with adopting paper straws, for some companies this could be partially offset by improvements to brand image.[81] An example of this is McDonald's restaurants banning plastic straws in the UK, which has received considerable media attention.

This increase in price is reflected by Eunomia's modelling study on the topic.[48] It was suggested in the study that for the adoption of single-use alternative straws, stirrers and cutlery there will be additional costs to consumers as retail turnover increases. This can be partially offset if MU alternatives are used more regularly, though savings would probably accrue to retailers who are unlikely to pass savings from avoided SUP item purchase to consumers.

In Section 4.6.3, reference is made to a study that suggests metal straws cost around 87 times more than plastic alternatives. Online market places for straws, however, suggest that the figure would be closer to 200 times the price, and around 100 times the price of a paper straw. Due to the value of metal straws, there could be a risk of theft from restaurants which supply these to customers. There are some examples of this in the news, from Europe to the US.[82] It is a difficult issue to reconcile, as restaurant use in the food service industry represents a good opportunity for the deployment of metal straws. Restaurants that have reported this issue highlight that this behaviour is not common, and is in part explained by the lasting perception that items like straws are provided free of charge (as this is the case with SUP straws) as this rarely occurs in the case of reusable cutlery (which people are aware cannot be taken home). Some have tackled the issue by adding the cost of the reusable straws to the bill, with the option left to consumers regarding whether to take the item home, or return it to remove the charge.

Metal cutlery also incurs a higher cost than single-use plastic alternatives on a per item basis. However, due to the scale of production and range of options there are many examples of good value stainless cutlery sets. This reduces the payback period and required number of uses. In parts of the world where cutlery is frequently used, consumers are likely to own items, limiting the need to buy new products.

4.6.4.3 Waste management/ litter impacts

Adopting SUNP and single-use alternative plastic products will not lead to a reduction in consumption, and will therefore have a negligible effect on the rates of littering. While paper and wood products will have a smaller impact in both terrestrial and marine environments due to their disintegration and biodegradability, alternative plastics such as PLA will be a more persistent problem. The previously discussed university campus study makes the observation that an additional issue with PLA was that consumers were unlikely to dispose of products in the correct (compost) bins due to its plastic appearance.[65] This creates a heterogeneous waste mix, where the level of contamination (with food waste) and the number of different materials in the stream normally means subsequent separation is not feasible, exacerbated by the throughput limitations of 2-way and 3-way sorting processes where these are in place. When correctly disposed of, and processing infrastructure is available, both wooden and PLA cutlery are beneficial as they can be composted with food waste while avoiding contaminating other waste streams.[83] Reusable cutlery poses a negligible risk of littering, and can be recycled at the end of its life. Therefore encouraging the use of reusable cutlery outside of ‘eat-in’ locations would have the most significant impact in reducing the impacts of litter.

With regard to waste from single-use straws, multiple-use options have the most potential for reducing this. Stainless steel straw products can be cleaned and reused many times, offsetting the use of plastic or paper alternatives and the costs associated with purchase and end-of-life management. They are a resilient design, durable and rust resistant, therefore they would most likely cease to be used if they were to be lost or stolen. Metal straws are unlikely to be littered due to their value and usefulness. In the case of isolated incidents of accidental littering, stainless steel is an inert material that would cause limited damage in terrestrial or marine environments. Stainless steel products can also be recycled at the end of their life.

4.7 Food and beverage containers for immediate consumption

4.7.1 Summary of Assessment

Table 10 below summarises the findings of this assessment for the alternatives considered. As in the assessment of other SUP items and their alternatives above, reusable alternatives outperformed the majority single use ones on environmental as well as economic indicators, particularly when considering the impacts at end of life (including litter). Of the single use items, it is possible that banana leaf will perform better due to its high degradability and wide availability as a by-product of banana cultivation. However, this market and the products in question are currently manufactured locally, with commercial markets for analysis lacking.

Table 10 Summary of Food/ Beverage Containers for Immediate Consumption Assessed

Material	Item Type	Advantages	Disadvantages
Rigid plastic/ Plastic-lined/ EPS	Single-use plastic	• Economically preferable • Least environmental impact in production phase	• Negative impacts at end of life significant in landfill, incineration and not practical for recycling • Highest littering potential and impacts of litter
Banana Leaf	Single-use non-plastic	• Lowest environmental impact in production/ waste management phases	• High potential for litter though very degradable • Markets localised and undeveloped
Paper/ Card	Single-use non-plastic	• More expensive than SUP • Environmental impacts in production phase higher relative to SUP (use of recycled paper improves this performance)	• High potential for litter though degradable • Lower impacts at end of life relative to SUP (widely recyclable)
Reusable Ceramic	Multiple use	• Preferable to single use alternatives across the majority of environmental indicators • Economically preferable to single use items	• High potential for breakage and associated negative impact on health and safety/ costs • High water use and retailer costs associated with washing products before they can be reused
Reusable Plastic	Multiple use	• Most preferable alternative across the	• High water use and retailer costs associated with

Material	Item Type	Advantages	Disadvantages
		majority of environmental indicators (related to production and waste management phase) • Economically more favourable than single use alternatives and reusable ceramic when reused a greater number of times • Least potential for litter	washing products before they can be reused
PLA (including PLA/PBAT)	Single-use alternative plastic	• More expensive than conventional SUP • Higher environmental impact at production phase relative to other single use alternatives	• Negative impacts at end of life significant (particularly in landfill) • High littering potential and impacts of litter

4.7.2 Alternatives Selected for Assessment

Food containers for immediate consumption refers to food packaging that is usually filled at the point of sale and consumption, including plates, trays, and cups made of rigid plastic, EPS foam and polyethylene-lined card. The consumption of such items is common due to their low cost, light weight, durability and insulating properties.

Their low value, durability and light weight also make them prone to littering and other forms of leakage into the wider environment, and they regularly feature in the top ten items found in beach, river and land litter surveys around the world. EPS foam cups, food packs and trays have similarly been identified in Belizean litter.[46]

Even if disposed of correctly, high amounts of food contamination associated with such items mean they have lower recycling rates owing to higher reject rates. Although increased awareness amongst brands of the negative public perception of EPS has, particularly in the case of coffee cups, prompted a switch to PE-coated card and paper composites, adoption of these materials does not address the issues of litter and recyclability associated with these items.

1. **Single-use Banana Leaf Containers:** Banana leaf has traditionally been used as a packaging material for food (for immediate consumption) historically in countries like Thailand, India and Nepal. It has applications ranging from fresh banana leaf wraps used in the place of plastic film[84] , to layers of leaves dried and pressed together (often bound with fibres) to provide more durable bowls and plates. In Germany, these traditional methods are also

being refined into an automated process of manufacturing multilayer banana leaf containers to enhance insulation and waterproof properties[85].

Figure 20: Example of banana leaf wraps used as a substitute for plastic films

Figure 21: Example of traditional multilayer banana leaf plates

2. **Single-use Paper/ Card Containers:** Single-use paperboard and card containers are already commonly in use, partidularly in the form of non-lined paper plates, card bowls, trays, and so on. Such containers are typically difficult to recycle as the pulp fibres cannot be separated from greasy, oily residues from food contamination. However some paper and card containers can be shredded and added to home or industrial compost due to their high degradability.

   It is also noted that these products typically lack the insulation and barrier properties necessay for some applications, particularly for hot food and beverages to be consumed immediately. However, the manufacture of paper cups with a mineral blended coating in place of the plastic lining are being trialled to enable them to be recycled in traditional paper recycling faciliities, to the extent that collection systems and contamination thresholds allow this.

Figure 22: Example of paper plate without plastic lining

3. **Reusable Ceramic Containers:** Reusable tableware is the most obvious alternative to single use plastic food containers used for immediate consumption (or for 'eat-in' options). However, this alternative necessitates additional effort and cost associated with washing

and storing such items and may not therefore be applicable in all contexts, though this can be adapted in many cases (e.g. mobile wash stations for public events, markets, etc.).

Figure 23: Example of reusable tableware

4. **Reusable Plastic** Containers: For immediate consumption of food and drink, reusable plastic containers can be used, with mono-material, clear coloured products providing the most potential for recycling at the end of life. Consumers can be required to pay a deposit for standardised containers, and be refunded when they return the container after consuming the product on the premises.

Figure 24: Example of a reusable cup provided for a deposit

5. **PLA Containers:** The use of single-use food containers made of bio-based polylactic acid (PLA), the feedstock for which can be a variety of starches (e.g. corn and potato), is increasing globally as a replacement for conventional single use plastic containers. However, though often advertised as compostable/ biodegradable products, this is often in reference to industrial conditions which are not always met in commercial facilities and the wider environment. In addition, these items are often confused with conventional plastics, and disposed of incorrectly, causing problems for conventional plastic recycling.

Figure 25: Example of PLA plates

4.7.3 Assessment of Environmental Performance

The findings of the environmental assessment of paper/card, reusable plastic and PLA food containers for transport (Section 4.4.3) are relevant to food containers for immediate consumption as well.

It can be argued that the litter impacts of these alternatives are likely to be lower in the immediate consumption scenario relative the transport scenario (due to the product being consumed on retailer premises as opposed to on the go), though this will depend heavily on the context for immediate consumption/ food transport. For example, immediate consumption at outdoor events, markets, or food stalls are likely to be associated with high rates of litter depending on the waste management systems in place in these contexts. Similarly, food containers that are transported to be consumed in the home rather than on the go are unlikely to end up as litter rather than in household waste. As a result, no conclusions can be drawn regarding the likelihood of litter associated with food and beverage containers in these two scenarios.

When considering reusable ceramic crockery for immediate consumption, the findings of a study carried out in the US are relevant. The study considered the environmental merits of a range of reusable crockery options (including metal, ceramic and plastic) against the available SUP options in three immediate consumption contexts: for catering in hospitals (non-patient catering only), in schools, and for hotel breakfasts. Impacts considered included ozone depletion, global warming, fossil depletion, acidification and terrestrial acidification, eutrophication, photochemical oxidation, agricultural land occupation, natural land transformation as well as cumulative energy demand and water depletion. It was found that all the reusable systems assessed showed a lower negative impact on the environment in all, or at least the majority of parameters considered. The exception was the parameter related to water use for washing, in which both the hotel and school scenarios showed a less favourable impact relative to SUP items (which do not require washing). [86]

Several LCA studies have also been carried out to assess the relative environmental impact of reusable ceramic and plastic plates and bowls when compared to single use PLA and paper alternatives. Several of these are reviewed and summarised in a paper for the Clean Water Fund as below [87]:

Broca (2008) conducted a life cycle study at Yale University that compared PLA compostable and ceramic reusable plates. She found that ceramic plates had lower overall environmental impact than PLA plates after only 50 uses (the "breakeven point"). While this metric incorporated multiple environmental impacts, it was dominated by fossil fuel use which correlates strongly with global warming impact. Wachter et al. (2013) examined food serviceware in cafeterias at the University of Colorado at Boulder. They found that reusable polycarbonate salad bowls had lower global warming potential impacts than single-use compostable bowls after as few as 10 uses. To and Chan (2006) compared singleuse paper and ceramic plates and concluded that beyond one year, reusing 400 porcelain plates daily is a better choice in terms of carbon emissions than using 36,000 single-use paper plates per year.

The study concluded that in all cases reviewed, reusable perform better environmentally across the range of parameters assessed than all single use alternatives assessed after a modest number of reuses.

While these results are not dissimilar to those found in the assessments of other SUP items and their alternatives in the sections above, it is noted that banana leaf is not commonly assessed in the LCAs that were reviewed as part of this work. However, banana leaf is likely to be completely degradable if littered, and compostable in home compost and food waste. The environmental impacts of this material at end of life are therefore likely to be low. This can vary depending on whether the banana leaf is used in combination with other products (e.g. plastic stickers for pricing) as well as they extent to which the material is processed to produce the ultimate items for consumption (e.g. raw banana leaf wrap vs. a dried multilayer banana leaf plate).

Similarly, in the production phase, assuming banana leaf is harvested as a by-product of banana cultivation, impacts in its production phase are likely to be low, with savings to be had from avoided landfilling of banana leaf. It is noted however that the cultivation of banana does tend to be water and land intensive, and transport costs are likely to be a consideration in markets in which banana is not grown locally.

4.7.4 Assessment of Socio-Economic Implications

The findings of the economic assessment of paper/card, reusable plastic and PLA food containers for transport (Section 4.4.3) are relevant to food containers for immediate consumption as well.

In addition, it is noted that ceramic reusable containers are likely to be more costly than reusable plastic, and more prone to breakage as well. It is therefore less appropriate in some situations (e.g. street food stalls etc.).

The cost of banana leaf containers is likely to vary, and could be provided for free in markets where banana is locally produced. Due to their high degradability and lack of durability, retailers are likely to incur additional costs associated with maintaining a regular stock of the material. These costs are likely to be offset by the low waste management and litter cost associated with these products.

5 Synthesis of Findings in Context

5.1 Implementing Restrictions

5.1.1 Bans

With reference to Belize, there are some key considerations to highlight from the review of restrictions in Section 3. In terms of **bans**, it is worth recognising that the development and implementation of a ban is an expensive process, relative to other measures. Development of ban legislation is required, as is awareness raising to ensure that all relevant stakeholders have been made aware of the incoming ban and have been able to adapt their practices. Such awareness raising will have a cost, as it may require radio, television, internet-based, or more targeted advertising. Some countries will hold stakeholder workshops in the development of the ban, engaging with stakeholders and allowing them to give feedback on the proposed ban. This, alongside a lead time between announcement and implementation of the ban to allow relevant stakeholders to adapt prior to the ban entering into force, is of some importance. As evidenced in the example of Zimbabwe, the absence of such a process can, in extreme cases, result in the ban needing to be temporarily lifted and re-introduced. Once in place, a ban requires enforcement to be successful, which in turn requires resources to be allocated to enforcement of the ban, and to penalising non-compliance. As a ban does not generate revenue, this can be an expensive process.

Furthermore, it is important to consider *how* the ban will be implemented. Restrictions on import of certain items can be an option. However, in this instance, the ban might to need to align with the existing categories or codes used for imports. In Iceland, customs codes are used successfully to apply tariffs as an advanced disposal fee which finances end of life management of products within the country.[5] However, this can provide a challenge in the instance of bans whereby items due to be banned, and those allowed to continue to circulate may be grouped under the same code. This can be an issue where codes apply by material rather than by product, and has required Belize to apply a restriction to import of all items under a certain code. The legislation as currently drafted requires importers to have a permit to import for the categories listed within Schedule I of the legislation, with an additional requirement that only those items which are in Schedule I, but not Schedule II (the prohibited list) may be imported at all.[1] The legislation is not yet in force.

5.1.2 Taxes/Levies

Bans might be considered to be **taxes** or **levies** set at an infinite level. In many instances, bans will not be appropriate, especially where some uses of the item have a particularly high value. In these instances, an appropriate levy on the SUP item will lead to a reduction in use of the

[5] Personal Communication with Gudlauger Sverrisson, Operational Manager, Icelandic Recycling Fund (2019)

SUP item, and a switch to alternatives (a demand effect, and a substitution effect). The strength of these two effects depends on:

1. The level of the levy applied to the SUP item; and
2. The level of any levy which is also applied to SUNP (and MU) items.

The higher the levy on the SUP, the more demand can be expected to fall closer to zero: the users of SUPs at this point can be expected to be those who derive particularly high value from their use. This allows those who would otherwise argue for exemptions from a ban to continue using the item, but at a higher cost. Where SUNPs are also problematic, it makes sense to implement a levy on all single-use items of a given type, aiming to foster a culture of using MU items. The higher such levies are set, the more likely it becomes that single-use items are used only in exceptional circumstances.

These charges have been referred to as "levies" – this has been done to show that the revenue from such a measure could be used in a way other than contributing to overall treasury budget. Revenue from levies may be significant to start with, whilst single-use items are still widely used, and are likely to decline over time as the item use declines. Such revenue could be earmarked for causes which contribute to the success of the levy, for example, to fund awareness raising and publicity. As such, levies could be a valuable instrument in Belize as they can generate revenue. It is understood that at present, Belize's public information campaigns around the proposed restrictions are limited by availability of funds.[6]

Taxes or levies have been demonstrated to be highly successful in reducing consumption of SUP items in other countries. As highlighted in Section **Error! Reference source not found.** with the example of Wales, whose carrier bag charge resulted in a 71% reduction in single-use plastic bag consumption between 2011 and 2014.[31] One method for ensuring that the reduction effect of the levy doesn't diminish is to allow for incremental increases to be made to the levy over time. This could either be done in light of maintaining the effect at the same level, or if there is a goal to reduce the consumption of the item to an absolute minimum.

5.1.3 Deposit Return Systems

Belize has a deposit system in place, called the Returnable Containers Act – introduced in 2009. The policy was developed by private sector organisation Bowen and Bowen who own the Belize Beverage Company.[88] The DRS does not cover all sizes of bottle, and only covers carbonated drinks. [89] In addition, it is understood that there are difficulties with enforcing the act at present.[7] As such, and given the positive impact that a well implemented DRS can have on collection and recycling of beverage containers (as discussed in Section 3.3), it would be pertinent to consider revision of the DRS in Belize.

Such a revision may look to cover the full range of beverage containers, not restricting coverage by size or contents. Given the widespread consumption of bottled and bagged water in Belize it

[6] Personal Communication with a Department of Environment Representative (August 2019)
[7] Personal Communication with a Department of Environment Representative (August 2019)

would be a priority to include these containers in the DRS. Including bagged water may be a challenging concept for some stakeholders, as the water pouches have low value at end of life compared to PET bottles or metal cans but are one of the most common items in Belize's beach litter counts at present.[46] However it is for this reason that attaching a value to these items to ensure their return could be particularly important, as the only way to create an incentive for others to pick up water pouches which have been littered, and acting to monetise, in part, the impact of them leaking to the environment.

5.2 Identifying Appropriate Alternatives

5.2.1 Belize – Current Approach to Waste Management

To more fully understand the relative merits of single-use alternatives to SUPs for Belize requires consideration of the possible fate of such items at the end of their short use phase. Accordingly, it is appropriate to review existing waste management and recycling systems as this is the system in which the items that are appropriately captured will be managed when they become waste. Assessing them in this context can aid understanding of what benefits the alternatives may deliver when compared to the plastic items they are replacing.

In terms of facilities, Belize has one central sanitary landfill which is relatively new and started receiving waste in 2013.[90][91] The landfill is not covered, and doesn't include gas capture technology. Material reaches this site via waste transfer stations, at which point waste pickers may remove items of high value.[92] This is generally restricted to PET bottles, deposit bearing items, and metals - including metal cans which are exported for recycling. However, the success of this is dependent on the market and demand for these materials.[92]

There are several 'open dump' type sites alongside this, and while access to formal waste collection in most urban areas is high (90%-100%), a large proportion of the rural areas are not currently served by waste collections (25%-95% uncollected waste). These communities may burn their waste, dispose of it into the environment, or take it to a waste transfer station if feasible. This is also an issue in some of the cities, with an article from 2017 raising the issue of waste being dumped alongside the road in San Pedrito.[93] This is outlawed in the Environmental Protection Act, which states that *"No person shall dump or dispose or deposit any garbage, refuse, toxic substances or hazardous wastes in any place that may directly or indirectly damage or destroy flora, fauna, or pollute water sources and the environment."* However, this is not well enforced.[93][94]

There is planned investment in improving waste management, initially looking at providing waste transfer stations in the 'northern and southern corridor' by replacing six existing dumps, and expanding the existing sanitary landfill to increase capacity. The programme of development will last five years and is funded with $10 million USD.[95] This follows from the construction of the sanitary landfill and development of a formal collection and disposal system throughout the central corridor of the country – co-funded by the International Development Bank following a significant fire at the Belize City dump in 2009.[92] Further funding of $500,000 has recently been made available to run a pilot project in selected tourist areas to promote source separation, composting, reuse and recycling. This funding will also cover design of a system to facilitate solid waste collection and transport in rural villages as well as looking into route optimisation for collection in urban areas.[96]

As such, at present, there is minimal capacity for recycling in Belize. Separate collection of recyclables is lacking, as is separate collection of organic waste which makes up a significant proportion of household waste according to composition studies at ~40%.[97] Whilst there are plans for a pilot trial into source separation it seems that wide scale recycling collections are a fair way off. There are no plans at present to develop capacity for composting or anaerobic digestion in Belize as a method for treating the volumes of organic waste generated.

5.2.2 Understanding Alternatives in the Belizean Context

Following on from the discussion of Belize's waste management system, here, pathways for the management of SUP alternatives are explored in the Belizean context. An overview of Belize's waste flows is shown in **Error! Reference source not found.** and discussion is provided in the sections which follow on the pathways for certain alternatives in the current system. As shown in the diagram, waste is likely to end up in one of five major destinations in Belize:

- Export for recycling;
- Sanitary landfill;
- Open dumps;
- Open burning; and
- Release to the environment.

There is also likely to be some movement of waste between the destinations; this is shown with dashed lines in the diagram. Belize's DRS (see Section 5.1.3) is not included in this diagram due to the relatively small share of Belize's overall waste it is relevant to.

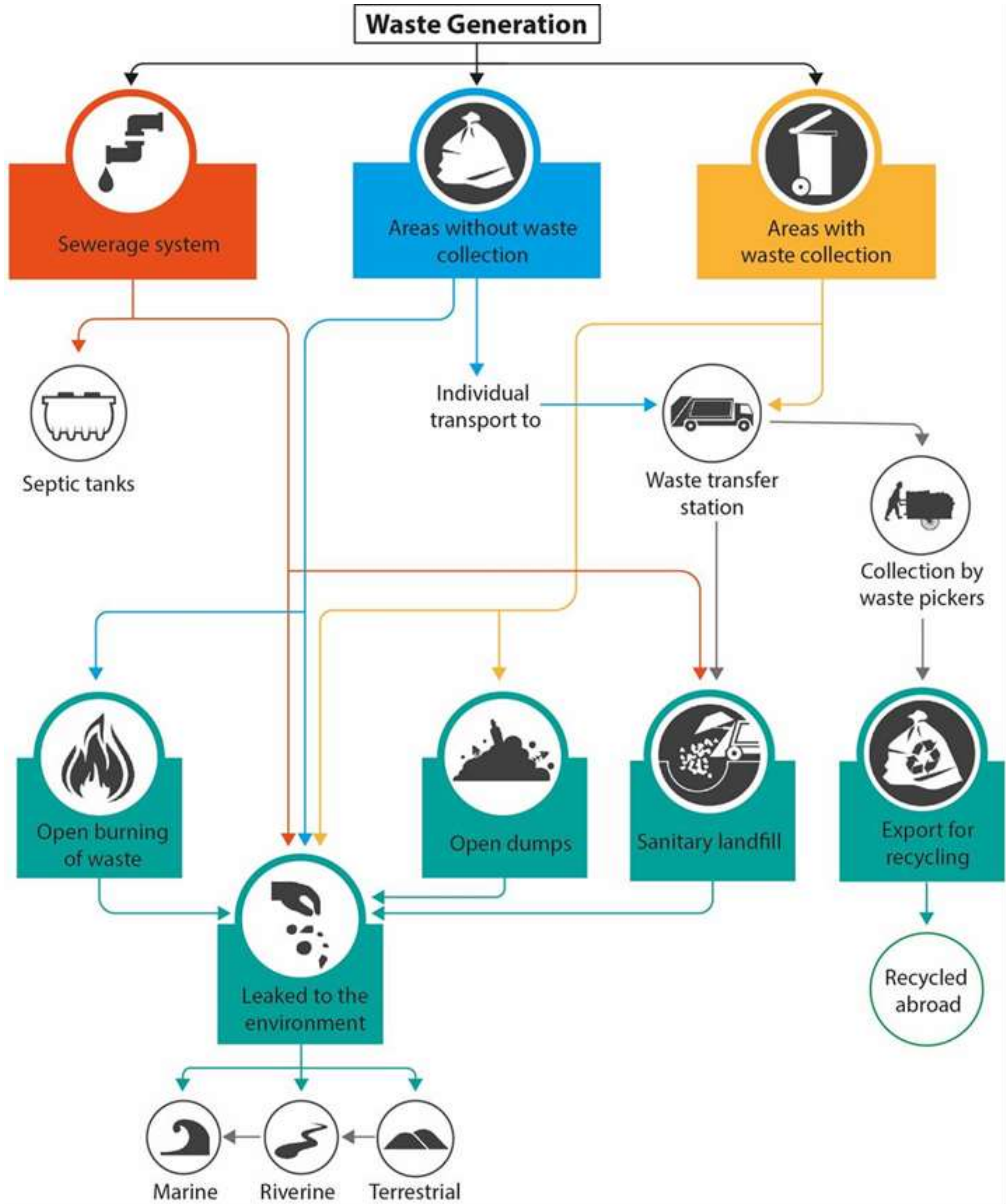


Figure 26: Overview of Waste Flows in Belize

Source: Eunomia, Information provided through personal communication with the Ministry of Environment in Belize, alongside sources[92][95][96]

Where a ban or levy may result in reduced consumption of the item type as a whole i.e. a complete or significant reduction in the consumption of the plastic item, without full replacement by an alternative single-use item, then this could be of significant benefit to Belize. The result in this scenario is one of reduced waste generation at source. As such, there will be less waste to manage, and, all else being equal, less waste entering the environment.

However, for the majority of items, unless reusable alternatives are promoted, a ban will result in a switch to consumption of an alternative item which serves the same purpose. This may be an alternative single-use plastic – such as a biodegradable or compostable plastic, a single-use non-plastic item such as a paper or cardboard alternative, or a multi-use item. In the following sections, the impacts associated with the predicted pathways and end destinations of each type of alternative are discussed.

5.2.2.1 Alternative single-use plastics

For bio-based biodegradable and compostable alternatives, those which are burnt in the open will have similar impacts to conventional plastics. There will be a small difference in overall contribution to net GHG emissions as burning conventional plastics represents combustion of a fossil-based source. By comparison, combustion of a bio-based plastic entails the emission of carbon dioxide which was relatively recently sequestered in the process of growing the plant from which the plastic feedstock has been derived (assuming that the production of such items genuinely involved negative emissions once land take has been accounted for). As such, the net emissions may be smaller than combustion of a conventional plastic. However, this pathway should not be encouraged as it is not a sustainable use of resources and is not the most favourable in terms of environmental outcome compared to other alternatives. Those biodegradables derived from fossil sources provide no benefits compared to conventional plastics in this circumstance.

For those leaked to the environment, the materials will behave in a similar way to conventional plastics as compostable and biodegradable plastics are not generally developed to bio-degrade under environmental conditions. This is due to the lower temperatures, and lower levels of microbial activity in the environment as compared to the industrial composting scenarios which the standards for these materials tend to be based on. In particular, this affects the marine environment where the environment is saline and temperatures are low.[98] For example, a recent study conducted in the UK found that biodegradable plastic bags were still able to carry shopping after three years of exposure to the marine environment. Compostable plastic bags fared better in the study, breaking down in the marine environment after three months, and losing structural integrity after being left in soil for 27 months. However, the researchers emphasised the need to understand what breakdown products were released by the compostable plastics (i.e. are they smaller pieces of plastic or polymers that still persist in the environment for significant periods of time).[99] As such, it may be that compostable plastics might ultimately provide some advantage when littered in the environment although it should also be noted that the focus of this study was bags, where the plastic is thin. Items using a thicker gauge of plastic may respond differently. Equally, it may still be possible for these products to cause environmental harm in the months prior to breaking down.

There is little evidence on what happens to compostable and biodegradable plastics which enter landfill, which would be the main other destination in Belize. One study, conducted in the Czech Republic, has looked at what happens to plastics advertised as biodegradable and compostable in a solid-waste landfill.[100] Five different samples (four plastic bag types, and a control) were placed in a landfill and monitored over the course of 12 months. No physical changes were reported to have occurred to the plastic labelled as biodegradable, bar a change in colour. The compostable samples did not decompose, with one of the two exhibiting what the authors describe as 'minor disruptions'.[100] This is in line with observations that the rate of degradation of organic materials in landfills is generally slow. This can be variable and will also depend on the stage of the landfill as the rate of degradation is a function of many variables, including moisture content, pH, temperature, micro-organisms present, and solid waste composition. [101]

Belize is at present working to develop a standard for the alternative plastics allowed on the market. A 'minimum standard' has been developed which would require a plastic to be at least 50% bio-based and break down in landfill in 365 days.[1] As such, these alternatives would need to break down more rapidly than those in the Czech Republic study. Defining what is mean by 'break down' would be important, but, in order to be sure of no environmental harm, it is likely to mean a complete conversion to CO_2 and water. However, the majority of a landfill is an anaerobic environment. In this environment, given the absence of available oxygen, these plastics would instead break down to release CH_3 – methane. Methane is a greenhouse gas which is ~28 times more potent than CO_2 on a 100-year timescale, and more than 80 times more potent over a 20 year timescale.[102] Without the presence of gas capture at the landfill site this could result in a significant contribution to Belize's greenhouse gas emissions which would be troubling in light of climate change. By comparison, conventional fossil plastics will not breakdown in landfill, as they are relatively inert and hence represent something of a carbon sink (if captured in landfill).[103]

5.2.2.2 Single-use non-plastics

Single-use non-plastic alternatives are generally paper, cardboard and wood/bamboo items. In open burning they will combust, releasing CO_2. However, this will involve the release of CO_2 which has been sequestered within a relatively recent timeframe. As such, the net contribution of these emissions is smaller than combustion of fossil plastics. In addition, combustion of fossil plastic may release toxic gases as a result of additives included in the material. In particular, the combustion of PVC results in emissions of dioxins which are carcinogenic, hormone disrupting and persistent – accumulating in body fat over time.[104] [105] This issue would be alleviated by switching to single-use non-plastics. Metals and glass may also replace plastic in certain cases such as with beverage containers. In these instances, metal is likely to be recovered for recycling as a higher value fraction. Glass would be inert under open burning, and in landfill.

With reference to items which end up in the environment, paper, cardboard and wood/bamboo items are likely to biodegrade in the environment in a relatively short time frame – although this will depend on local conditions. In this respect, they provide an advantage over plastic items. Glass and metal alternatives are relatively inert in the environment.

In landfill, paper, cardboard and wood/bamboo items would be likely to break down, albeit at a relatively slow rate for the reasons mentioned in section 5.2.2.1. This would be associated with the release of greenhouse gases that at present are uncaptured, as for biodegradable and compostable plastics.

5.2.2.3 Multi-use alternatives

Multi-use alternatives of several different materials have been proposed as alternatives for the items banned. Materials include metals, reusable plastics, and fabrics in the case of bags. It should also be recognised that in some instances, a ban will not result in an alternative item acting as a ‘full replacement’ for the banned item. For example, banning plastic straws may result in an overall decrease in the consumption of straws, as they can easily be avoided without substitution.

The major impact of switching to a multi-use alternative is the impact on waste generation. Reusables have a significant effect on waste prevention, reducing the volumes of waste generated by allowing the same item to be used many times for the same purpose. There are considerations for switching to reusables, which are generally applicable on an item by item basis, or by item type. For example, making a transition from single-use plastic water bottles or pouches to a reusable, refillable bottle requires that the vessel can be refilled with potable water, and may require changes to supply infrastructure. Equally, transition to reusable cups for beverages will either require the consumer to wash the cup post use, or for retailers to have washing facilities. However, these are barriers that have been overcome elsewhere and these relatively small logistical issues are vastly outweighed by the beneficial impact on waste prevention.

It is worth briefly recognising that multi-use items will reach end of life at some point. In this instance, the metal-based reusables are recyclable, and would likely be recovered for recycling by waste pickers. For plastic items, these may also be recovered for recycling, or could enter landfill where they will be relatively inert. If littered, plastic reusables would have the same impact as conventional SUPs. However, they are likely to enter the environment at a much reduced rate, both due to being present in smaller numbers and due to having a greater intrinsic value. For reusable plastic items there is no improvement if these items enter open burning. However, for the reasons cited above with respect to entering the environment – this is likely to happen less than with SUPs at present. Finally, it could be possible to develop a standard for reusable items that ensures their compatibility with export for recycling at end of life. This would counter issues around complex designs and material combinations which may prevent recycling of some reusable items available on the market at present.

Separately, for textile-based reusables, these are likely to have a significant waste reduction effect. In addition, they are likely to biodegrade if leaked to the environment, representing an improvement on the SUP option.

5.2.3 Going forwards

The above assessment makes clear that at present, reusable alternatives to single-use plastics are the most preferable options to prevent litter. Given the low rate of recycling and recycling capacity in Belize, selecting reusable options that are easily separated and can be exported for recycling (metals, reusable plastics, etc.) presents the most viable and environmentally favourable option. Going forwards, the benefits of the alternatives proposed could be significantly heightened through changes to the waste management system in Belize. Expanding both the capacity for source separation of waste materials, as well as recycling markets for additional streams of materials would allow a wider range of reusable alternatives, as well as some single-use non-plastic alternatives (such as paper) to become viable at the earliest possible stages of the development of infrastructure and corresponding material markets. This is in contrast to alternative plastics, which would require significant further development, as explained below.

Regarding improved source separation, given the prominence of plastic beverage containers in litter and waste in Belize, the expansion of the existing DRS to include these containers represents a quick win in terms of tackling litter in the short run, by providing a viable method of incentivising the separate collection of this valuable waste stream for recycling. Given that consumers are already familiar with the system of deposits in Belize, there would likely be good uptake of this measure subject to its robust design.

Finally, though bio-based plastics are not the most preferred option for SUP alternatives in Belize, if such alternatives are supported, not only is the development of clear standards for the design and degradability of such products necessary, but also the establishment of appropriate, local, end of life management systems focussed on processing these items. This would include widely accessible systems for the separate collection of these items (to ensure they do not end up as litter or in waste facilities that cannot process them in an environmentally sustainable way), and subsequent transfer to the appropriate composting/ digestion plants with gas capture. In Belize's context, this would have the added advantage of opening a clear route to the separate collection and treatment of other organic waste with a useful by-product, easing the burden on landfill capacity, which is currently being exhausted earlier than expected. The establishment of such end of life management systems should therefore be a prerequisite to supporting the development of bio-based plastics as alternatives to conventional plastics in order to avoid the creation of further problems with litter and waste management.

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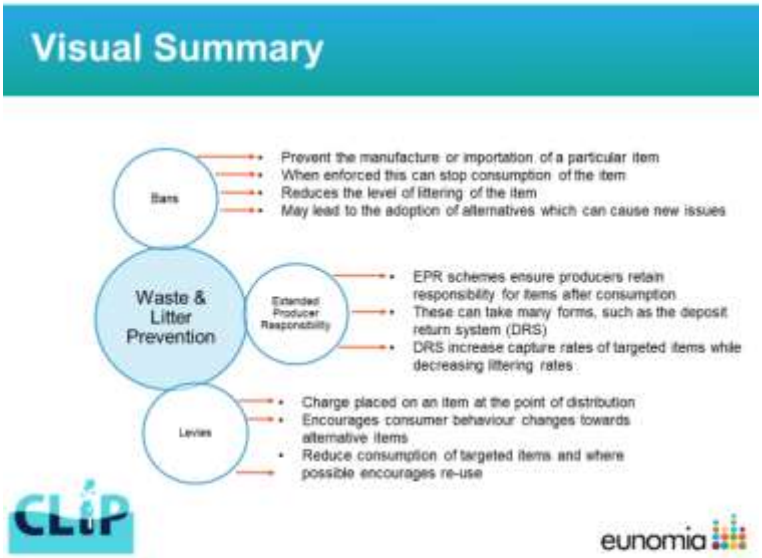
Appendix 1 - National Stakeholder Workshop Presentation (11th/ 12th July)



Key Message 1: Public Awareness

- **There is variation in how effectively bans are enforced.**
- **Enforcement of bans over several stages allows citizens and businesses to adapt and use alternatives.**
- **Raising public awareness facilitates adoption of alternatives and increases the ban's effectiveness.**

Case Study 1: Costa Rica

Covers: Straws, bottles, EPS foam, utensils, cups and plates
Date implemented: 2018 – 2021
Enforcement: Initial stages enforced

- Staged implementation is supported by public awareness campaigns of new laws and regulations - the #YoMeComprometo ('I promise') campaign to engage the public.
- Govt also developed a free online resource, Zona Libre de Plástico, where alternatives are publicised.
- First stage of the ban has covered all public institutions (schools, health centres, prisons etc.).

Zona Libre de Plastico

Key Message 2: Engage Industry

- **Failure to engage key stakeholders, such as businesses and industry, can result in backlash that can slow the ban's implementation.**
- **Equally, support and/or endorsement from key stakeholders can facilitate implementation.**

Case Study 2: New York

Covers: EPS food containers
Date implemented: 2019
Enforcement: From 1st July 2019

- New York first tried to implement a ban in 2013 and met legal challenge.
- These were a result of industry backlash, which felt it was poorly consulted on the issue.
- Ban re-introduced in Jan 2019, with 6-month grace period.
- From July 1st, the ban will be primarily enforced by the Dept. of Sanitation - stepped fine system.
- Industry backlash has therefore caused a delay of 6 years.

CBS News

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Key Message 3: Assess Costs

- **There is limited scope for raising tax revenues through bans, with the exception of financial penalties for offending organisations.**
- **However, there are significant costs of the ban, arising through its implementation and enforcement.**
- **These can be direct costs such as policing and indirect costs such as the loss of jobs.**

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Case Study 3: Kenya

Covers: Plastic bags
Date implemented: 2017
Enforcement: Well-enforced

- Kenya's plastic bag ban was one of the world's first, to tackle the nation's consumption of 24 million bags p/m.
- The ban is strictly enforced across the country, with only some marginal use continuing in border regions due to smuggling activity.
- Job losses as a result of the ban are estimated to be around 60,000.[4]

DW

4 - Kenyans (2018) Kenyans to Lose Their Jobs After Government Ban on Plastic Bags. Available: www.kenyans.co.ke/news/60000-kenyans-lose-their-jobs-after-government-ban-plastic-bags-17523

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Key Message 4: Assess Impact

- **There is a widespread evidence-gap on the effectiveness of bans as a policy instrument.**
- **There are significant differences in their impacts which can be correlated to a number of variables including implementation and enforcement.**
- **Often there is no pre-ban baseline established, against which impacts can be compared.**

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Case Study 4: Vanuatu

Covers: Plastic bags, bottles, straws/ utensils, EPS containers, nappies

Date implemented: 2018 - 2020

Enforcement: Well-enforced

- One of the world's strictest, indicative of Vanuatu's commitment as co-Chair of the Commonwealth Clean Oceans Alliance.
- The ban's enforcement through financial penalties has resulted in national compliance for the first stages.
- However, no baseline of the original situation was established. This increases uncertainty for outcomes.

Global Citizen

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Bans: Summary of Key Messages

Design
- Develop Baseline
- Assess Costs
- Engage Industry

Implement
- Public Awareness
- Staged Implementation

Enforce
- Assess Impact

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Levies: Context

- Levies are a set charge, placed on products or services.
- Generally more easily set by regional governments while national governments are responsible for taxes.
- Can raise funds, which can help to cover the costs of waste management programmes or other causes.
- Tend to have stronger evidence base for evaluating effectiveness
- Good enforcement requires coordination between regulating authorities and retailers/ effective governance structures.
- Coupled with bans, levies can be an effective in shifting consumer behaviour and reducing demand.

CLiP

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Key Message 1: Point of Application

- Levies can be applied at a number of points throughout the supply chain.
- These can raise funds for covering the costs of the policy.
- Charging at the point of import or manufacture (tax) increases the cost to suppliers and allows efforts to be focused on fewer physical locations. Similarly, subsidies to producers/ imports of positive can influence the market from the supply side.
- Charging at the point of consumption is a clearer message to consumers, and is therefore a more effective approach for encouraging behaviour change.

CLiP

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Case Study 1: Wales

Covers: Plastic bags
Date implemented: 2011
Enforcement: Well enforced

- SUP bags (carrier bags) can only be provided by retailers for a fee.
- The levy resulted in a 71% reduction in single-use plastic bag consumption between 2011 and 2014, while consumer support for the charge increased from 61% to 74% between 2011 and 2015.
- Wales was the first UK nation to introduce a plastic bag charge, which has remained at £0.05.

Financial Times

CLiP

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Key Message 2: Governance

- There are still issues around the enforcement of levies, and they require effective governance systems to ensure compliance.
- Smaller businesses are generally more difficult to regulate, especially in economies with larger informal sectors.

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Case Study 2: China

Covers: Plastic bags

Date implemented: 2008

Enforcement: Weakly enforced

- Bags less than 25 microns thick were banned, while thicker bags had a charge placed on them.
- This has led to an estimated 66% decrease in plastic bag use.
- However, recent assessment found that only 17% of retailers were charging as stipulated in national law. The majority of these were large supermarkets.

China Daily

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Key Message 3: Access to Alternatives

- Levies can only have impact if there are readily available/ accessible alternatives for a consumer to switch to.
- Levies can incentivise the uptake of alternative products, which in turn may need to be managed in a certain way.
- Therefore, it is important that the national waste management system can deal with alternative materials, decreasing the risk that they are littered or end up in landfill.
- The following example draws on lessons learned from Kenya's ban. While it is not a levy, the lessons are relevant and transferable.

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Case Study 3: Kenya

Covers: Plastic bags
Date implemented: 2017
Enforcement: Well-enforced

- The ban gave limited attention to the availability and accessibility of alternatives.
- Synthetic woven fibre bags, known as 'totes', have been widely adopted as alternatives.
- Although reusable, littering of totes has become an issue across the country.[5] Microfibre release is an added concern.

Ewaso Lions

5 - National Geographic (2018) Plastic bag bans are effective, but are they spreading?. Available: https://www.nationalgeographic.com/environment/2019/04/plastic-bag-bans-kenya-to-us-reduce-pollution/

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Levies: Summary of Key Messages

Design
- Develop baseline
- Engage industry

Implement
- Public awareness
- Consistent governance and management
- Ensure alternatives are available

Enforce
- Assess Impact
- Ensure comprehensive coverage of the scheme

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DRS: Context

- Deposit return schemes (DRS) are interventions, where products are sold with a refundable deposit. After use, the consumer can return the product to retrieve their deposit.
- Schemes are a well-established option for reducing litter and increasing capture rates of items.
- There are around 23 active national DRS around the world, though there is a concentration in Europe.
- DRS generally require a high level of infrastructure and management. Automated reverse-vending machines are common place in Europe.

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Key Message 1: Capture Rates

- Deposit Return Schemes (DRS) are a highly effective tool to increase capture rates of targeted items, as consumers retrieve their deposits.
- Increasing capture rates also decreases the proportion of items that are littered.
- There are DRS operations that have been active for a number of years, which can provide reliable quantitative data for their impacts to be assessed.

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Case Study 1: Norway

Covers: Metal and plastic containers
Date implemented: 1999
Enforcement: Well-enforced

- Infinitum, a publicly owned company, operates Norway's national DRS.
- The scheme achieves one of the world's highest capture rates, 96% for PET plastic bottles.[6]
- A deposit of £0.10 to £0.25 on plastic and metal items encourages their return through a national network of automated machines.

Green Visits

6 - Infinitum (2018) Annual Report. Available: https://infinitum.no/english/infinitum-annual-report-2017

eunomia

Key Message 2: Adaptability

- DRS are primarily implemented in developed nations, incurring costs due to infrastructure and management. However, the intervention can be adapted to developing country contexts through the use of registered agents.
- This is likely to have a positive impact on litter and recycling rates, though in the following example there is a lack of quantitative data.

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Case study 2: Palau

Covers: Glass, metal and plastic containers

Date implemented: 2009

Enforcement: Well-enforced

- Palau operates a DRS, which charges $0.10 for every single-use container imported into the country. Consumers pay an additional deposit of $0.10 when purchasing a container.
- The importation charge is used to cover the cost of recycling, while consumer deposits are returned at Koror State Redemption Center.
- Employment opportunities are created through the use of agents, via which the costs of reverse vending machines are avoided.

Asian Development Bank

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Appendix 2 – Longlist of SUP Items Alternatives

SUP Category	SUP Items	SUNP Alternatives	MU Alternatives	Alternative Plastics
Food Containers for Transport	• Clamshells • Food containers • Soup containers • Cups (with lids)	• Card • Bagasse • Wheat fibre	• Reusable crockery • Reusbale plastic • Reusable metal	• PLA (polylactic acid) • PHA (polyhydroxyalkanoates) • PBS (polybutylene succinate)
Beverage Containers for Transport	• Plastic beverage bottles and beverage bottle lids • Beverage Cartons • Water/ other beverage pouches	• Metal cans • Glass bottles, or reusable glass bottles (as in soft drink return/refill schemes/beer refillables, and in 'milkman' type schemes)	• Refillable plastic bottle • Refillable metal bottle • Refillable glass bottle	• Biobased PET (polyethylene terephthalate) bottle, biobased beverage cartons are also available using biobased polyethylene for the waterproof layer. • Recycled PET (polyethylene terephthalate) • PLA bottles
Food/beverage Containers for Immediate Consumption	• Plates • Bowls • Cups • Lids • Tumblers	• Cardboard/paper plates/bowls (moulded fibre). • Banana leaf (or alternative) wrapping may be suitable in some instances, though not widely	• Crockery/cups for eat in (china) • Reusable plastic cups/containers (e.g. silicone based) • Reusable bamboo cups/ containers	• CPLA (crystallised polylactic acid) • PLA (polylactic acid) • PHA (polyhydroxyalkanoates)

SUP Category	SUP Items	SUNP Alternatives	MU Alternatives	Alternative Plastics
		used. Plates/bowls can also be made from processed palm leaf Bagasse and wheat fibre products		
Eating/ Drinking Implements	• Cutlery • Plastic stirrers • Straws	• Wood • Bamboo • Paper straws	• Reusable metal • Reusable plastic	• CPLA (crystallised polylactic acid) • PLA (polylactic acid) • RCPLA (reclaimed CPLA)
Wrappers	• Sweet Wrappers • Crisp Packets/Savoury Snack packets • Single portion sachets (condiments/ cosmetic/ hygiene)	• Some waxed paper type alternatives, foil plus paper combination (separable) • Wood based biodegradable wrapper • SUNP options are not available for crisp packets or sachets at present.	• Shared dispenser/ paper cups or reusable containers for refill • Reusable/refillable glass bottles	• Emerging compostable packaging (e.g. Tipa) • Emerging compostable/monopolymer (recyclable) plastic packaging • Emerging compostable packaging (e.g. Ooho)
Carrier Bags	Plastic Carrier Bags	Paper carrier bag	• Cotton and canvas • Jute / Hessian • Hemp • Bamboo"	• Biobased PLA PBAT (polybutylene adipate terephthalate) combination • Biobased PLA

SUP Category	SUP Items	SUNP Alternatives	MU Alternatives	Alternative Plastics
			• High density polyethylene • Woven polypropylene • Non-woven polypropylene • PET (potentially with recycled content) • Nylon • Polyester" • Woven polypropylene • Non-woven polypropylene • PET (potentially with recycled content) • Nylon • Polyester"	
6-pack Rings/ Yokes	Yokes for multiple cans	• Cardboard carrier/fibre based • Redesigned 'stackable' metal cans • Glue based option	Plastic crate (with deposit)	N/A
Balloons/ balloon sticks	Balloons/ balloon sticks	• Bamboo • Cardboard / rolled paper	N/A	N/A

SUP Category	SUP Items	SUNP Alternatives	MU Alternatives	Alternative Plastics
Cigarette Packaging	• Cigarette filters • Plastic/ plastic lined cigarette packaging	• Cellulose/cotton filters • Paper filters	• E-cigarettes • Tobacco pipe / hookah • Tobacco pipe / hookah	N/A
Hygiene Products	• Nappies • Sanitary pads • Tampons/ applicators • Wet wipes • Plastic cotton bud sticks • Dental floss, plastic picks	• Cotton towels • Cotton tampons • Cotton wet wipes / Paper based wet wipes • Cotton pads (suitable for some applications, not all) • Cardboard sticks • Wooden tooth picks • Silk based floss	• Cloth nappies (washable separable inner, waterproof outer) • Reusable menstrual cup (e.g. Moon Cup) • Washable sanitary towels • Fabric flannel • Specific MU wipe (e.g. 'cheeky wipes') • MU plastic sticks (e.g. Utility Tip) • Reusable plastic dental floss pick	PLA Wet wipes are available

Centre for Environment Fisheries & Aquaculture Science

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