PACIFIC OCEAN LITTER PROJECT

Development of a Pacific Region Compendium and Assessment of Current Research into Substitutes for Single-Use Plastics and their Practical Application

Australian Aid

SPREP
Secretariat of the Pacific Regional Environment Programme

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SPREP's vision: The Pacific environment, sustaining our livelihoods and natural heritage in harmony with our cultures.

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Contents

Definitions

Terms	Definitions
Compendium	A compendium is a comprehensive collection of information and analysis pertaining to a body of knowledge.
Bio-based plastics	Bio-based plastics are plastics entirely made of renewable sources of plant, animal or fungal origin (i.e. biomass).
Bioplastics	In this report, the term bioplastics is interchangeable with bio-based plastics.
Composites	Composites are materials made of two or more different components, which can be partially or entirely bio-based. The term "biocomposites" encompasses materials that have at least one component made of biomass.
Biodegradable plastics	Biodegradable plastics are plastics of either bio-based or fossil-based origin that can, due to their structure, be degraded by microorganisms into monomeric units followed by their conversion to water, carbon dioxide or methane, and biomass.
Oxo-degradable plastics	Oxo-degradable plastics are a mix of non-biodegradable plastics (e.g. polyethylene, polypropylene) and additives that facilitate and speed up degradation, such as starch and metals. The result of this degradation are microplastics.
Compostable plastics	Compostable plastics are plastics that can be decomposed in controlled conditions in an industrial composting facility (i.e. elevated temperatures) or in a home composting setup with the aim of producing compost (i.e. nutrient-rich organic material). Composting involves biodegradability in a short period of time (weeks to months).
Composters	Composters are industrially controlled environments that enable biodegradation.
Conventional plastics	Conventional plastics are synonymous with fossil-based plastics. The most common conventional plastics are polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polyvinyl chloride (PVC), and polystyrene (PS).
Non-plastic substitutes	Non-plastic substitutes are natural materials originating from mineral, plant, animal, marine or forestry origin that have similar properties as plastics (UNCTAD, 2023).
Plastic alternatives	Plastic alternatives include bio-based plastic materials synthesised from biogenic materials and include biodegradable and non-biodegradable bio-based plastics (UNCTAD, 2023).
Microplastics	Microplastics are minute plastic particles (< 5 mm) that are either purposely made in small sizes (e.g. various abrasives) or are a product of mechanical degradation of larger plastic objects or fragments.

"Plastics' omnipresence has pushed waste management capacities to their limits; thus, it is of the utmost importance to identify what materials or products could successfully substitute plastics and how to implement this transition" (UNCTAD, 2023).

Executive summary

Background

The Pacific Ocean Litter Project (**POLP**) is working to reduce single-use plastic (**SUP**) marine litter in the coastal environments of Pacific Island Countries (**PICs**). It has been developed in recognition of the threat plastic pollution poses to the environment, public health, and economic development of the Pacific region. PICs are particularly vulnerable as they are heavily reliant on packaged imported goods and international development assistance. They are also remote from international recycling markets and regularly lack environmentally sound waste and resource management systems.

This study is being undertaken for the POLP, with the aim of providing a region-wide compendium of local and regional manufacturers and distributors and to assess state-of-the-art research into environmentally acceptable non-plastic substitutes for SUPs and their practical application. As part of this study, research has been undertaken in all countries within the scope of POLP, with further detailed assessment undertaken in three case study countries: Samoa, Solomon Islands, and Kiribati.

Scope

SUP items addressed in this report include the most commonly used SUPs in the Pacific and worldwide, including plastic bags and containers for **beverage, food, and personal care products**. The items do not include plastic packaging for supermarket food.

Single-use plastics

The core of the problem with SUPs is the resilient and non-biodegradable nature of their materials which are disposed of after just one use. This, coupled with ever-increasing consumption of SUPs, has led to increasing levels of plastic pollution worldwide. Plastics are also mostly produced from non-renewable resources, such as fossil oil and gas.

Despite recent efforts to reduce plastic use, global production continues to steadily increase from 370.5 million tonnes (Mt) in 2018 to 400.3 Mt in 2022, with plastics from fossil-based resources comprising 90.5% of all plastics produced (PlasticsEurope, 2023). Most plastic waste ends up in either landfills (40%) or the environment (32%) or is incinerated, while only 14% is recycled.

International Coastal Cleanup (ICC) annual beach cleanups, organised by Ocean Conservancy, provide lists and amounts of plastic debris, most commonly found on beaches in PICs. This data provides incomplete information on the types and numbers of items contributing to marine plastic pollution in PICs but, nevertheless, gives a useful indication of the types of items causing the pollution. Major plastic items include plastic beverage bottles and caps, plastic bags, food containers, and paper cups (generally plastic-lined).

Non-plastic substitutes and bio-based plastic alternatives to SUPs

Small Island Developing States (SIDS) are investigating potential materials that could serve as replacements for SUPs. Key considerations for the replacing materials include durability, recyclability, and/or biodegradability in nature. Of particular interest are a range of traditional materials and their potential as viable replacements for plastic.

There are two fundamentally different approaches to replacing SUPs – reusable products and disposable products. Utilising any reusable products, regardless of their material composition, aligns with waste management principles that prioritise waste reduction and sustainable use of resources.

For this study, the concept developed by UNCTAD (2021, 2023) has been adopted, in which the materials that replace conventional plastics are divided into two categories: **non-plastic substitutes** and **bio-based plastic alternatives,** as detailed in section 2.2 below.

Examples of non-plastic substitute materials include plant fibres and materials (e.g. banana leaves, bamboo, coconut husk, hemp, jute, sugarcane bagasse), fungal fibres and materials (e.g. mycelium material), as well as animal fibres and materials (e.g. wool, silk, leather). Bio-based plastic alternatives have also become increasingly relevant in global SUP management efforts. These include sugar-based polymers, starch-based polymers, and cellulose-based polymers.

Not all bio-based plastics are designed to be biodegradable. Those that are biodegradable can be, but are not necessarily, compostable either on a small scale at home or on a large scale in a composting facility. To ensure that materials marketed as bio-based, biodegradable, or compostable hold true, several international and national testing and standards organisations have developed standards that define acceptable levels of biodegradability and compostability. Understanding standards and labels is crucial for future procurement of bio-based materials and plastics in PICs.

Availability analysis

Local coordinators faced challenges in gathering data from distributors and importers, while research into local non-plastic substitutes and bio-based plastic alternatives proved difficult due to minimal activity in this area. Traditional handmade production dominates, with only three producers in the Solomon Islands making reusable items, mainly as souvenirs, though they could be a starting point for scaling up production.

Our investigation revealed a lack of local bio-based plastic alternatives in PICs. The Scientific Research Organisation of Samoa is exploring PHAs production, but commercial viability seems uncertain, owing to lack of material supply.

An internet search for bio-based product manufacturers in the Asia-Pacific region yielded limited results, with common substitutes including paper, bagasse, wood, bamboo, and cotton, and PLA as the primary bio-based plastic alternative. However, information on materials, standards, and origins of raw materials was often incomplete, posing challenges for sustainability considerations in procurement.

Suitability of substitutes and alternatives for PICs

The process of introducing new materials and products into PICs as substitutes or alternatives to SUPs, or expanding the production of the existing ones, requires their evaluation against a range of suitability criteria. These criteria include: **environmental impact**, **human health**, **market accessibility**, **technical feasibility**, **financial viability**, **circular economy considerations**, **end-of-life options, community acceptance,** and **regulatory compliance**.

Suitability criteria

- Environmental impact
- Human health safety
- Market accessibility
- Technical feasibility
- Financial viability
- Circular bio-economy considerations
- Products' end-of-life options and waste management
- Community engagement and acceptance
- Regulatory compliance

Ideally, new substitutes and alternatives should undergo a life cycle analysis (LCA). Given the complexity and time required for LCAs, it is not always feasible nor practical to perform a full analysis. In this situation, relevant guidelines that can help in the decision-making process are recommended.

Compendium of SUP substitutes and alternatives

A detailed compendium of products available to be purchased within the region, colour-coded for suitability (based on the criteria above), has been prepared in parallel with this report and forms the key outcome of this project.

1 Background

1.1 The Pacific Ocean Litter Project (POLP)

The **Pacific Ocean Litter Project (POLP)** (2019-2027) is funded by the Australian Government and implemented by the **Secretariat of the Pacific Regional Environment Programme (SPREP)** in collaboration with Pacific Island Countries (PICs). POLP is working to reduce single-use plastic (SUP) marine litter in the coastal environments of PICs. It has been developed in recognition of the threat marine litter poses to the environment, public health, and economic development of the Pacific region.

Pacific island countries (PICs) are economically vulnerable as they are heavily reliant on packaged imported goods and international development assistance. They are remote from international recycling markets and lack environmentally sound waste and resource management systems. These countries are also extremely vulnerable to the impacts of climate change and severe weather events, which can generate excessive disaster-recovery loads to the normal or predicted waste levels.

POLP's long-term goal is cleaner coastal environments for PICs. The end-of-project outcomes are:

1. Measures, policies, or practical strategies to reduce single-use plastic are developed and provided to pilot countries.
2. Local and visiting consumers of all ages and genders are using less single-use plastics and more alternative products.
3. Target sectors, companies, and businesses adopt plastic reduction measures.
4. Alternative products are identified for adoption.

POLP is designed to support a scalable roll-out to multiple PICs. The project builds skills and capacity for PICs through the provision of technical support at regional and national levels and by the development of regionally appropriate plastic reduction initiatives and measures.

1.2 The purpose of the study

This study is being undertaken as part of the POLP, with goals of the study being to:

- assess state-of-the-art research into environmentally acceptable non-plastic substitutes for single-use plastics (SUPs) and their practical application, and to
- provide a region-wide compendium of local and regional manufacturers and distributors of the substitute products.

Primary research has been undertaken in all countries within the scope of POLP. These include: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.

Further detailed assessment of the suitability of substitutes and local production has been conducted for the following countries:

- Polynesia: **Samoa**
- Melanesia: **Solomon Islands**
- Micronesia: **Kiribati**

SUP items addressed in this report are listed in Table 1. They include the most commonly used SUPs in the Pacific and worldwide. The list does not include plastic packaging for supermarket food as it exceeds the scope of this work.

Table 1: List of targeted SUPs.

	General item	Specific item
BEVERAGES	Drink cups	Cold drinks
		Hot drinks
	Plastic straws	Large drink straws
		Small drink straws
FOODS	Takeaway food containers	'Clam shell' containers
		Sushi containers
	Food trays and plates	Food trays
		Picnic/party plates
	Cutlery	Spoons, knives, forks, chopsticks
OTHER	Plastic bags	Light shopping bags
		Thick shopping bags
		Fruit & veggie thin bags
		Dog poo bags
	Personal care products	Nappies
		Sanitary pads
		Tampons
		Cotton buds
		Wet wipes

*

1.3 Production, use, and misuse of plastics

Humanity spent over a century developing plastics into the “perfect’’ material, only to find that a complete rethink is needed on what this means. Plastic use experienced rapid growth from the early 1950s, linked to material advances during World War II. Early in this growth phase, plastic was a highly praised material, but within two decades, evidence of the negative effects of plastics on marine environments started to emerge in the scientific literature (e.g. Carpenter & Smith, 1972; Scott, 1972; Cundell, 1973; Rothstein, 1973; Colton et al., 1974; Hays & Cormons, 1974) (**Figure 1**). The core of the problem with SUPs is that they are widely-used and non-biodegradable materials that are usually disposed of after just one use. This, coupled with ever-increasing consumption of SUPs and outpacing of the capacity of waste streams, has significantly contributed to the high and increasing levels of plastic pollution we are dealing with today.

Figure 1: Evidence of plastic pollution reported in academic journals from the 1970s.

Plastics are predominantly produced from non-renewable resources such as fossil oil and gas. After extraction, oil and gas are refined by the petrochemical industry and turned into pellets of various types of polymers (primary plastics). The polymers are chemically altered into a variety of intermediate or final plastic products using numerous additives, which include polycyclic aromatic hydrocarbons (PAHs); polychlorinated biphenyls (PCBs); and dichlorodiphenyldichloroethylene (DDE), a breakdown product of Dichloro-diphenyl-trichloro-ethane (DDT), also known as hazardous chemicals (UNCTAD, 2023). After use, disposal pathways can include reuse, recycling, incineration, landfilling, open burning, and littering or dumping, depending on the available waste management service, local cultural practices, and individual preferences.

Despite recent efforts to reduce plastic use, global production continues to steadily increase from 370.5 million tonnes (Mt) in 2018 to 400.3 Mt in 2022. Plastics from fossil-based resources comprised 90.5% of all plastics produced in 2022, while only 8.9% come from mechanically recycled plastics and 0.6% from bio-based plastics (PlasticsEurope, 2023) (**Figure 2**). The largest manufacturer of plastics is China, which produced one third (32%) of plastics placed on the global market in 2022, followed by the rest of Asia (19%), the United States (17%), and Europe (14%) (**Figure 3**).

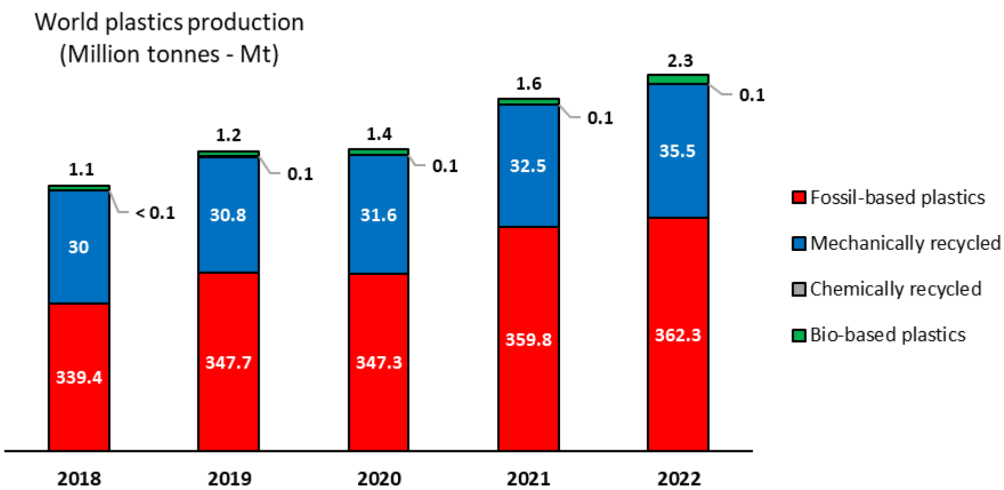


Figure 2: Plastics production (adopted from Plastics Europe, 2023)

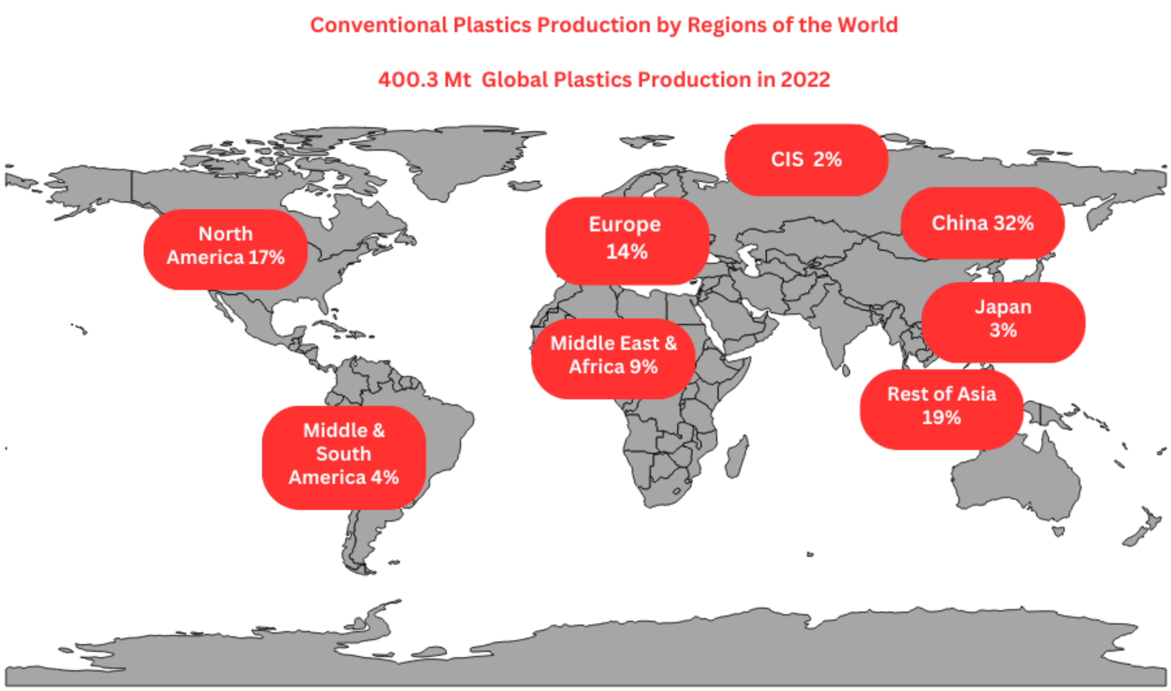


Figure 3: Plastics production (adopted from Plastics Europe, 2023)

According to UNEP (2021), most plastic waste ends up in landfill (40%) and the environment (32%), while 14% is incinerated and another 14% recycled (**Figure 4**). About 45% of plastic products are plastic packaging (**Figure 5**). Single-use plastic packaging holds minimal inherent value, primarily serving as a potential recycling material. However, due to technical challenges and significant expenses, its recycling rate remains low, resulting in limited utilisation of this resource.

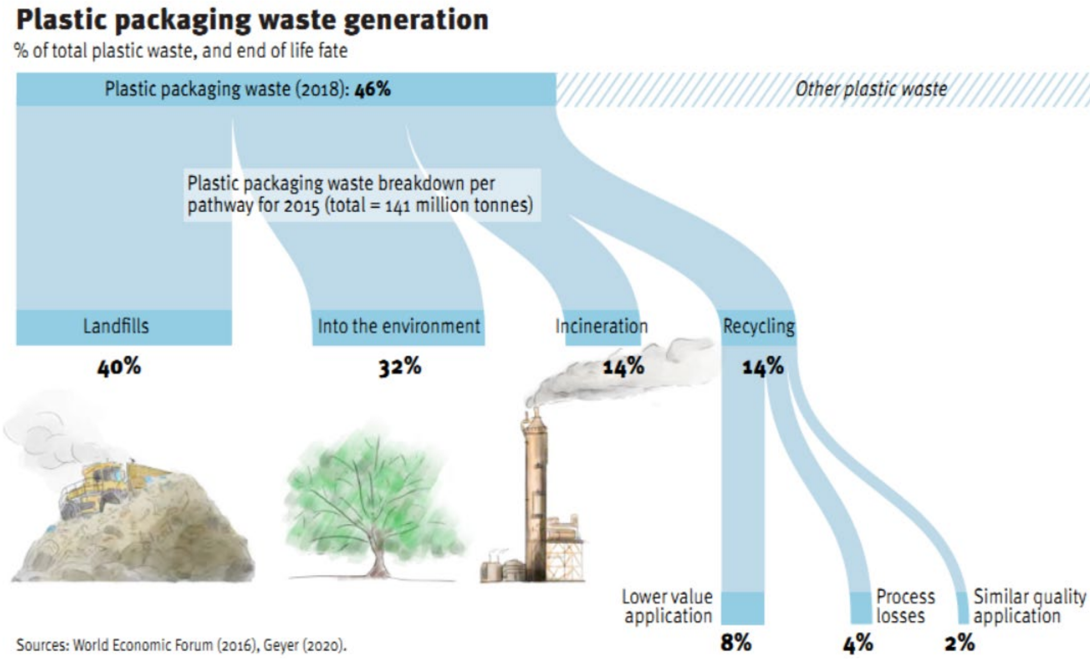


Figure 4: Plastic packaging waste generation based on data from 2018 (image taken from UNEP 2021)

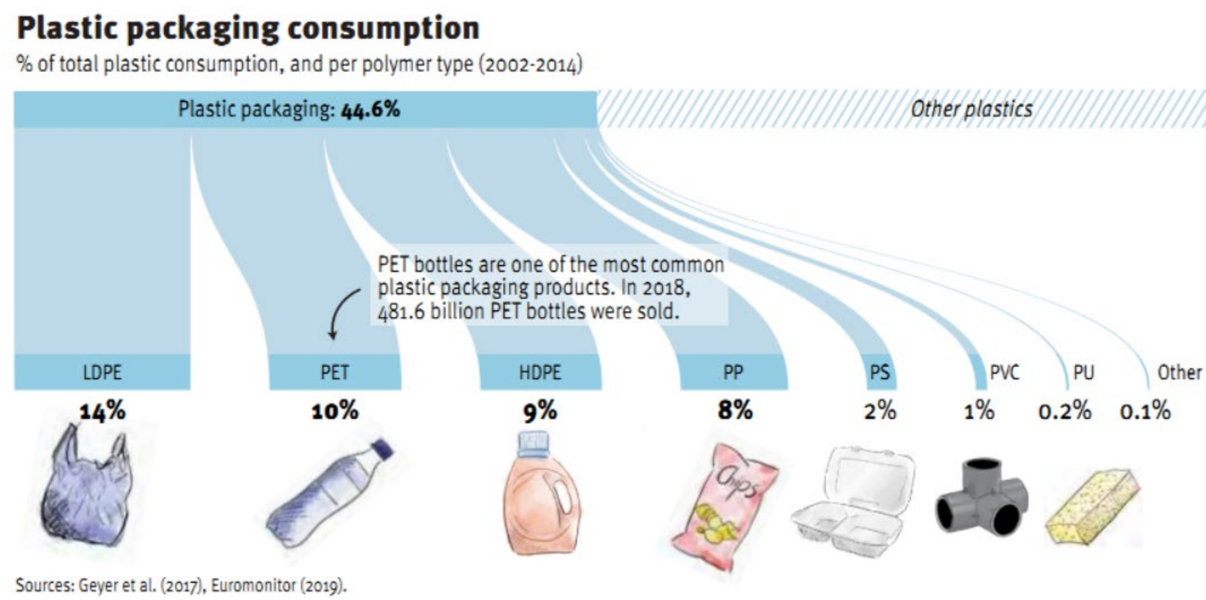


Figure 5: Plastic packaging consumption based on data from 2022-2014 (image taken from UNEP 2021)

1.4 Plastic waste in the case-study Pacific Island Countries (PICs)

Annual beach cleanups by International Coastal Cleanup (ICC), organised by Ocean Conservancy, provide lists and amounts of plastic debris most commonly found on beaches (**Table 2**) (Ocean Conservancy, 2023). This data provides incomplete information on the types and numbers of items contributing to marine plastic pollution in PICs), but nevertheless, gives a useful indication of the types of items causing the pollution. Of the three case-study countries, the 2023 report contains information only for Samoa and Solomon Islands. **Since these reports do not specify the size of the area where debris was collected, the values across countries are not directly comparable.**

Table 2: The most common items collected during the Ocean Conservancy ICC in 2022.

Litter assessments 2022	Samoa	Solomon Islands	Kiribati
Cigarette butts	n/a	108	no info
Plastic beverage bottles	1055	2114	
Food wraps	290	68	
Plastic bottle caps	354	600	
Plastic grocery bags	25	405	
Other plastic bags	25	400	
Food containers – foam	15	360	
Food containers – hard plastic	191	38	
Paper cups & plates	732	8	
Plastic straws & stirrers	n/a	41	

Notes: The values are the total number of items collected, but the area sampled is not specified, thus not directly comparable. Besides Samoa and Solomon Islands, the only other country that this information is available for in the Pacific is Vanuatu.

Despite efforts to curb plastic usage, global plastic production continues to rise, with China leading global plastic manufacturing, followed by Asia, the United States, and Europe. Most plastic waste ends up in landfills (40%) or the environment (32%), with only 14% being incinerated and another 14% recycled.

The International Coastal Cleanup (ICC) organized by Ocean Conservancy provides data on the most common plastic debris found on beaches. In 2022, the most frequently collected items in Samoa and Solomon Islands included plastic beverage bottles, food wraps, plastic bottle caps, and various types of plastic bags and food containers. Specific counts varied, with significant numbers such as 1,055 plastic and 2114 plastic beverage bottles in Samoa and Solomon Islands respectively.

2 Replacements for SUPs

Amid the global trend of banning SUPs, Small Island Developing States (SIDS) are investigating potential materials that could serve as replacements for SUPs, with the two fundamentally different approaches to replacing SUPs being reusable products and disposable products that are biodegradable and/or recyclable (Barrowclough & Vivas Eugui, 2021). Replacement of single-use plastics is a complex task that requires addressing the entire life cycle of plastic and the replacing materials. Global management efforts still concentrate predominantly on downstream issues (recycling and waste management post-use). However, initiatives addressing the upstream and midstream stages of the life cycle of plastics and their replacements are on the rise, with the aim of adopting materials that minimise resource consumption across value chains and promote transition towards circular economies (UNCTAD, 2023).

2.1 Reusables

According to UNEP (2023), 70% of plastic reduction could come from reuse, refill, and new delivery models. The adoption of reusable tableware for takeaway food and beverages, for example, is gaining popularity, particularly among younger demographics (Agarwal et al., 2020).

Reusable products can be made from renewable materials such as jute and palm leaf (for shopping bags), wood, and bio-based plastic, but common materials for manufacturing reusables include non-renewable sources such as stainless steel, glass, ceramic, and petrochemical plastic. Even when non-renewable sources are used, however, these materials are often highly recyclable.

Thus, utilising any reusable products, regardless of their material composition, aligns with waste management principles that prioritise waste reduction and sustainable use of resources. For instance, Changwichan and Gheewala (2020) found that using a stainless-steel cup more than 140 times outweighs the impacts of both bagasse and plastic disposable cups. Unlike single-use tableware, reusable food containers, plates, bowls, and cups can be used repeatedly before reaching the end of their lifespan. Reusable tableware also includes repurposed items such as glass jars, peanut butter and ice-cream containers, or other sturdy packaging.

While it has been demonstrated that reusable products are usually a more environmentally justified replacement option than disposable options, and are the recommended replacement option, this project focuses primarily on immediate solutions to replacing SUPs primarily because reusable systems require infrastructure and longer lead times for implementation. Immediate solutions mainly include disposable biodegradable products. Also, more attention will be given to the renewable substitutes from plant, animal, and fungal origin, as opposed to non-renewable materials such as mineral and metal-based (stainless steel, glass, ceramics), which are most often utilised as reusable options.

2.2 Disposable non-plastic substitutes and bio-based plastic alternatives

For this study, the materials that replace conventional plastics for disposable products are divided into two categories: **non-plastic substitutes** and **bio-based plastic alternatives**. This aligns with the approach developed by UNCTAD (2021, 2023).

1. **Non-plastic substitutes**. Non-plastic substitutes are made of any natural material of mineral, plant, animal, marine or forestry origin that have similar properties as plastics (UNCTAD, 2023) (**Table 3**). These natural biodegradable materials have a long history in SIDS and provide a strong foundation for replacing SUPs, applying either traditional production methods or modern and innovative processes such as compression moulding, injection moulding and hot pressing.

   Some of the most common substitute materials include plant leaves, sugarcane bagasse, coconut husk, rice husk, bamboo, jute and hemp. Sugarcane bagasse is particularly versatile and has numerous applications in disposable service ware, such as containers, plates, trays and bowls, as well as bagasse paper, textiles, biofuels and furniture.

   SUPs are already being widely replaced by non-plastic substitute paper products, and paper cups, plates and containers are now commonly available in takeaway food industries and supermarkets. UNEP (2023) reports that average GHG emissions would be reduced by 25% if flexible plastic was replaced by sustainably sourced paper. However, it is important to note that some disposable paper products include a plastic lining (e.g., PE), which makes them neither recyclable nor compostable, and thus they cannot be considered purely non-plastic substitutes.

Bio-based and biodegradable plastic alternatives. Bio-based plastic alternatives include bio-based plastic materials that are synthesised from biogenic materials and include biodegradable and non-biodegradable bio-based plastics, usually polymer materials produced from renewable biomass sources (**Table 3**). Bio-based plastic alternatives have also become increasingly relevant in global SUP management efforts. Unlike conventional petrochemical (fossil fuel-based) plastics, these polymers are derived from biomass – plant and animal-based materials such as corn, wheat, potatoes, cassava and food waste. The resulting bio-based polymers commonly discussed in academic literature are polylactic acid (PLA), thermoplastic starch (TPS), polyhydroxyalkanoates (PHAs) (polyester), polybutylene succinate (PBS) and polybutylene adipate terephthalate (PBAT).

Not all bio-based plastic alternatives are designed to be biodegradable. The ones that are biodegradable are compostable on either a small scale at home or a large scale in a composting facility (i.e. industrial composting). In this report, recommendations relating to bio-based plastic alternatives will include only bio-based alternatives **that are also biodegradable.**

Table 3: Plastic substitutes vs plastic alternatives (adapted from UNCTAD, 2023)

Non-plastic substitutes	Bio-based and biodegradable plastic alternatives
Natural materials **excluding** fossil-based or synthetic polymers	Bioplastics or biodegradable plastics (usually polymer materials produced from renewable biomass sources)
Mineral, plant, marine or animal origin	Vegetable fats and oils, corn starch, straw, woodchips, sawdust, and recycled food waste
Similar properties of fossil fuel-based plastics	
Should be biodegradable/compostable or erodable and should be suitable for reuse, recycling, or sound waste disposal	Should be subject to material recycling, biodegrade in the natural environment or that can be composted (end of life)
Should have lower environmental impact along their life cycle (e.g., natural fibres, agricultural wastes, and other forms of biomass)	
Can include by-products	Can include by-products
Should not be hazardous for human, animal or plant life	Should not be hazardous for human, animal or plant life
NON-PLASTICS	BETTER PLASTICS

The advantage of non-plastic substitutes over bio-based and biodegradable plastic alternatives is that non-plastic substitutes do not include significant chemical alteration of the raw material, while the production of bio-based and biodegradable plastic alternatives include substantial physical, thermal, and mechanical processing and/or chemical treatments and/or the use of chemical treatments including dyes.

Some bio-based materials perform better in combination with other materials, creating so-called ‘biocomposites’. For example, coconut husk can be used in combination with other bio-based materials to produce a bio-based foam replacement for expanded polystyrene.

Ideally, both non-plastic substitutes and biobased and biodegradable alternatives should demonstrate lower environmental impact along their life cycle, compared to conventional SUPs, by using renewable resources such as natural fibres, agricultural wastes, vegetable fats and oils, corn starch, straw, woodchips, sawdust, recycled food waste, and other forms of biomass. Also, they should not be hazardous for human, animal, or plant life (UNCTAD, 2023). Preferably, they should be biodegradable and compostable or otherwise manageable, including their by-products, in accordance with national, regional or international regulations and standards.

Non-plastic substitutes have greater potential for local production, drawing on local feedstocks. Of particular interest are a range of traditional materials, their local production potential and export-related advantages, as viable replacements for plastic. Many natural fibres and value-added products, such as jute, abaca, coir, kenaf, and sisal (or JACKS fibres), are already produced and exported by several developing countries, improving livelihoods of small-scale farmers. Additionally, widespread traditional biodegradable materials, such as bamboo and cotton, along with easily recyclable mineral-based options like glass and aluminium, offer satisfactory replacement options (UNCTAD, 2021).

In summary, where they are available in PICs, non-plastic substitutes are generally preferred over bio-based and biodegradable plastic alternatives on both environmental and social grounds.

Further details of biodegradable substitutes and alternatives to SUPs are provided in Appendix A.

2.3 Bio-based materials and plastics industry

In recent years, there has been a considerable expansion of the global bioplastics market. According to Business Research Company (BRC, 2024), the market reached a value of 9.22 billion USD in 2023, with projected growth to 10.91 billion USD in 2024 and 20.48 billion USD in 2028, with an average annual growth rate of 17.2%. Nevertheless, compared to the conventional plastics market, bio-based plastics still comprise a very small fraction of the total plastics market (0.6%, or 2.3 Mt of 400.3 Mt – PlasticsEurope, 2023). China and Europe are the primary drivers of growth in the bio-based plastics sector (**Figure 6**). The packaging industry is the largest market segment, with up to 43% of the total bioplastics market (EUBP, 2023b).

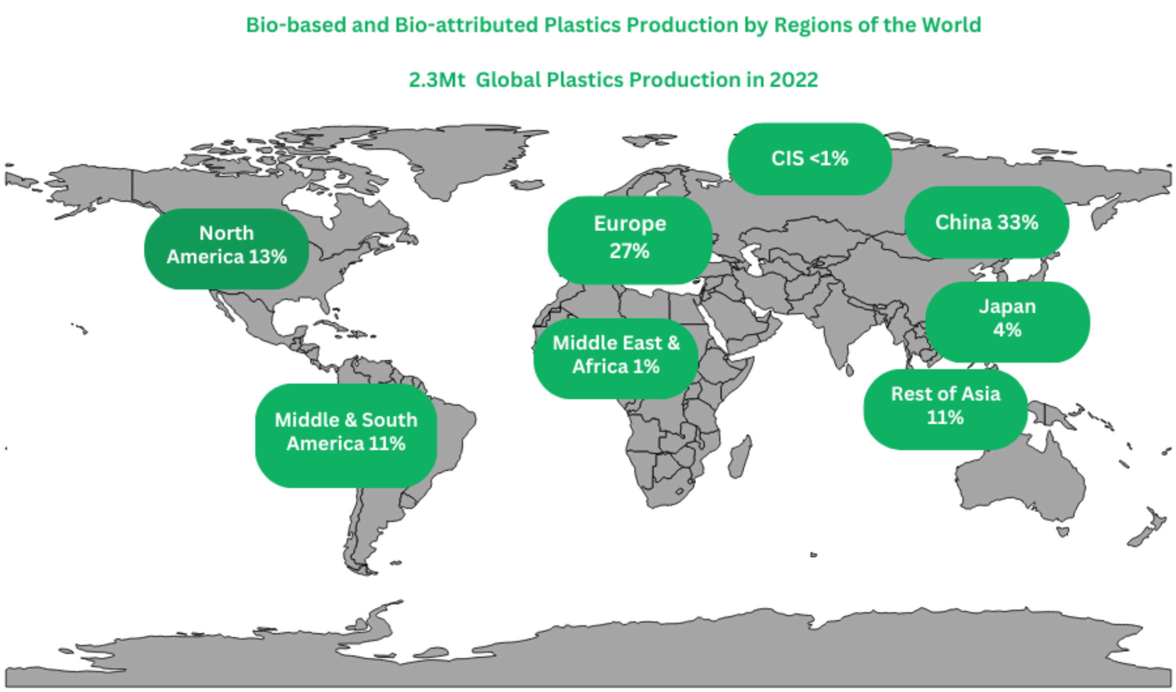
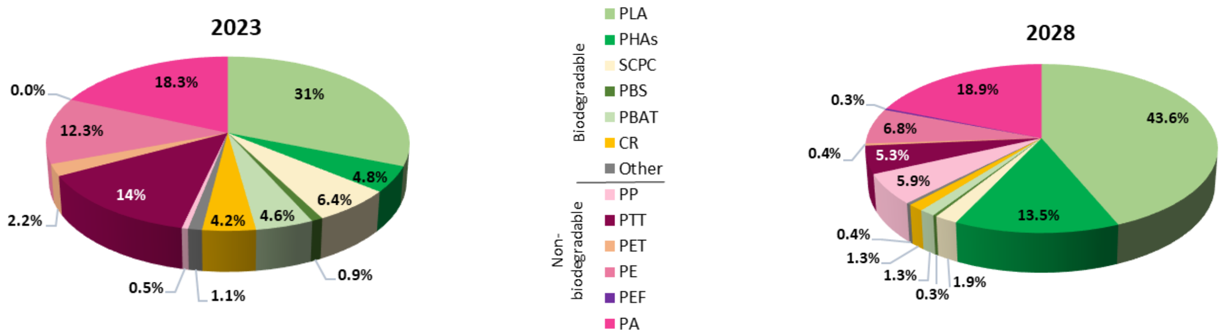


Figure 6: Global production of bio-based plastics (PlasticsEurope, 2023).

According to UNCTAD (2023), the production of other bio-based materials suitable for SUPs replacement (338 billion USD) also shows an increasing trend, with about two thirds of exports in 2020 associated with plant and animal fibres and minerals as raw materials, while one third is in the form of products. Of the total global production of fibres in 2018, 29% were of natural origin and 71% were chemical fibres (Townsend, 2020). About 80% of natural fibres were from cotton, 2.7% jute, about 0.9% wool and coir each, and 1.3%

specialised fibres (e.g., abaca, agave, flax, hemp, kapok, ramie, silk and sisal, and animal fibres other than wood).

There is also a growing trend in the use of biodegradable bio-based plastics, as opposed to non-biodegradable bio-based plastics, which in 2022 represented 52% of the global bioplastics production (EUBP, 2023b). The evidence on whether the increased bioplastics production is favouring home compostable bioplastics or industrially compostable is mixed. Schick et al. (2023) suggest that there is a shift towards increased production of home compostable bioplastics, such as PBAT and PBS, with industrially compostable PLA production decreasing. In contrast, estimates of EUBP (2023b) indicate an increase in PLA and PHA production and a decrease in PBAT and PBS (**Figure 7**).



	2023	2028
Bio-based/non-biodegradable	47.9%	38%
Biodegradable	52.1%	62%

Figure 7: ***Production of bioplastics in 2023 (adapted from EUBP, 2023b).***

(PEF is currently in development and predicted to be available at commercial scale in 2024.
CR are regenerated cellulose films.)

When comparing cost and import tariffs, conventional plastic products tend to be generally much cheaper than their non-plastic counterparts, disincentivising substitution (**Figure 8**). Under present circumstances, market pressures alone would perpetuate the unsustainable consumption of plastics as observed today (UNCTAD, 2023). Based on trade data for a list of 282 HS codes encompassing plastic substitutes, plastic materials and products typically benefit from lower tariffs, often below 10 percent. In contrast, tariffs for product substitutes vary more widely, ranging from 5 percent to 25 percent.

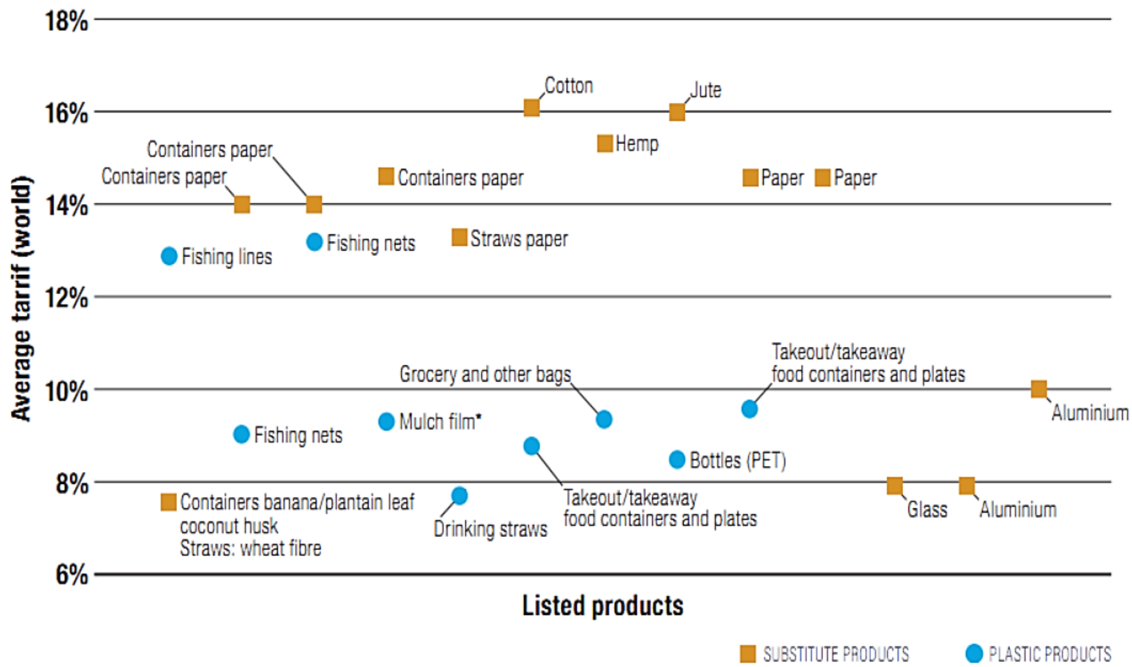


Figure 8: ***Comparison of import tariffs applied globally to selected plastic products vs substitutes***

(Sourced from UNCTAD, 2023: Compiled by authors, based on OEC data 2020 and HS 2022 codes. Note: Aluminium, paper, container paper, and fishing nets are repeated in the graph because of different items represented in different HS codes. For example, Aluminium's are 761290, 761699 and 761510).

2.4 Why is biodegradability and compostability important?

The primary reason we are now dealing with a plastic pollution crisis of global proportions lies in the inherent properties of plastic materials. Conventional plastics are designed to be negligibly biodegradable, which allows them to accumulate in the environment and persist much longer than natural materials. In nature, biological matter is broken down in the process of **biodegradation** in which the materials are metabolised by microorganisms into water and carbon dioxide (in aerobic processes) or methane (in anaerobic processes), while the remaining breakdown products are incorporated into new biomass (bacteria, archaea, and fungi), leaving no residue behind (Lott et al., 2021; Andrady and Koongolla, 2022).

> The claim "biodegradable" is meaningless unless it includes the conditions – when, where and how!
> —Australasian Bioplastics Association (2020)

Biodegradation greatly depends on environmental factors, such as temperature, inoculum, and humidity, as well as the composition of the material (EUBP, 2023a). The time frame of biodegradation is crucial. For materials specifically designed as biodegradable, particularly disposable products, the time frame of biodegradation should be as short as possible. **Compostability** of a material refers to its biodegradability in a short period of time (few weeks to few months) in composting conditions, in either an industrial facility or a home composting setup. Thus, to claim a product's biodegradability, the ambient conditions have to be specified and a timeframe for biodegradation must be set in order to make claims measurable and comparable. This is regulated in the applicable standards (EUBP, 2023a).

Not all biodegradable materials are compostable.

Biodegradable and compostable plastics will not biodegrade fast if dumped in land or marine environment.

2.5 Standards and certificates for bio-based, biodegradable or compostable materials

To ensure that materials marketed as bio-based, biodegradable, or compostable hold true for these properties, several international and national testing and standards organisations have developed a number of standards that define acceptable levels of biodegradability and compostability for a material. These organisations include (Figure 9):

- ISO – International Organization for Standardization,
- ASTM – American Society for Testing and Materials,
- CEN – European Committee for Standardisation
- AS – Standards Australia (national level)
- AFNOR – Association Française de Normalisation (national level)
- DIN – German Institute for Standardization (Deutsches Institut für Normung, national level)

There are also other national standardisation organisations, such as the Japanese Industrial Standards Committee (JISC), Standardization Administration of China, and Bureau of Indian Standards (BIS), but there is little information readily available on the standards developed or accepted for bio-based materials.

Figure 9: Relevant standardisation bodies

Understanding standards and labels is crucial for future procurement of bio-based materials and plastics in PICs. There are quite a few relevant international and national standards referring to compostability and biodegradability (**Table 4**). They are complex and their understanding requires training. The standards should be well understood by professionals dealing with bio-based materials and plastics, including customs, importers/distributors, and waste management staff. A claim on the product that it is biodegradable or compostable does not give sufficient information on its actual properties. Instead, a standard corresponding to the product's properties should be visibly labelled. For example, according to The Australasian Bioplastics Association, if a plastic material is biodegradable and compostable in Australia, its properties must correspond with Australian standard **AS 4736-2006**. This standard provides assessment criteria for plastic materials that are to be biodegraded in municipal and commercial aerobic composting facilities. To comply with the AS 4736-2006, plastic materials need to meet the following requirements:

- minimum of 90% biodegradation of plastic materials within 180 days in compost;
- minimum of 90% of plastic materials should disintegrate into less than 2mm pieces in compost within 12 weeks;
- no toxic effect of the resulting compost on plants and earthworms; and
- hazardous substances such as heavy metals should not be present above the maximum allowed levels, and plastic materials should contain more than 50% organic materials (ABA, 2021).

Similar to AS 4736-2006 is the European standard **EN 13432**, which establishes requirements for packaging recoverable through composting and biodegradation. It requires at least 90% disintegration after twelve weeks, 90% biodegradation (CO_2 evolvement) in six months, and includes tests on ecotoxicity and heavy metal content (EUBP, 2023a). It is the standard for biodegradable packaging designed for treatment in industrial composting facilities and anaerobic digestion. The extended messaging could include the following: *Intended for industrial composting only, *No proof of home compostability, *Check if accepted by your local biowaste disposal service, and *Do not litter.

Table 4: Standards for biodegradability and home compostability of biodegradable plastics.

Standard	Description	Organisation
Industrial composting and anaerobic digestion		
ISO 18606	Packaging and the environment – Organic Recycling	ISO
ISO 17088	Specifications for compostable plastics	ISO
ISO 15985	International standard for products suitable for anaerobic biodegradation	ISO
AS 4736-2006	Biodegradable plastics suitable for composting and other microbial treatment	AS
ASTM D6400-21	Standard Specification for Labelling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities	ASTM
ASTM D6868	Standard Specification for Labelling of End Items that Incorporate Plastics and Polymers as Coatings or Additives with Paper and Other Substrates Designed to be Aerobically Composted in Municipal or Industrial Facilities	ASTM
EN 13432: 2000	Packaging – requirements for packaging recoverable through composting and biodegradation	CEN

EN 14995	This standard describes the same requirements and tests as EN 13432, while applying not only to packaging but plastics in general	CEN
DIN V 54900-1	Testing of compostability – Determination of disintegration of plastics under simulated composting conditions in a laboratory-scale test (industrial composting)	DIN
Home composting		
ISO 17088:2021	Plastics – Organic recycling – Specifications for compostable plastics	ISO
AS 5810	Biodegradable plastics – biodegradable plastics suitable for home composting	AS
ASTM WK35342	Specification for Home Composting of Biodegradable Plastics	ASTM
EN 17427	Packaging – Requirements and test scheme for carrier bags suitable for treatment in well-managed home composting installations	CEN
OK compost Home	Certification scheme that requires at least 90% degradation in 12 months at ambient temperature	TÜV AUSTRIA, Belgium
NF T51-800	Plastics – Specifications for plastics suitable for home composting	AFNOR

Besides biodegradability and compostability standards, there are also standards that refer to other properties of a bio-based material, including the bio-based content, life cycle, carbon and environmental footprint, as well as biodegradability in soil and marine environments (**Appendix A, Table 13**). However, currently, there is a lack of standardised pass/fail criteria for assessing the degradation of plastics in seawater. The standards listed in the table primarily serve as guidelines and do not offer clear directives regarding conditions and timeframes (EUBP 2023a).

For some standards, there are specific logos, which can be used only in cases where the product's tested properties match the standard (**Figure 10**). In the example below, the Seedling logo on the product should always be shown together with the valid registration number (7PXXXX) printed below the logo. Note that there are two OK compost logos, one for home composting (HOME) and the other one for industrial composting (first and last in the second row, **Figure 10**).

Figure 10: Some useful logos for compostable plastics, from left to right, for the following standards:

AS 4736, AS 5810, EN 13432, NF T51-800, DIN EN 17033

OK compost Home, OK biodegradable MARINE, OK biodegradable SOIL, OK compost Industrial

Several voluntary certification programmes are available worldwide to assess compostability, including the following (UNCTAD, 2021; Jayakumar et al, 2023):

- Australasian Bioplastics Association (ABA)
- Biodegradable Products Institute (BPI)
- German Institute for Standardisation Certco (DIN CERTCO)
- European Bioplastics (EUBP)
- TU Austria & Vinçotte (TUV, Austria & Belgium)
- Japan BioPlastics Association JBPA (Japan)

These programmes adhere to international standards such as EN 13432, ASTM D6400, and ISO 17088, incorporating comparable criteria (see **Table 4**).

As global trends push towards banning SUPs, SIDS are exploring various materials to replace them. The approach to replacing SUPs must consider the lifecycle of materials, from production to disposal. A significant reduction in plastic waste, up to 70%, can be achieved through reuse, refill, and new delivery models (UNEP, 2023).

Bio-based plastic alternatives, synthesized from renewable biomass like corn or cassava, include both biodegradable and non-biodegradable plastics such as polylactic acids (PLAs) and polyhydroxyalkanoates (PHAs). While these alternatives are relevant in managing SUPs, they require significant processing and sometime chemical treatments. Non-plastic substitutes, on the other hand, have local production potential, which can contribute to boosting local economies while providing viable replacement for plastics.

According to UNCTAD (2023), the production of bio-based materials suitable for SUPs replacement, valued at 338 billion USD, shows an increasing trend, along with the use of biodegradable bio-based plastics. However, it must be noted that, in comparison to the conventional plastics market, bio-based plastics still make up a very small proportion of the total plastics market. A comparison of costs and import tariffs reveals that conventional plastic products tend to be generally cheaper than their non-plastic counterparts, which disincentivizes substitution.

In procuring bio-based materials and plastics, standards and certifications are crucial for ensuring the reliability of biodegradable and compostable claims, which are essential for the implementation of sustainable SUP replacement strategies.

3 Suitability of single use substitutes for SUPs

3.1 Criteria for suitability

The process of introducing new materials and products in PICs, as non-plastic substitutes or plastic alternatives to SUPs, or to expand the production of the existing ones, requires their evaluations against a range of suitability criteria (**Appendix B**, **Table 14**). These criteria can be used by stakeholders to develop targeted strategies and solutions to facilitate the successful adoption of substitute or alternative materials and products.

Given that the primary reason for replacing SUPs arises from environmental concerns related to pollution, toxicity, non-biodegradability, and unsustainable resource use, the first suitability criterion involves **environmental safety**. It is essential to assess potential environmental impacts of materials throughout their life cycle, including raw material extraction, manufacturing, use, and disposal. Predicting and mitigating potential environmental harm, such as pollution, habitat destruction, and resource depletion is fundamental. In addition to environmental safety, substitute materials must be **safe for human health** and must not adversely impact food security.

To know whether materials and products are safe, information on the chemical composition and properties of the material and additives must be clearly and visibly provided on the product. Challenges concerning the transparency of bio-based materials and plastics currently exist. These include **mislabelling**, **false advertising**, **ambiguity,** and **lack of knowledge**. Lack of transparency is very common in the bioplastics market (Bhagwat et al., 2020), particularly with biocomposites made from conventional and bio-based plastics, which are often advertised as biodegradable with the name of the petrochemical polymer entirely excluded from the product content. The same applies to oxo-degradable or oxo-biodegradable plastics whose biodegradation processes are subject to debate and controversy. Thus, for importers, distributors, and customs offices, it is of utmost importance to strictly follow guidelines on standards and entirely understand the properties of imported products.

Some biodegradable plastics, such as PLA, require industrial composting conditions to biodegrade. However, even if biodegradable and compostable disposable materials and plastics are not yet present in a PIC's waste stream, there is still a need for a **composting facility**, primarily to save landfill space, produce compost, reduce methane emissions, and control leachates. The fact that about half of all household waste is comprised of food and various other types of organic waste highlights the need for industrial composting infrastructure. Furthermore, even with home compostable plastics, the requirement for a composting plant remains relevant, as not all households have the necessary conditions for home composting.

Contamination of the plastics recycling stream with biodegradable plastics has become a new challenge for plastics recyclers. Generally, mechanical recycling is susceptible to contamination by materials not suitable for recycling. This is already an ongoing issue with plastic waste sorted and collected for recycling being contaminated with conventional plastics of unknown composition and without labels, heavily degraded environmental plastic (e.g. collected from the ocean), and dirty and oily plastic. With the introduction of biodegradable materials, the contamination problem has become even more common (Samper et al., 2018; Titone et al., 2023). These issues can be avoided by producing and importing properly labelled products and correctly sorting them prior to disposal.

Similar issues have been reported regarding the **contamination of industrial composting**, where the compostable waste is contaminated with non-compostable materials, including conventional plastics and plastic coating on paper products. Furthermore, some experimental studies demonstrated that bio-based materials and products, including their additives, are not necessarily much safer than the conventional plastics, inducing similar toxicity to conventional plastics (Zimmermann et al., 2020; Su et al., 2022). This underscores the importance of prioritising chemical safety in the development of genuinely improved plastic substitutes and alternatives, as well as rigorous testing and accurate labelling prior to their placement on the market.

To avoid further environmental pollution, education on the fate of biodegradable materials in the natural environment is also important. Inaccurate and misleading advertising of biodegradable products might lead to them being perceived as safe when littered or dumped in the environment. Regarding biodegradability of bio-based products in the marine environment, research and development endeavours are continuously working towards creating standardised measures for marine biodegradation, which are essential before relevant products can be commercialised (EUBP, 2023a).

Local production of new materials should follow **circular economy principles**, aiming to break away from the linear production and consumption model (UNCTAD, 2023). This approach should encompass the entire value chain, spanning from the introduction of materials like bagasse and coconut to the implementation of innovative technologies. Additionally, it should explore novel financing mechanisms to support sustainable practices across industries. Establishing a **reliable supply chain**, developing necessary infrastructure for production and distribution and ensuring adequate logistics and transportation capabilities are essential for successful market entry. The **cost-effectiveness** and **economic feasibility** of producing and using the new material or product needs to be assessed. Factors such as production costs, pricing competitiveness, and return on investment need to be carefully evaluated.

With respect to **social and cultural factors,** understanding societal attitudes, cultural norms, and behavioural patterns that may influence the adoption of the new material or product is important. Addressing social concerns, ethical considerations, and community engagement can facilitate smoother integration into society. Furthermore, educating stakeholders, including consumers, businesses, policymakers, and industry professionals about the benefits, uses, and implications of new materials or products is crucial for fostering acceptance and adoption. Finally, it is crucial to **identify pioneers** who are either starting local production or switching from conventional plastics to bio-based products, and to **support** their initiatives and businesses.

3.2 Life cycle analysis

Ideally, new substitutes and alternatives should undergo a **life cycle analysis** (LCA) (**Figure 11**). LCA is a tool used to assess the overall environmental impact of a product throughout its entire life cycle (Muralikrishna & Manickam, 2017). Various stages of a product's life are typically evaluated, including resource extraction, material processing, manufacturing, packaging, distribution, product use, and end-of-life considerations.

Given the complexity and time required for LCAs, it is not always feasible nor practical to perform a full analysis. In this situation, relevant guidelines that can help in the decision-making process are recommended. These are outlined in **Table 5**.

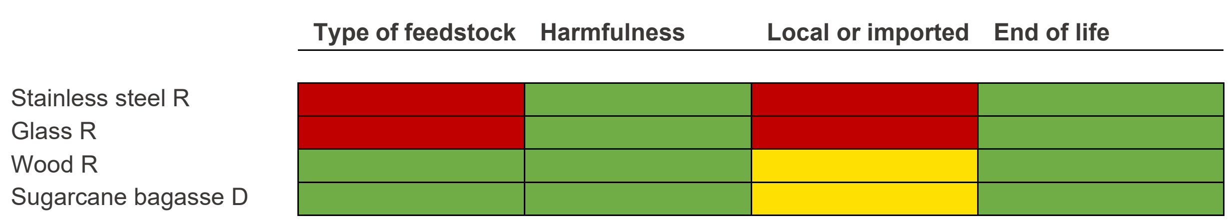
Figure 11: Life cycle analysis conceptual model.

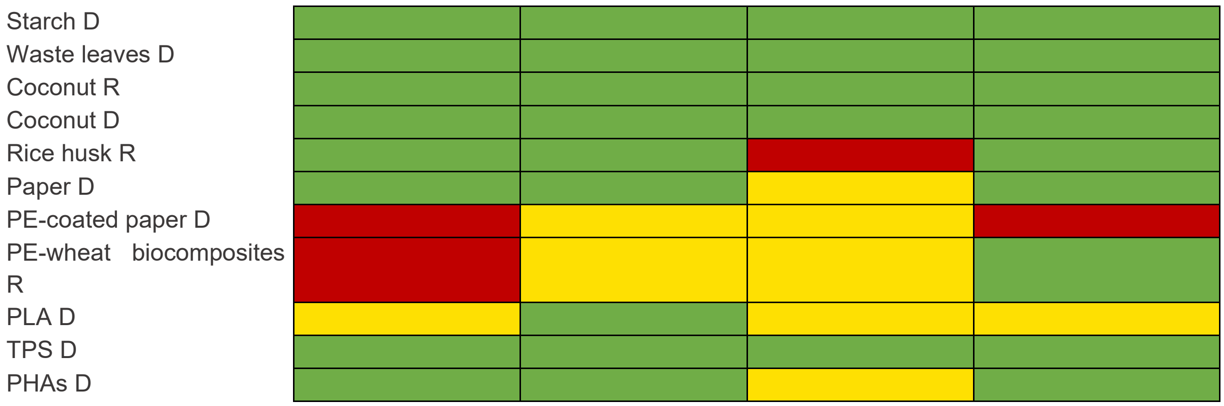
Table 5: Guidelines for substitutes and alternatives to SUPs.

	More suitable	Less suitable
Renewability of materials	Renewable materials made from plant, animal or fungal biomass are more suitable	If non-renewable materials are chosen, the preference is given to highly recyclable materials such as metals and glass
Substitutes or alternatives	Substitutes from natural materials are the preferred option. Also, substitutes are often reusable	Home compostable fully biodegradable bioplastics are preferred over industrially compostable or non-biodegradable plastics
Feedstock	Waste as a resource for producing SUPs replacement is more suitable – 2nd and 3rd generation feedstock	If the 1st generation feedstock is used, then animal feed as feedstock is preferred over human food
Local production or import	Locally produced products, preferably an existing traditional (artisanal) practice and local crafts	Import from shorter distances, such as Oceania, is preferred over long distances, such as Asia, Europe, and the Americas.
Biodegradability	Home compostable	Industrially compostable
Reusability	Reusables	Disposables
Standards and certificates	Clearly displayed information on the composition and end-of-life options of the product, i.e. compostability and recyclability	Any information is better than none.

A simplified life cycle assessment of several disposable and reusable tableware and other items of our interest that are most commonly used or could potentially be used in PICs is shown in **Table 6**. The table considers the qualitative aspects of a product's life cycle. These aspects are just examples, and it would not be feasible to address all the combinations of materials, their origins, reusability, harmfulness, and end-of-life options. For example, PLA is often produced from cornstarch, which is considered 1st generation feedstock; however, starch for PLA can be obtained from other starchy plants as well. In **Table 6**, the example given refers to PLA made from 1st generation feedstock. Paper is also a type of feedstock that is quite controversial. It can be obtained from sustainable sources, such as waste products of wood, sugarcane or bamboo industry, or unsustainable sources such as poorly managed forests.

Table 6: A simplified life cycle analysis for some materials and items used or potentially used in the Pacific region (R – reusable, D – disposable).





(More desirable) Low impact	2nd or 3rd gen. feedstock	No direct harm proven	Produced locally	Home compostable/ Reusable
(Less desirable) Medium impact	1st generation feedstock	Unknown/ speculative	Imported from Oceania	Recyclable/ Ind. compostable
(Not desirable) High impact	Non-renewable	Direct harm proven	Imported from Asia	Landfilled

The introduction of new materials and products in PICs as alternatives to SUPs necessitates thorough evaluation against various suitability criteria to ensure environmental and human safety, health, transparency, and practicality. Environmental safety is a concern, requiring a comprehensive life cycle assessment to mitigate potential impacts. Human health safety is equally crucial, demanding clear information on chemical compositions. Transparency issues, particularly in the bioplastics market, pose significant challenges.

Biodegradable materials, while offering potential environmental benefits, present practical challenges, such as the need for industrial composting facilities, which can also be used to process food and organic waste generated in households. Proper labelling and sorting are essential to prevent issues with contamination in the composting and recycling streams. Economic considerations also play a critical role, with the need for cost-effective production and distribution systems, reliable supply chains, and logistical capabilities to ensure accessibility. Technical feasibility involves ensuring materials meet durability and performance standards and are compatible with existing manufacturing infrastructure. Financial viability is assessed through investment requirements and potential returns, while circular bio-economy considerations emphasize using waste streams as feedstock and promoting recycling and reuse. Adequate infrastructure for waste management and community engagement is vital for successful adoption.

Regulatory compliance and policy support are crucial for facilitating market penetration of bio-based materials. Accurate labelling, rigorous testing, and education on biodegradable materials' fate in the environment are necessary to avoid misleading perceptions and further pollution. Life cycle analysis (LCA) is recommended for evaluating overall environmental impacts, although practical constraints may necessitate simplified guidelines for decision-making.

4 Availability analysis – Single use substitutes for SUPs

4.1 Methodology

Our initial review of the current situation across the Pacific region regarding replacement options for single-use plastics indicated that readily available information on replacement options was limited. In response, we have sought to undertake a more detailed assessment for the three case study countries: Samoa, the Solomon Islands and Kiribati. Information requested through local coordinators from importers, distributors, and local manufacturers included the following:

- local production of SUP non-plastic substitutes and plastic alternatives (artisanal and commercial products);
- import of SUP non-plastic substitutes and plastic alternatives;
- potential for local production of non-plastic substitute or plastic alternatives (feedstock and infrastructure availability, potential for local plastics manufacturers to switch to biodegradable materials); and
- potential for import of more acceptable non-plastic substitutes and plastic alternatives.

Additionally, an extensive internet search for manufacturers (i.e. exporters) of bio-based tableware and other items of our interest in the Asia-Pacific region was carried out, with the aim of shortlisting five to ten manufacturers with the most diverse range of products.

4.2 Results

Information obtained by the local coordinators showed that data gathering from distributors and importers was difficult due to non-responsiveness and/or confidentiality. Research into the local production of non-plastic substitutes and plastic alternatives also proved fruitless, not due to difficulties gathering information but due to these activities being minimal and confined to non-commercial handmade traditional production such as basket weaving, coconut cup making, and plant leaf packaging. In the Solomon Islands, there are three producers or artisans who produce shopping bags made of panadas leaves and tree barks, as well as coconut and kerosene tree wood cutlery, but these products are reusable, expensive and intended to be used as souvenirs rather than daily used products. However, these manufacturers could be a good starting point for the production of other non-plastic substitutes, such as pressed-leaf plates and bowls, coconut cups and fibre baskets, and wooden cutlery, on a more commercial scale.

Our investigation into local bio-based plastic alternatives revealed a complete absence of such production in PICs. Currently, the Scientific Research Organisation of Samoa (SROS) is exploring the feasibility of PAHs production. However, during a stakeholder meeting in Samoa, we learned that their latest findings indicate the production's lack of commercial viability.

Research on the replacement of SUPs in other PICs, similar to the three case-study countries, was also limited. Online information was not readily accessible, and conducting a comprehensive investigation into each PIC would exceed the scope of this report.

Internet search for manufacturers of bio-based products in the Asia-Pacific region showed limited availability of materials. The most common non-plastic substitutes are paper, bagasse, wood (e.g. pine), bamboo, and cotton, while the bio-based plastic alternative is mainly PLA. The search often yielded only partially useful information. Materials, feedstock, standards, and prices were often either not available or unclear. For example, for the containers that are designed to hold wet food or beverages, the information about the coating material used for waterproofing was often missing or unclear. Plastic coating on paper tableware is commonly used as a liquid-resistant barrier material but, considering that it makes the product both non-recyclable and noncompostable, it is highly inadvisable. Furthermore, the origin of raw materials is also important yet often omitted. For example, PBAT can be derived from fossil-based and plant-based sources, and this should be taken into account before purchase.

The bioplastics industry is rapidly expanding, creating space for fraudulent or non-transparent businesses. As previously discussed, it is crucial that importers, distributors, and customs officers are trained in understanding conventional plastics, bioplastics, standards, and certification. We recommend thorough investigation of materials and products before procurement, making sure it is fully understood what is being imported into the country to avoid creating new problems with falsely advertised and in fact non-biodegradable products. Often, a large manufacturer has several options and combinations of materials for the same product type, and we advise that any decisions about selecting and using biodegradable and home compostable products need to be carefully considered before being made. Before full use, we strongly recommend ordering samples to test suitability of the product.

4.3 How to use the compendium

A comprehensive list of manufacturers has been compiled for all the types of SUPs targeted in this report (provided as an excel document along with this report). The main focus is on disposable items, but there are a few manufacturers on the list that offer reusable products. Also, all products made from non-renewable materials were excluded, including conventional plastics, glass, metals, and ceramics. There are 3 groups of products: **tableware** (beverage and food-related items), **bags,** and **hygiene products**.

The list is colour-coded with the following meanings:

Green – These companies provide fully acceptable products that are home compostable or fully biodegradable natural products such as wood and bamboo.

Yellow – Information on these products on the website is incomplete or ambiguous, and the details of home compostability of the product should be verified with the manufacturer prior to ordering. Yellow colour can also indicate that the product is industrially compostable, which is acceptable where there is a composting facility in place.

Red – These products are paper coated with plastic or industrially compostable bioplastics, thus not home compostable nor recyclable. For some products, information is entirely absent. We do not recommend import of these products.

Compendium Assessment

The table below assesses the most common materials that have been found in the list of products included in the compendium. The compendium is colour-coded, with those manufacturers coded with green being the most highly recommended vs those coded with red being the least. There are a few key points of caution for all materials listed:

- MSDS information has not been reviewed for any of the products listed, and therefore the suitability of these products cannot be guaranteed without further investigation. The sourcing risks are listed below as the type of things that should be investigated prior to purchasing.
- Lack of information is considered worse than information that has been provided and details the material lists and possible harmful effects. This is because lack of information means that LCA and impact analysis is potentially unavailable, and any potential information risks cannot be mitigated.
- The simple sourcing risk assessment (**Table 7**) should be read together with the simplified LCA provided by material type in **Table 6**.
- Only two examples per material type are selected for a full list provided in the compendium. The examples provided in the table below are not the only recommended sources; rather, the selection should be based on the material type.
- The material types presented below are listed in order of priority by product type.

Table 7: Assessment of materials found most commonly in the compendium and associated risks

Material	Composability	Sourcing risks	Possible sources
		Tableware and bags	
Leaves/bark/bamboo	Home compostable	- Can include glues and additives that can be harmful to the environment - Can include resins like formaldehyde - Can potentially be grown purely for production of SUP substitutes instead of as agricultural by-products, leading to destruction of ecosystem and habitats and high carbon footprint if not grown locally	Example: Ecoplate and Good Choice Pak, Husk Group
Sugarcane/Bagasse/ other agricultural by-products	Home compostable	- Can include glues and additives that can be harmful to the environment	Example: BioPak, GreenPak, Green Olive Environmental Technology Co, Misterrye
Paper and cardboard	Industrially compostable/Home compostable	- Paper is the most challenging material type for products, due to the coating that is used to make it more useful for carrying liquids. - Mostly contains plastic coating or PLA coating or coating with an aqueous dispersion for wet content - Often the same manufacturer will offer products with and without the coating. - Can include glues and additives that can be harmful to the environment - Can potentially be grown purely for production of SUP substitutes instead of as agricultural by-products, leading to destruction of	Example: Just Earth papers, Leetha

Material	Composability	Sourcing risks	Possible sources
		ecosystem and habitats and high carbon footprint if not grown locally	
PHA, TPS	Home compostable	- These are natural polymers that are polymerised into bioplastics. - Generally considered home compostable - The certification should always be required prior to wholesale purchase	
PLA/PBS	Industrially compostable	- These are natural polymers that are polymerised into bioplastics. Often, the composition is questionable, and full MSDS sheets should be requested prior to sale of products as claimed - Can include additives and colours that can be potentially harmful to the environment - These are the products needing the most stringent testing at the point of sales and for minimum standards to be instituted. - The degradation of these polymers in the human/animal body post-ingestion is not fully understood and needs to be investigated.	Good Choice Pak GoodBioPak GreenPak
Hygiene items			
Bamboo/cotton	Home compostable	- Can include glues and additives that can be harmful to the environment - Can potentially be grown purely for production of SUP substitutes instead of as agricultural by-products leading to destruction of ecosystem and habitats and high carbon footprint if not grown locally	Pee Safe, Bamboo Babe
Bamboo/PHA	Home compostable	- These are natural polymers that are polymerised into bioplastics. - Generally considered home compostable - The certification should always be required prior to wholesale purchase	Enee
PLA	Home/industrially compostable	- These are chemically altered bio-polymers that can contain synthetic materials and resins. - Often, the actual composition is not known, and full MSDS sheets should be requested prior to sale of products as claimed - Can include additives and colours that can be potentially harmful to the environment - These are the products needing the most stringent testing at the point of sales and for minimum standards to be instituted.	Lady Napkins

4.4 Summary of Key Findings

Summarised information on case-study countries can be found in the following pages. Information includes key findings for each country, generation of plastic waste, results of the stakeholders' meetings, legislation, waste infrastructure and services, import of bio-based products, and local agricultural production.

Samoa

OVERVIEW

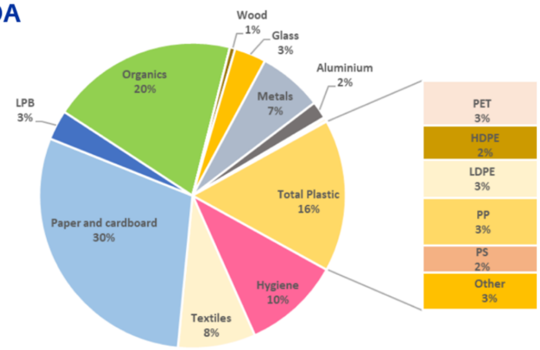
GDP	USD 3,743 per capita
Population	222,382 in 2022 (1.6% growth rate)
Land area	2,830 sq. km, consisting of 9 islands, 4 of which are inhabited

KEY FINDINGS

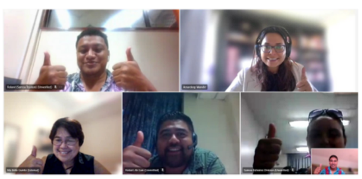
- More than 20 plastic importers import about 6 million items per year. About 4 importers of SUP substitutes and alternatives.
- No local production of substitutes or alternatives reported but, there is interest within the private sector to pursue opportunities.
- Important next step is to investigate the feasibility of local production based on availability of feedstock (Non-PHA).

PLASTIC WASTE IN SAMOA

- **15,000 tonnes of MSW** is generated annually in Samoa.
- **16%** or almost **2,500 tonnes is plastic** and an additional 10% contributed by hygiene items.
- Almost **50% of the waste is compostable** with 20% organics & 30% paper and cardboard.
- Of the 16% plastics, about **700 tonnes** or 28% are **Single Use Plastics** (**g**arbage bags, coffee cups and SUP containers are the most prevalent).



STAKEHOLDERS SAY



Private Sector

- The key challenge is the cost and low demand for substitutes and alternatives.
- Education around SUPs and their replacements is lacking.
- More interest in buying env. friendly substitutes and alternatives rather than local production.

Government

- Lack of human resources and staffing for enforcement and compliance.
- Currently sees gaps in legislation and the need to update it.
- Organics projects in the pipeline.
- Highlighted the importance of sector-based data and engaging with the relevant sectors like tourism and fisheries.

Research and NGO Sector

- Highlighted the need for education and awareness at all levels.
- Is keen to support the government in implementation.
- Would like to see the government lead the way by mandating all government-sponsored events to be plastic free.
- Generally supportive but would like to see the economic feasibility of local production before supporting.

Single-Use Plastics and Their Replacements

LEGISLATION

1961
Police Offences Ordinances
Offences against public cleanliness and convenience – A person commits an offence and is liable to a fine of up to 2 penalty units

2006
Plastic Bag Prohibition on Importation Regulations .
Delcaring penalties for the importation of plasic products into Samoa.

NATIONAL ENVIRONMENT SECTOR PLAN 2017-2021
Waste & Environmental pollution are identfied as major problem. Ongoing efforts to improve solid waste management.

NATIONAL WASTE MANAGEMENT STRATEGY 2019-2023
Analysis of current solid waste and chemical/hazardous waste management systems, identifies issues, and challenges and adopts priorities and action plans.

2018
Waste (Plastic) Managment Regulations.
Declaring the ban of shopping bags, packing bags and straws.

2022
Addition of styrofoam to the list of SUPS

1961-2026

SUMMARY

- **January 2019** - Ban on plastic shopping bags, packing bags, and straws
- **January 2020** - Polystyrene food containers and cups
- **Enforcement** and **lack of human resources** are the key challenges in implementation of legislation
- Government currently considering a **revamp** of existing SUP legislation
- **ARFD** to commence with beverage containers in mid-late 2024 with additional items to be phased in

In focus

Local production of SUPs has been attempted in Samoa with the following key learnings:

- Market for alternatives needs to be developed for a successful roll out.
- The community needs education around the importance of alternatives.
- The cost of alternatives needs to be comparable or the SUPs need to be disincentivised.

INFRASTRUCTURE AND SERVICES

- 60% of the country has **collection services** (service extends to all of Samoa).
- **No source separation** in place
- **No composting facilities** in place despite 50% of the waste being organic
- **Two landfills** (Tafa'igataand Vaia'ata landfill)
- **None** of the SUPs part of the study are currently being **recycled.**
- Current recycling efforts are limited to: Metals, PET, HDPE, Waste oil and E-waste.

Collection services to all four islands

Two official landfills servicing Upolu and Savai'i

No source separation

No Composting infrastructure

SUBSTITUTES AND ALTERNATIVES

1 **Currently imported**

- Paper: Cups, plates, straws, sushi trays, trays
- Bagasse: Clamshell containers
- Wood: Cutlery

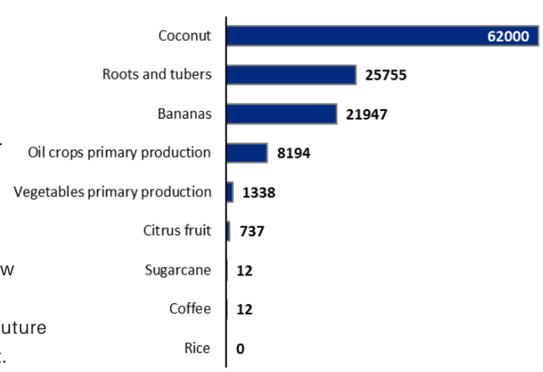
2 **Current local production**

- No known local production of SUPs being studied.
- One producer of palm leaf products is no longer operational.

3 **Potential for future local production**

- Study for POLP by SROS concluded inadequate raw materials for PHA production
- Coconut, roots and tubors are the best option for future feasibility studies. Will have private sector support.

Samoa agricultural production in 2022 (tonnes)



Kiribati

OVERVIEW

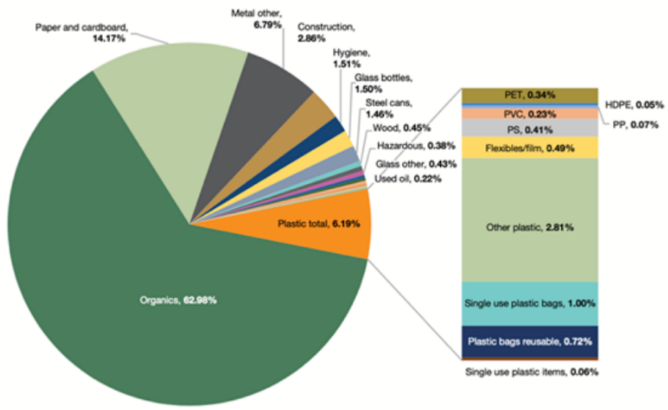
GDP	USD 1,702 per capita
Population	131,232 in 2022 (1.8% growth rate)
Land area	811 sq. km, consisting of 33 islands, 21 of which are inhabited 3.44 million sq. km. EEZ, one of the largest in the world

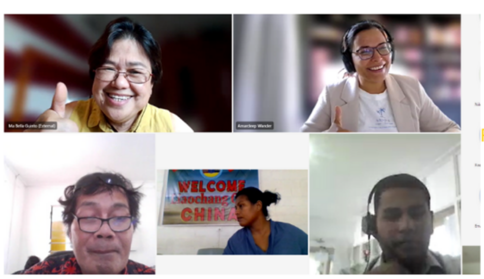
KEY FINDINGS

- About 8 importers of plastics with no reported importation of substitutes and alternatives
- No local production of substitutes or alternatives reported and the private sector is more interested in exploring importation rather than local production.

PLASTIC WASTE IN KIRIBATI

- **Over 16,200 tonnes of MSW** is generated annually in Kiribati
- Biodegradable waste, including organics, paper, and cardboard constitutes more than three-quarters (77%) of the waste generated, while plastics (6.2%) and metals (6.8%) are the other dominant waste streams
- 6.2% plastics represent 991 tonnes of waste
- Among the various types of plastic waste in Kiribati, the most problematic categories are 'other' plastics and SUP bags.





STAKEHOLDERS SAY

Private Sector

- The key challenge is the cost and low demand for substitutes and alternatives.
- Education around SUPs and their replacements is lacking.

Government

- Illegal importation of SUPs by companies, often overlooked by customs
- Financial gaps, budget cannot sustain or monitor the availability of SUPs
- Need proper waste management system

Research and NGO Sector

- See the SUP alternatives as important to support the bans and NGOs can help in advocating the use of these.
- The NGO would also like to see reduction measures included.
- Believe that the ban will drive market demand for substitutes.

Single-Use Plastics and Their Replacements

LEGISLATION

2020-2029
Kiribati Waste Management Resource Recovery Strategy (KWMRRS 2020-2029)
The Strategy aims to enhance Kiribati's national capacity for safe and healthy environment through effective waste management, focusing on priority waste streams like plastic, asbestos, oil, e-waste, recyclables, and waste.

2007
Environment Amendment Act 2007
Establishing the integration of development control, environmental impact assessment (EIA), and pollution control to prevent, control and monitor pollution

2019
CUSTOMS ACT 2019
The Customs authority through its Customs Act 2019 has solidified the banning of abovementioned targeted products through its legislation.

SUMMARY

- **No specific legislation** for waste management in Kiribati; instead, Kiribati Waste Management and Resource Recovery strategy 2020-2030 covers major policy priorities.
- **A draft Environmental Act 2021** has been prepared, which includes wide-ranging reform to waste management and littering.

Customs Act 2019 bans SUPs like ice blocks, nappies, and plastic bags.

In focus: Kaoki Maange

Special Fund (Waste Materials Recovery) Act 2004 is coordinated by MELAD and administered by Ministry of Finance. This Act regulates the current advance recovery fee (ARF) system that includes PET bottles, aluminium cans, and lead-acid batteries.
Since 2003, approximately 550 tonnes of waste has been exported—more than 200 tonnes of aluminium cans, 90 tonnes of PET bottles, and more than 200 tonnes of scrap car batteries. No PET bottles have been exported since 2018 due to lack of markets.
Logistics for export have been the biggest issue for Kiribati.

INFRASTRUCTURE AND SERVICES

- 70% coverage of putrescible and 90% of non-putrescible material through the green bag system in South Tarawa 50% coverage in Kirimati.
- **Collection fee:** A$27/yr for households and A$596/yr for commercial premises
- **The green bag system** allows the separation of putrescibles and non-putrescibles.
- **No composting facilities** in place despite >75% of the waste being organic
- Four dumpsites: Naanikai, Bikenibeu, Betio and Tabwakea
- **None** of the SUPs part of the study are currently being **recycled.**
- Current recycling efforts are limited to: Aluminium cans, PET, EOL Vehicles and ULABs.

Collection services to all four islands

Four landfills/ dumpsites

Putrescible/Non-putrescible collected separately- green bags

No composting infrastructure

SUBSTITUTES AND ALTERNATIVES

1 **Currently imported**

- Paper: Cups, plates, straws, sushi trays, trays
- Bagasse: Clamshell containers
- Wood: Cutlery

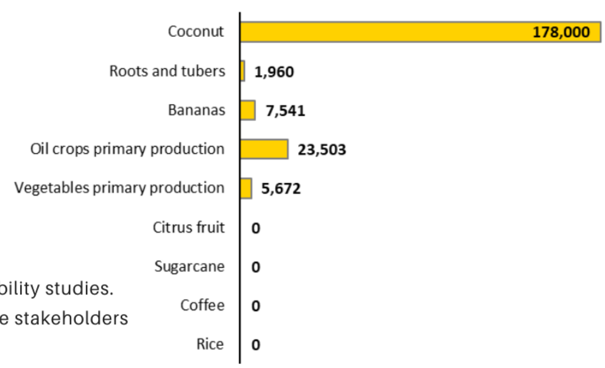
2 **Current local production**

- No known local production of SUPs

3 **Potential for future local production**

- Coconuts are the best option for future feasibility studies.
- Will require support to be canvassed from the stakeholders

Kiribati agricultural production in 2022 (tonnes)



Solomon Islands

OVERVIEW

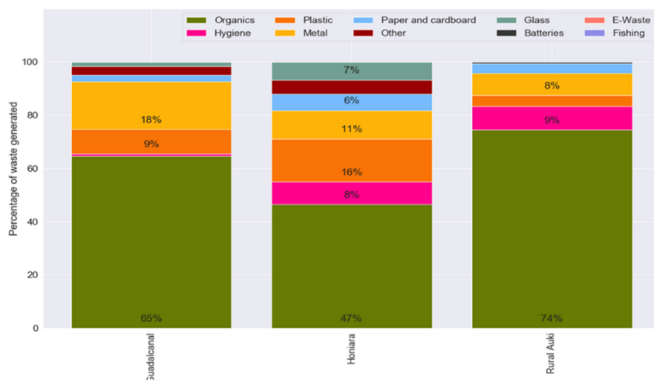
GDP	USD 2,205.3 per capita
Population	753,059 in 2024, (2.1% growth rate)
Land area	28,466 km2 sq. km, consisting of 6 main islands, and 900 small islands.

KEY FINDINGS

- Plastic import and distribution business is thriving due to high demand, low cost, accessibility, and ease of use.
- Uptake of SUP alternatives can be enhanced through comparable costing, tax exemptions or subsidies, and accessible sources.
- Provision of continued support towards existing businesses undertaking design and production of substitutes (reusable/single use)

PLASTIC WASTE IN SOLOMON ISLANDS

- 864g/person/day is generated each day and 310 gram/person/day is collected. Almost half a kg per person per day is not collected.
- **Plastics** represent 4% to 16% of waste in Solomon Islands, depending on the location
- Plastic bags (4%), nappies (4%), PET bottles (3%), and plastic bags (2%) **most common SUPs**
- **Organic waste** is between 47% to 74% of the overall waste stream, depending on location



STAKEHOLDERS SAY

Private Sector

- Challenge is distribution of SUPS across the provinces, using local materials
- Biodegradable bags and straws are already seen in the market and it may not be difficult to introduce other SUP alternatives.
- Willingness to shift business to SUP alternatives if there is demand

Government

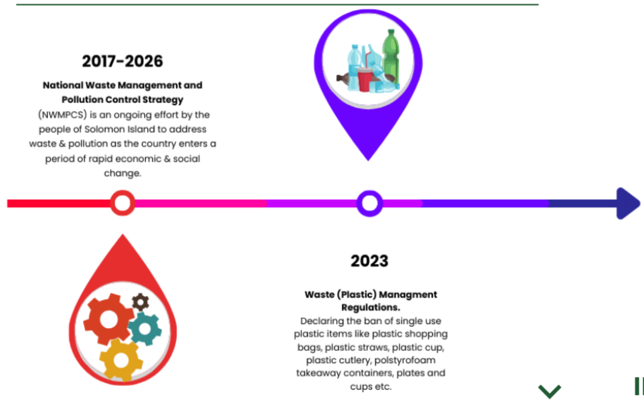
- Preference for both global and local sources of SUP alternatives
- Opportunity for betel nut, bamboo and wild grass as raw materials
- Limited capacity to implement the bans- enforcement and monitoring
- Need to improve collection system and infrastructure for composting
- Highlighted the need to enhance awareness campaigns.
- Subsidy for SUP alternatives considered but not adopted yet- investigating the economics of plastic banning

Research and NGO sector

- Concerns about the lack of infrastructure to manage waste from SUP alternatives
- Strong belief that SUP alternatives can be produced locally
- Raw materials abound even in the provinces.

Single-Use Plastics and Their Replacements

LEGISLATION

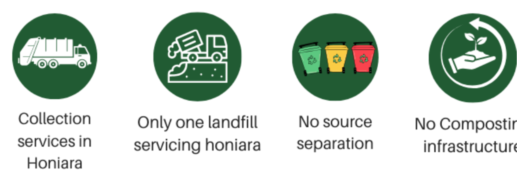


SUMMARY

- **January 2017**- (NWMPCS) is an ongoing effort by the people of Solomon Island to address waste & pollution as the country enters a period of rapid economic & social change.
- **January 2023** - First SUPs ban (Waste Plastic Management Regulations)-Items include plastic shopping bags, straws, cutlery, styrofoam, takeaway containers, plates, and cups .

INFRASTRUCTURE AND SERVICES

- 37%-45% of waste currently being collected
- **No source separation** in place
- **No composting facilities** in place, and new landfill design does not include composting
- Landfill currently in the design phase in Honiara-all other islands have unregulated dumpsites
- **None** of the SUPs part of the study are currently being **recycled.**
- Current recycling efforts are limited to: Metals, PET, HDPE, Waste oil and E-waste.



In focus

Supported through the DFAT funded Strongim Business, a local business woman (Debbie Lukisi-MK Local foods) is making reusable replacements for SUPs from coconut bark. Youth groups are being empowered to collect waste materials and produce substitutes. The substitutes being produced include cups, plates and cutlery.

SUBSTITUTES AND ALTERNATIVES

1 **Currently imported**

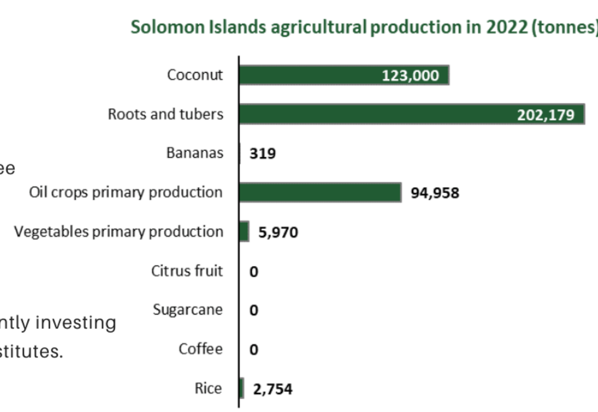
- Paper: Cups, plates, straws, sushi trays, trays
- Corn Starch: Cups, plates, straws, trays
- Wood: Cutlery, meat and vegetable trays

2 **Current local production**

- Shopping bags from pandanas leaves and tree bark
- Spoons and forks from coconut tree and kerosene tree wood

3 **Potential for future local production**

- Private enterprise in Solomon Islands is currently investing in undertaking trials for making reusable substitutes.
- Need to be replicated across the country.



5 Potential for local production – single use substitutes for SUPs

Raw materials or feedstocks for bio-based materials and bio-based plastic alternatives encompass a diverse array of materials, including corn, potato, wheat, cassava, wood pulp, sugarcane, vegetable oil, jute, hemp, collagen, gelatine, and algae, among others. Feedstocks can be classified into three generations (Wellenreuther and Wolf, 2020):

- **first generation feedstock** – products that can be used as food or animal feed,
- **second generation feedstock** – non-food biomass or waste materials from the first-generation feedstock, and
- **third generation feedstock** – innovative feedstock (e.g. algae biomass).

First-generation feedstocks are highly efficient but, being of value as food or animal feed, there is now more focus on developing and using second and third generation feedstocks. For example, plates and trays have been successfully made from waste banana and areca leaves by applying a heated mould to shape the leaves. Drinking cups can be made from bamboo and bowls from coconut shells. In the Pacific region, natural materials are still widely used as tableware, packaging or carry bags. Banana leaves or other large leaves are often used for packaging but also serve as plates. Weaved baskets and coconut cups are also part of everyday life. More applications of local materials should be explored and supported.

Based on the analysis of potential feedstock availability for the local production of substitutes and alternatives in the three case studies, the raw materials found to be the most abundant are in the form of agricultural waste from **roots and tubers** and the **coconut industry**. Roots and tubers are an excellent source of starch, while coconut waste has plenty of fibres (cellulose and lignin). Data indicates, however, that Fiji produces a large quantity of sugarcane, indicating that bagasse products should be investigated for potential future production of substitutes locally. Banana fibre products should also be investigated, considering that PNG cultivates large quantities of bananas.

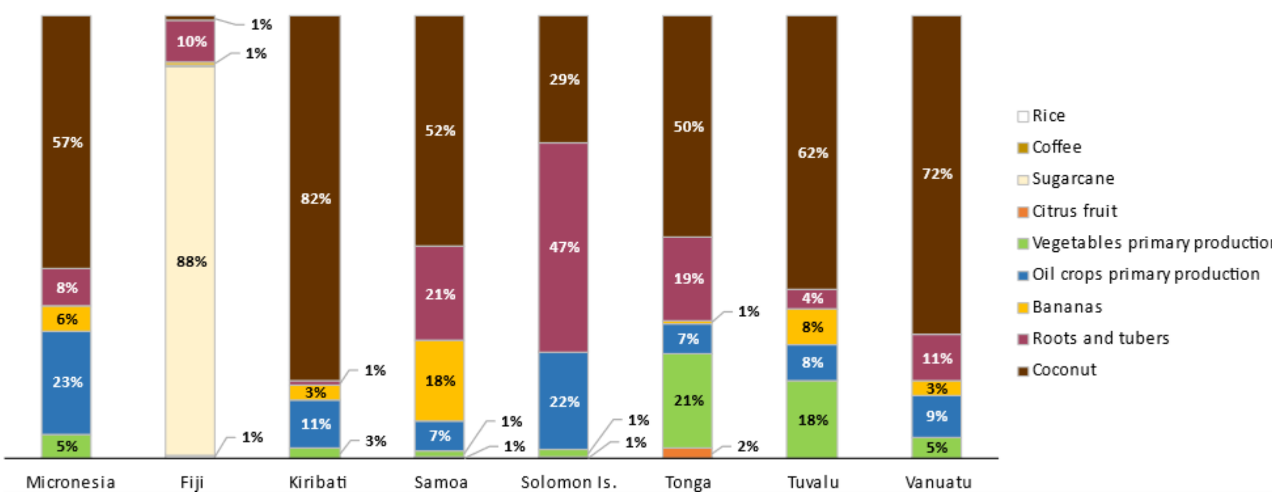


Figure 12: Agricultural production and by products in the Pacific Region (Source: Konema)

While the data above may indicate local production of materials, stakeholder consultations indicate that accessibility of these materials can be challenging. Most agriculture in the PICs is undertaken in backyards and on traditionally held land, which could make it difficult to access materials that are being generated as byproducts.

Regardless, some research is presented below on the potential of using the more abundant agricultural by-products for production of substitutes.

5.1 Starch

5.1.1 Thermoplastic starch

Plasticised starch, the so-called thermoplastic starch (TPS), is obtained after disruption and plasticisation of native starch, with water and plasticiser (e.g. glycerol) by continuous extrusion process, using thermomechanical energy. Unfortunately, TPS shows some drawbacks such as poor mechanical properties and strong hydrophilic character. To improve these weaknesses, TPS is usually associated with other compounds (biocomposites) to form a more solid structure (Averous et al., 2003). In the Pacific region, where the source of starch from taro and cassava is ample, we can consider the production of bioplastics made from starch and plasticiser to obtain bioplastic films that can be used for food packaging (Bangar et al., 2021; Gupta et al., 2022). A great advantage of TPS is that it is home compostable.

5.1.2 PLA

Starch can be readily extracted from plant taro, cassava, and other starchy crops, and converted to fermentable sugar by enzymatic hydrolysis. The carbon and other elements in these natural sugars are then converted to lactic acid though fermentation. There are two possible ways of further polymerization of lactic acid:

Polycondensation of lactic acid – chemical reaction that involves the removal of water by condensation and the use of chemical solvent under high vacuum and temperature. With this route, only low to intermediate weight polymers can be produced, but higher weight stable polymers are needed for bioplastics production.

Ring opening polymerisation – the reaction is based on removing water under milder conditions, without solvent, to produce a cyclic intermediate dimer, lactide. Ring-opening polymerisation of the dimer is accomplished under heat. By controlling the purity of the dimer, it is possible to produce a wide range of molecular weights (Blackburn, 2005).

The main application for PLA is in the food industry. It is used to produce cups, food plates, and trays. However, it is important to note that the PLA, due to its fragility, is not recommended for other packaging processes.

Nature Works LLC has developed a patented, a low-cost continuous process for the production of lactic acid-based polymers.

Composting of PLA – The moisture and the heat in compost pile break PLA polymer chains, creating smaller polymer fragments at first and ending with lactic acid. Bacteria and fungi found in active compost piles consume the smaller polymer fragments as an energy source. This results in the production of carbon dioxide, water, and humus. Since this process is temperature and humidity dependent, PLA is more easily compostable at industrial composting facilities (Blackburn, 2005).

5.2 Coconut coir

Coconut is rich in fibre (lignocellulosic biomass) that can be used to make plastic alike films by using glycerol as a plasticiser. There are two types of coconut fibre, brown and white. Brown fibre is extracted from matured coconuts, and white fibre is extracted from immature coconuts. Brown fibres are strong and thick and have high abrasion resistance, while white fibres are smoother and finer, but weaker. There are numerous advantages of brown coconut fibre. They are moth-proof, resistant to fungi, excellent insulators against heat and sound, not easily combustible, flame-retardant, unaffected by moisture and dampness, tough and durable, resilient, and easy to clean (Babalola et al., 2019). Therefore, these fibres can be used to reinforce starch-made structures in production of fabrics or even reusable objects. An experiment done with coconut husk fragments demonstrated that coconut husk can be directly processed into bioplastics through the partial removal of lignin, followed by hot-pressing. This is a low-cost procedure that should be researched more (Leow et al., 2022).

5.3 Biocomposites

Lignocellulosic biomass is commonly used as a filler material incorporated into a polymer matrix to form biocomposites. In the Pacific region, there is a potential for developing biocomposites derived from starch-based bioplastics (i.e. TPS or PLA) and coconut fibres. Coconut husk, considered as lignocellulosic biomass, could be added to PLA or other polymers obtained from starch (matrix), since starch contains polar groups that can interact with the hydroxyl groups present in lignocellulosic fibre, making it an ideal matrix for the cellulosic fibre reinforcement. The resulting materials are stable and biodegradable in a short time (Wahyuningtyas et al., 2017). There are some interesting results obtained in different experiments, wherein bioplastic material was produced with starch and varied coconut husk fibre content. In most cases, the optimal amount ranged from 10-15% of the total mass of coconut husk (Babalola et al., 2019). These biocomposites options should be further investigated.

The production of bio-based materials and plastics involve using a diverse range of raw materials or feedstocks, which can be classified into three generations: first-generation (food or animal feed), second-generation (non-food biomass or waste) and third-generation (innovative sources like algae). While first-generation feedstocks are efficient, there is an increasing focus on second and third-generation feedstocks due to their non-food applications. Notable applications include making plates and trays from waste banana and areca leaves, cups from bamboo, and bowls from coconut shells, particularly in the Pacific region where natural materials are extensively used. The abundance of agricultural waste, such as starch from roots and tubers and fibers from the coconut industry, banana fibers and sugarcane bagasse present significant opportunities.

Thermoplastic starch (TPS) and polylactic acid (PLA) are two primary bioplastics derived from starch sources like taro and cassava, though TPS has limitations in mechanical properties and hydrophilicity, and PLA is fragile. Both materials are compostable, with TPS being home compostable and PLA requiring industrial composting facilities. Coconut coir, rich in lignocellulosic fibers, offers advantages such as resilience and moisture resistance, making it suitable for reinforcing bioplastic structures and producing biocomposites. Experiments with coconut husk fragments suggest a potential for low-cost bioplastic production through lignin removal and hot-pressing. Combining starch-based bioplastics with coconut fibers to form biocomposites shows promise, these developments indicate a significant potential for bio-based materials in the Pacific region, although challenges in material accessibility due to traditional land use practices remain.

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6 Artisanal Products as Replacements for SUPs in the Pacific Region

Small business opportunities can be fostered and potentially bring greater value to the Pacific region. By their very nature, artisanal products are labour-intensive and lack the ability to be mass produced, which is reflected in their price; however, they tend to be more durable and are reusable.

To support reusable alternatives, appropriate behaviour change programmes and education campaigns are essential. Scaling up these activities requires a full feasibility study to ensure the longevity of the products or businesses.

6.1 Suitability criteria for Artisanal products

The key suitability criteria for the use and promotion of artisanal products in PICs are described below and should be thoroughly investigated.

6.1.1 Availability of raw materials

It is recommended that prior to investigating the scale-up of certain artisanal activities, the availability of raw materials required to produce these products commercially should be investigated. This includes the availability of coconut leaves and bark, pandanus and banana leaves, etc.

The raw materials should not threaten conservation efforts within the country; for example, while using invasive species as a source of production can be seen as beneficial, relying on using them can lead to their proliferation.

The potential rate of growth of the raw material being used should also be investigated to ensure a sustainable supply of the raw material in the long term.

Consistent local suppliers of the raw material should be established prior to investment in the scale-up of the artisanal production.

6.1.2 Sustainability of the production process

A number of considerations are important to ensure the feasibility of an environmentally friendly product that offers a substitute to SUPs. Some of these considerations are described below:

- Lead time of production (from preparation to completion): The production lead time should be a day or less, with the capacity to produce the minimum daily required number of items to replace the SUP items of interest.
- The product should be made from 100% natural material (proven), without using any harmful glues, dyes and additives.
- The production process should not require expensive facilities.
- The production process should not create additional environmental hazards that will need to be managed.
- Availability of local artisans will be required to continue training and continuous improvement.
- Business and financial sustainability, including product marketing, should be considered.

6.1.3 Product lifespan

It is important that the product is reusable and has a shelf life of more than a week to ensure cost-competitiveness with SUPs, as well as imported SUP substitutes.

6.1.4 Cost

Prior to investment in the scale-up of artisanal products, costs of raw materials, production, and point of sale should be investigated. It is important that the product is cost competitive with the imported SUP substitutes to ensure large-scale uptake. The production also should not create an additional environmental cost burden for the country by creating competition for resources.

6.1.5 End of life management of the product

Any product, whether a single use or reusable substitute, should be able to be disposed of responsibly at the end of its lifespan. These products, at the end of their lifespan, should not produce waste requiring special collection and disposal facilities. The ability to degrade or decompose naturally, especially through home composting, is highly desirable.

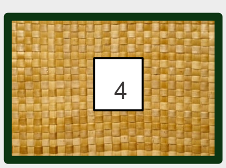
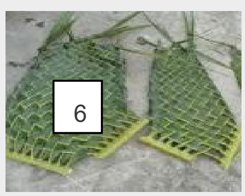
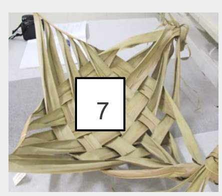
6.2 Artisanal products for potential substitution of SUPs in the Pacific

This section lists the artisanal products for potential substitution of SUPs in the Pacific and details the challenges and barriers to their production, use, and scaleup.

Table 8: Artisanal products, their shelf life, production methodology, and production status in PICs

Category	Shelf life	Production methodology	Production status in PICs
Tableware			
Coconut Shells[1] 	2 - 5 years depending on the use	Each bowl is made from a single coconut shell (half of a whole coconut nutshell). Demonstrations are provided in these video links[2].	Currently produced for serving kava in Samoa, Tonga, Fiji, Vanuatu, Solomon Islands, FSM, and other PICs Few restaurants and hotels in PICs use these for serving cold and warm beverages and food.
Bamboo Cups 	1- 2 years if not used with hot food and beverages	A cup or bowl can be quickly produced using matured and fresh bamboo. A bowl is produced by selecting a bamboo with a large diameter, which is then cut to the length necessary to achieve the required bowl height. For a cup, a smaller diameter bamboo is	Barely produced in PICs due to the availability of modern cups Also limited by the availability of bamboo

[1] https://youtu.be/JwTidRl8oa8?si=V5esUEhkqzUIJA1c / https://youtu.be/KYcaGWVc6YY?si=cy-8rvTUdMHYIJ7O
[2] https://youtu.be/zwHMlPAPXQ0?si=ZjVXl5f8xpKbzZJa / https://youtu.be/gPUFR6vE3f8?si=9DkdbOB9Vl29ekWG / https://youtu.be/uNOkXmu6sYc?si=FK-XwHS9CoSqXB1-

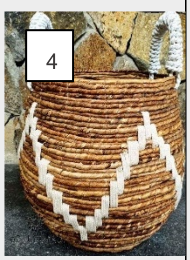
Category	Shelf life	Production methodology	Production status in PICs
		selected, and then cut to the needed height. The methodology is provided in this link[3].	
Coconut / pandanus leaves (woven)     	1 week to 5 years Products 14 can last for a year. Products 5-6 can last for a month. Product 7 can last for a week. When the colour of these products turns brown, coconut oil can be applied to make it shiny and last longer. Pandanus leaves can be used to produce product 2, 3 and 4	**Coconut Leaves:** Products 1, 5, 6, and 7 can be produced quickly in large amounts using coconut leaves. **Pandanus leaves:** Pandanus leaves require pre-preparation as they require removal of sharp thorns, flattening, rolling, boiling in hot water, and drying for up to a week. There is also limitation in the time of the year that the leaves can be harvested. There are other woven coconut leaf products available in PICs that can serve the same purpose and are much quicker and easier to produce; however, these are less popular due to the visual outcomes. For example, products 5,6 & 7,  	Limited production in PICs in recent years due to the high dependence on the available imported products Most of these products are only produced as part of tourist attractions but not for regular use. E.g., Hawaii Polynesian Culture Centre, Samoa Tourism Centre, etc. Products 1, 5, & 7 are still produced in small quantities as part of SUP alternatives promotion in PICs such as Vanuatu, Samoa, and Solomon Islands. Pandanus is limited by the ease of supply, especially if needed on short notice, due to the required pre-preparation of pandanus leaves.

3 https://youtu.be/q8tM0AUhils

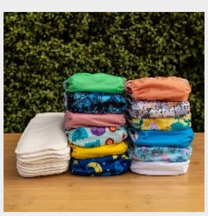
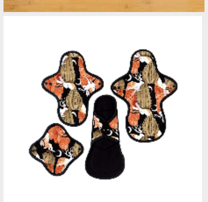
Category	Shelf life	Production methodology	Production status in PICs
1.1. Palm leaves  	Up to a month depending on the manner it is used	Production method is available using the following link: https://youtu.be/o9sZWvwMjvE	Was produced in Samoa and Yap (FSM), but the business case for continuing has proved challenging.
Bamboo, rattan, banana fibre etc.    	Products 1 (bowl) and 2 (plate) from bamboo last for more than 2 years. Product 3 (tray) from rattan fibres last for over 10 years. Products produced from banana fibres of the same types can last for over a year.	This third group of reusable products made from plant fibres requires more time to prepare the raw materials before they are produced. However, these are more durable. The products' production is complex and can be learnt from identified experts in PICs as part of any training programme to promote these reusable natural products. An alternative process reduces matured bamboos to sawdust and fibre. These are moulded into plates, bowls, and cutlery, and then bound together using a melamine chemical.	Rattan and bamboo products are continually produced in PNG, Solomon Islands, and Vanuatu. Production is limited in the Polynesian and Micronesian countries.
Bags			
Coconut / Pandanus woven  	Products 1- 3 last for over a year. Products 4 & 5 last for a month.	Coconut products: The products 1-5 can be produced quickly, using fresh and green coconut leaves without drying. Products 4 and 5 are easier and quicker to produce. They take between	These products are produced in small volumes for household use, mostly in rural areas. Products 4 and 5 are commonly produced in almost all PICs, mainly by

Category	Shelf life	Production methodology	Production status in PICs
 	Pandanus woven bags last longer than coconut woven ones.  	15mins and 20mins for smaller bags, to 40mins for bigger bags. There are varieties of designs similar to products 1-5, which are specific to some PICs. This can be learnt directly from the local experts. Products 1-3 can also be produced with pandanus leaves but take time due to required pretreatment and other preparations for the pandanus leaves. This is unlike the coconut leaves, which do not require special treatments.	remote and rural farmers, for carrying their produce from the farms. They are also being sold by some local people at the markets and as a tourist attraction. Products 1, 2, and 4 have limited production.
Cloth & Cotton   	1-5 years, depending on the material used  	Item 1 is produced from clothing materials available in PICs. The cloth material is cut to the shape of the targeted bag designs. A sewing machine is then used to sew or mend the loose ends to form a bag. Another piece of cloth is cut and shaped to sew a hanging holder. Items 2 and 3 are mostly handmade by local women in PNG, Solomon Islands, Vanuatu, and the Micronesian countries. This is known as Bilum in PNG and Solomon Islands. The production methodology is provided in this link[4]. Items 4 and 5 are made from plastic packing materials such as noodles and rice bags in Vanuatu. The method for these products is unique to the local women involved in making them.	Item 1 is mostly produced in all PICs. Items 2 and 3 are actively produced by women groups in PNG, as there is market demand for these products. Items 4 and 5 are produced in Vanuatu by the Auki Women's Group. Items 6 and 7 are massively produced overseas and imported to fill the shortfalls in PICs.

[4] https://thebrooklynrefinery.com/bilum-videos/

Category	Shelf life	Production methodology	Production status in PICs
		Training can promote the production of these products. A cloth bag is made by cutting a piece of cloth based on the size and design of the bag. After cutting, the sides are then sewn manually by hand, or using a sewing machine, which can be quicker.	
Plant fibres woven bags – rattan, banana, bamboo, etc.   	More than 5 years 	The production of these bags requires special skills and weaving experience to produce more efficiently. The preparation of the raw materials from rattan, banana, bamboo, and other plants involves lots of preparation, which is done manually. Items 1 and 2, with other different designs and sizes, are produced from rattan plants, which are abundant in PNG and Solomon Islands. Its production method is provided in this link [5]. Item 3 is produced from bamboo, which is also available in PNG, Solomon Islands, Vanuatu, and Fiji. The production method is provided in this link[6]. Item 4 is produced from banana stems and is rarely produced in PICs. The production method is provided in this link[7].	Items 1-3 are produced in PNG with some production in Solomon Islands and Vanuatu. Item 4 has limited production in PICs but is available in Asia. However, with training, the production is possible in PICs.
Cutlery			
Wooden	Depends on how	The typical process to create bamboo cutlery involves cutting bamboo culms to size and shape (spoon, fork or	Cutlery is not produced in large volumes or considered a profitable venture. Some

[5] https://thanhcongcraft.com/how-to-make-a-rattan-basket-step-by-step-for-beginners/
[6] https://thanhcongcraft.com/how-to-make-a-bamboo-basket-step-by-step-with-pictures-at-home/
[7] https://youtu.be/9h3S2Q95-uI / https://youtu.be/gbwSMdFlyGo

Category	Shelf life	Production methodology	Production status in PICs
 	frequently they are used	knife), and engraving, sanding, polishing, and coating the piece. This is often done by bamboo artisans, carpenters, or other trained professionals. The demonstration videos are provided in these links[8]-[9]. An alternative production process is more complex and involves more supporting equipment and facilities. This is only available in developed countries in Asia, Europe, and other regions[10]. Tree stems or logs are fed into a specialised machine to remove the bark and outside portion of the stem, then another machine peels the stem layer by layer to produce thin timber for the production of different cutlery.	entrepreneurs in Solomon Islands are currently considering their production. Limited supply of bamboo straws in PICs, mainly for domestic use., E.g. Vanuatu
Nappies and Hygiene Items			
Cloth  	Reusable for 5-10 years (Sometimes diapers can be passed on for generations.)	Sewing and access to materials	Some women's groups in Vanuatu and Timor Leste are producing these products locally. Challenging to produce enough to meet demand, but enough space in the market to complement compostable nappies if used in combination through a systems approach

[8] https://thanhcongcraft.com/how-to-make-bamboo-utensils/ https://youtu.be/V52JiCML_Uo
[9] https://youtu.be/PmelqyJWUF4 / https://youtu.be/0L3rEfq99UQ
[10] https://youtu.be/NdVo8zMTEwM / https://youtu.be/8_j_ISuWBQE

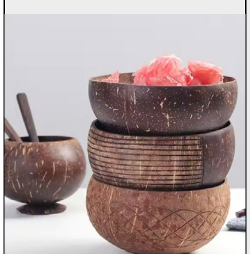
6.3 Suitability, challenges and potential of local production

Whilst a range of artisanal products are being developed and sold around the Pacific region, scaling-up requires investment in proper training, sometimes in business models and processes rather than the skill itself. There is also a need to ensure any scaled-up product can be sustained both financially and environmentally without impacting the local environment and economy.

All artisanal products are labour intensive, leading to the per unit cost being higher and only a reuse model would allow for the products to be truly used substitutes for SUPs, that are a large part of the market in the PICs currently.

The table below describes the suitability of each of the categories of artisanal products discussed in the section above and the challenges and barriers to their widespread use and scaleup.

Table 9: Suitability and barriers to the use and scaleup of artisanal products in the PICs

Category	Suitability	Challenges & Barriers
Tableware		
Coconut shells[11] 	• Can be used as cup and bowl for serving hot and cold beverages and food • A formal cup for serving kava in line with cultural parameters in some PICs • Raw materials are abundant in PICs. Can use shells generated from coconut cream production at household level • Easy to make using traditional methods • 100% natural and reusable for years • Environmentally friendly and could degrade naturally	Low demand as a SUP substitute Lacks education and awareness about its environmental friendliness and its significance in maintaining the culture and identity of the Pacific Islands
Bamboo cups  	• Can be used as cup for cold and warm beverages, and bowl for cold and warm food Hot serve may split the bamboo. • Raw materials available in PICs like PNG, Solomon Islands, Vanuatu ,and Fiji, but will need to be researched • Environmentally friendly and 100% natural without chemicals • Can degrade naturally without special waste management facilities	Not suitable for hot beverages and food Bamboo is not available in all PICs.

[11] https://youtu.be/JwTidRl8oa8?si=V5esUEhkqzUIJA1c / https://youtu.be/KYcaGWVc6YY?si=cy-8rvTUdMHYIJ7O

Category	Suitability	Challenges & Barriers
Coconut / pandanus  	• All products are produced from coconut and pandanus leaves. • Raw materials are abundant in all PICs. • Product 1 has been used as bowls for semi-solid food like salad, ice cream, etc. • Products 2, 3 & 7 have been used as plates. • Products 4, 5 & 6 have been used as trays. • Products 1-7 can be produced just in time when needed for community events. • The products are part of PICs identity and culture. • They can be locally produced by local communities without having to purchase materials. • No need to wash after use. A single use cover (banana leaf or breadfruit leaf, etc.), is placed as the base of all these products to keep them clean. • Highly suitable for remote areas and islands without waste management services • 100% natural and without chemicals	Lacks education/ engagement/promotion for use at community functions and gatherings where SUPs are mostly used (plastics, paper, etc.) Few local people with the skills and expertise to produce these materials are currently available in PICs. Some products are not attractive enough for people to keep them and reuse several times. E.g., Products 5,6 & 7.
Palm leaves 	• 100% natural without chemicals and degrade naturally • More suitable for PICs with an abundance of palm trees like PNG, Solomon Islands • Processing facility setup and production process is simple and not expensive • Good for cold and hot food	• Limited and unsustainable supplies of raw materials • Cannot compete with the imported cheaper alternatives • High production cost
Bamboo, rattan, etc. 	• 100% naturally produced from plant fibres without chemical • Suitable for semi-solid food service with a natural cover to place at the base (banana, breadfruit, etc.) • Biodegradable and no need for special waste collection and disposal • Washable after use for multiple reuses for more than a year. • Raw materials are available in PICs, especially PNG, Solomon Islands, and Vanuatu. • Local skills are available.	Raw materials are only available in a few PICs that have established plantations The products are not easy to produce. Cannot be produced in large amounts for community events when needed to replace SUPs Few people with the skills
Bags		

Category	Suitability	Challenges & Barriers
Coconut / Pandanus woven	• Products 1-5 have been used as shopping bags in the past in PICs before the introduction of plastic bags. • Raw materials from coconut and pandanus trees needed for these products are abundant in PICs. • Environmentally friendly as they degrade naturally • Suitable for remote islands and areas without waste management facilities • Local skills are available in communities to train others to promote their production and use. • Different bag sizes can be produced to pack light or heavy shopping. • Items 1-3 are suitable for small to medium (light) shopping from supermarkets. • Items 4-5 suit medium to heavy shopping, mainly from agricultural markets.	Few local people with the skills and knowledge continue to practise it. Limited promotion of knowledge and skills The production of these products is reduced due to the availability of modern reusable bags and sacks, which are convenient for people.
Cloth & cotton	• Items 1-5 are locally produced in PICs. • Suitable for all PICs for shopping purposes • Reusable until they are worn out • Locally produced • Some bags are unique to some PICs, like PNG with the Bilum bags (items 2 and 3). • Appropriate for remote places and areas without waste management facilities (collection and final disposal)	High cost compared to imported ones Low volume production to match any demand Unavailability of locally produced products at points of sale like supermarkets, etc. to promote their use
Plant fibres woven bags – rattan, banana, bamboo, etc.	• Raw materials are available in PICs, especially for banana (all PICs), rattan, and bamboo (in PNG, Solomon Islands, Vanuatu and Fiji). • Local experts are available with skills and experience, which could be used to promote the production in PICs as alternative options that are 100% natural without special waste management needs. • More appropriate for remote areas and communities surrounded by these plants. • Beautiful products can become source of income for the local people if adequately promoted. • Reusable	Few local producers with the expertise Lack of promotion and support from governments to promote these products' production Availability of raw materials from rattan plants and bamboo is limited mostly to PNG, Solomon Islands, Vanuatu, and Fiji. High cost per unit

Category	Suitability	Challenges & Barriers
Wood	• Can be locally made using raw materials available in PICs. E.g., bamboo plants • Environmentally friendly and degrade naturally • Washable with water and soap and ready to be reused multiple times Reusable multiple times until they are worn out • Appropriate for many remote places in PICs that are still without any basic waste management service	High cost of production if produced in small volumes in PICs with varieties of cutlery Limited and unsustainable raw materials Cannot compete with the cheaper imported alternatives
Diapers and Hygiene items		
Cloth	• Can be produced locally using imported materials • Washable and reusable • Require appropriate sanitation facilities to be available for disposal of human waste prior to washing • Require access to appropriate washing facilities to ensure there is no runoff of water into the coastal areas leading to further environmental damage	High cost of production and high per unit price Competition expected with cheaper imported compostable substitutes

6.4 Relevant stakeholders

Table 10: Relevant stakeholders and recommended actions

Category	Comment	Relevant stakeholders
Tableware		
Coconut shells[12]	Highly recommended for promotion in PICs Project support to fund education and promotion, and conduct training for women's groups, hotels and resorts, and tourism and education agencies	Tourism, Culture and Art Government Agencies in: - Samoa - Fiji - Tonga - Vanuatu - FSM - Specific Groups: - Rural villages in Samoa, Tonga and Fiji.
Coconut & pandanus woven products	Highly applicable for PICs to promote and produce due to the abundance of raw materials and without any cost to the communities	Tourism, Culture, Art and Industry Government Agencies in Samoa, Tonga, Fiji, PNG, Solomon Islands,

12 https://youtu.be/JwTidRl8oa8?si=V5esUEhkqzUIJA1c / https://youtu.be/KYcaGWVc6YY?si=cy-8rvTUdMHYIJ7O

Category	Comment	Relevant stakeholders
	Prioritise products that are easier to produce and more attractive to be kept for long. E.g. 1, 2, 3, 4 & 5	Vanuatu, Palau, FSM, RMI, etc. These agencies are the focal points for the development and promotion of arts and culture, which artisans are largely part of. Specific NGOs: - SWAG, Samoa. - WIB, Samoa - SIWIBA, Solomon - Auki Market Vendor, Solomon - Gizo Market, Solomon - Sanma Creative Industries Community Company (SCICC) Women weavers of Milne's Bay Incorporated. - Fiji Arts Council. Palm leaves: Samoa Green Products Company, Samoa Yap, FSM Eco Leaf Plate
Bamboo / rattan / banana fibres woven	Considered as the next option after coconut and pandanus products More appropriate for PNG, Solomon Islands, Vanuatu, and Fiji with adequate land and diverse raw materials	PNG Office of Tourism, Art and Culture Solomon Islands Ministry of Culture and Tourism Ministry of Tourism, Trade, Industry, Commerce, and Ni-Vanuatu Business (MTTICNVB) Department of Heritage and Art, Fiji Art Council
Bags		

Category	Comment	Relevant stakeholders
Coconut / Pandanus woven	Highly recommended for PICs	All tourism, culture and arts related government agencies in all PICs: - Melanesians - Polynesians - Micronesians Others: - SWAG, Samoa - WIB, Samoa - SIWIBA, Solomon - Auki Market Vendor, Solomon - Gizo Market, Solomon - SCICC, Vanuatu. - Weavers of Milne's Bay Incorporated - Fiji Arts Council - Langafonua Handicrafts Centre, Tonga
Cloth & cotton	Support local producers through appropriate funding mechanisms, while continuing the import of appropriate substitutes to ensure the community has options	
Plants fibres woven bags – rattan, banana, bamboo. Etc.	Collaboration with Tourism and Culture agencies in PICs to promote as income generation source for people Assess the feasibility of promoting rattan and bamboo introduction to the region	
Bilum bags	Prominent in PNG but has recently expanded to Solomon Islands.	Milne`s Bay Woven Group, PNG Plasticwise Gizo, Solomon Islands Auki Market Vendor, Solomon Islands
Diapers and Hygiene items		
Cloth	Highly recommended as an option to be promoted through women's groups Need to ensure access to appropriate sanitation and washing facilities to allow for proper disposal of human waste and washing of diapers	Mamma's Laef Vanuatu (commercially) Various women's groups across the PICs

6.5 Strategic measures for potential future scale-up

Scaling up any of the artisanal products discussed in this section would require a strategic approach to ensure that sponsored projects do not only stop at providing training. A medium to long term investment to ensure the financial viability of these enterprises and ongoing troubleshooting will be needed as these small projects are scaled up.

Some key steps are identified below:

I. **Identify potential trainers of artisanal products:** Although a range of products is being produced across the pacific, not all are being produced in all countries. A "train the trainer" programme held at a central location that allows for an exchange of skills is recommended. The key first step would be to identify the range of skills needed and potential candidates who could act as trainees and trainers at the same time.

II. **Develop training programmes:** Once appropriately skilled individuals or organisations have been identified, a comprehensive training programme should be designed. This programme should include product design and development, business development, marketing (including digital marketing), and cross-cultural collaboration. Research and development on establishing adequate supplies of required materials, like bamboo and rattan, for the large-scale production in PICs should align with conservation strategies.

III. **Collaborate and train**: Once a training programme has been developed, collaboration and training should be undertaken. As mentioned above, this can be done through "train the trainer" programmes held in one location or within each country, depending on the availability of budgets.

IV. **Monitor and provide ongoing support:** About 20% of new businesses fail in the first year and 50% in the first five years[13]. Ensure business monitoring and ongoing support is available for trained entities to ensure long-term success. This should be supported through the promotion and use of these products through awareness campaigns linking to sustainability, environment, and culture.

V. **Collaborate with national governments on tariffs:** Consider introducing tariffs for specific products significant to PICs if they are actively produced locally and are part of peoples' identity, to promote their sale and production by local firms. E.g., PNG Bilum, reusable nappies, etc. This could promote their use and provide a competitive pricing advantage.

VI. **Support legislation and education campaigns:** Promotion and scale-up of artisanal products must include supporting legislation at the national level to promote and mandate the reuse and use of reusable materials. This will need to be heavily supported through education campaigns and promotion through schools, tourism boards, women's groups, and NGOs already active in the PICs.

Eliminating disposable SUPs stimulates the market for substitutes and promotes more durable, locally produced artisanal products. This shift can foster small business opportunities, bringing greater value to the Pacific region. Artisanal products, while labour-intensive and less able to be mass-produced, tend to be more durable and reusable.

To support reusable alternatives, behaviour change programs, education campaigns, and feasibility studies are essential. Key considerations for promoting artisanal products include ensuring the availability of raw materials, such as coconut and pandanus leaves, without threatening conservation efforts, and establishing consistent local suppliers. Sustainable production processes should use 100% natural materials without harmful additives and avoid creating additional environmental hazards.

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[13] https://www.lendingtree.com/business/small/failure-rate/

The products must be reusable with a lifespan longer than a week, cost-competitive with imported substitutes, and responsibly disposable at the end of their life cycle. Various artisanal products like coconut shell tableware, bamboo cups, and woven bags have potential as substitutes for SUPs, though challenges such as limited production skills, high costs, and competition with modern alternatives exist. Strategic measures for scaling up include identifying and training potential artisans, developing comprehensive training programmes, providing ongoing business support, collaborating with governments on tariffs, and enacting supportive legislation and education campaigns.

7 Status of SUP management in PICs

Quantification studies have been undertaken in 2019-2021, using a common methodology across the Pacific. The results from these studies indicate that plastics are a problem item of concern in PICs, representing about 12% of the **total waste** in the region by weight. However, plastic waste is being generated more often in the consumer context than this figure suggests. A detailed analysis of household and commercial waste stream indicates that plastics and hygiene items can represent anywhere between 15%-66% of the **household waste stream** and 8%-68% of the **commercial waste stream**. While this data indicates that future action on plastics should be focused on these household and commercial waste streams, it is important to note that waste data has not been systematically collected for key sectors in the Pacific, including fisheries and tourism.

7.1 Summary of current legislative actions

A growing number of countries within the Pacific are beginning to adopt measures to better manage plastics entering their markets and the environment. Regulations on imports, bans on SUP items, and adaptive legislation such as container deposit schemes are being implemented to mitigate plastic consumption, as well as disposal and leakage across the region. The development of specific regulations and legislative instruments designed to reduce the impact of specific plastics on the marine environment is growing in PICs, driven by a plethora of donor projects in this space and the visual impact of littered plastic. These actions cover four main SUP groups – hygiene items, plastic bags, take-away items, and beverage containers. Plastic bags are the SUP item with the greatest number of restrictions (10 countries), and diapers have the least restrictions (3 PICs). A summary has been prepared for the items of interest and the relevant legislative intervention currently in place for these items. These are presented in **Appendix C**, **Table 15**.

It must be noted that it is impossible to determine the status of **enforcement** of the legislation. Therefore, **Table 15** notes the instances where enforcement is built into legislation. The key takeaways from the review of legislation in the PICs are summarised below:

- **Lack of clarity on details of targeted items:**

The legislation and regulations lack appropriate detail, creating difficulty in confirmation of the exact items that are being targeted by the legislation. For example, the provision of set thickness, dimension, and biodegradability specifications are lacking in most legislations. This creates issues not only for the private sector trying to comply, but also with monitoring and enforcement as the regulations leave the requirements open to interpretation. Further, there is lack of consistency in the types and specifications of items covered by these regulations, resulting in countries not being able to learn from each other. For example: the legislative provisions within Vanuatu, Fiji, and FSM for plastic bags specify the thickness and dimensions of bags that are banned, but this is not the case for other countries. Similarly, Vanuatu sets a size limit of 30cm (length or width) for any disposal containers entering the country, and Solomon Islands and Tuvalu legislation restricts the size of beverage container bottles entering the countries to below 1.5L. This is not the case for the remaining PICs.

- **Absence of Supporting Legal Mechanisms for Effective Monitoring**

As summarised in the table (for instances that have a ban or a levy but no enforcement measure legislated), a number of PICs' legislation for SUP does not include legal measures for enforcement. These legal mechanisms help not only to control the number of importers but make the monitoring and enforcement more practical for the responsible government agencies (Customs and Waste Management Agencies) by focusing attention and effort on the licensed importers, as the only pathways of the banned items in the country.

Examples of these measures include the license system for Samoa (2006) and Cook Islands (2012). These countries include provisions that prohibit the importation of non-biodegradable plastic bags, while at the same time allowing the importation of starch-petroleum biodegradable bags. The license system allows only approved importers to import banned items. The approved importers have to include their names and other details on all the imported items for easy identification and monitoring by the government officials. There are also reporting requirements for the importers as part of the license system. Failure to abide by the set conditions results in disqualification of the importer. The license systems could be made flexible to add more materials as research on substitutes becomes available.

- **Lack of Capacity for Monitoring and Strict Enforcement**

The effectiveness of any legislation depends on the level of monitoring and enforcement. Due to the lack of capacity in terms of staff and supporting resources, the responsible government agencies are ill-equipped to implement ongoing monitoring and enforcement. For example, in some countries, packing bags exempted for food safety and hygiene purposes only are being used as shopping bags at rural and remote shops where monitoring is impractical. This could lead to other businesses following suit and cause the initiative to gradually fail. There are also instances of illegal import of banned items as the department of Customs do not have qualified staff to check the validity of compostability claims.

- **Limited to No Appropriate Testing Facilities**

In some PICs, biodegradable, reusable, and recyclable bags are exempted or not covered under the ban. The absence of appropriate testing facilities to confirm the quality of these bags creates a gap for the flow of banned items to enter. PICs do not have appropriate testing facilities and expertise to test and confirm whether a bag is recyclable and compostable under the specified compostable specifications. This creates a grey area for the influx of fake items and needs to be mitigated through mandatory minimum standards and random testing regimes.

7.2 Beyond legislation

It is apparent from the case studies and experience in PICs that legislative intervention is becoming increasingly common in these countries. However, banning or levying a SUP is not enough. Stakeholder consultation shows that the countries are struggling with a range of issues including:

a) Availability and cost of alternatives
b) High cost and challenging nature of waste collection, transport, and recycling services
c) Lack of appropriate end-of-life infrastructure for disposal of compostable SUPs
d) Lack of technical and human capacity for monitoring and enforcement

These are some of the factors hindering the progress on SUPs in the region. In no small part, this situation stems from the small, remote, and dispersed populations in many PICs which, in the case of alternatives to SUPs, can accentuate their cost disadvantage or hinder local producers from achieving economies of scale. Similarly, for waste management and recycling service providers, collection and transport services can be prohibitively costly, especially to outer islands and other remote locations. Finally, there is no composting infrastructure currently in place in the PICs. For example, research undertaken for the Samoa case study indicates that when the Samoan government banned Styrofoam takeaway containers, the market moved to the next cheapest available alternative in the form of PET takeaway containers. Similarly, even though diapers were banned by the Vanuatu government in 2019, no progress has been made on the implementation of the ban because of the lack of suitable alternatives, as well as the lack of end-of-life disposal facilities like composting.

Therefore, any substitutes allowed entry into the PICs must be reviewed for standards and composability as well as the availability of appropriate composting infrastructure. Source separation becomes the most important issue to address. Regional procurement could be considered if there was harmonisation for banned items within the region and minimum standards for all compostable substitutes entering the region. SOPs could also be prepared for regular testing of SUPs entering the countries to ensure compliance.

Quantification studies conducted from 2019 to 2021 across the Pacific Islands indicate that plastics constitute about 12% of the total waste by weight. However, plastics and hygiene items are more prominent in specific waste streams, representing 15% - 66% of household waste and 8%-68% of commercial waste. Despite this, systematic data collection is lacking for key sectors such as fisheries and tourism.

Legislative measures in the region are growing, focusing on container deposit schemes and bans on SUP items, plastic bags, and take-away items, with plastic bags facing the most restrictions. However, enforcement of these regulations is inconsistent due to unclear legislation, lack of supporting legal mechanisms, and limited monitoring capacity, Furthermore, the region lacks appropriate testing facilities to ensure the quality of biodegradable and compostable alternatives. Beyond legislation, challenges include the high cost of alternatives, waste management and recycling services, as well as the absence of composting infrastructure. These issues are exacerbated by small, remote populations in the Pacific Islands, making regional cooperation and standardisation essential for progress.

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8 Recommendations

Based on our findings, we recommend a comprehensive approach for transitioning away from single-use plastic products towards non-plastic substitutes and bio-based plastic alternatives. The recommendations include:

1. Consider harmonisation of legislation

Although legislative action has been taken in a number of countries, legislation still lacks a range of items that are not covered within each country. Legislation also often covers different items, and enforcement actions are lacking. Harmonisation of legislation across PICs would allow collaboration among the distributors and purchasers to access appropriate materials. It would also lead to ease of enforcement and implementation.

Refer to section 7.1

2. Exploration of reusable systems

Conduct thorough research into reusable systems to identify optimal models and develop customised systems tailored to the unique needs of each PIC. Also, encourage the adoption of reusable alternatives through incentives and subsidies.

Refer to section 6.3

3. Support for traditional and artisanal production

Provide support and incentives to enhance the production and commercialisation of traditional and artisanal products, fostering their increased usage and market viability. This may be through medium to long-term investment support to ensure the financial viability of artisanal enterprises as they scale up, or through "train the trainer" programmes to share techniques in creating artisanal products.

Refer to section 6.5

4. Research and development funding

Investigate local options for producing bio-based biodegradable plastics using locally available raw materials, leveraging regional resources for sustainable alternatives. Also, allocate resources and funding for research and development initiatives aimed at advancing the innovation, scalability, and affordability of sustainable replacements for SUPs. Meanwhile, encourage investment in research projects that explore novel materials and manufacturing processes.

Refer to sections 3.1, 5.3, 6.1.1, Appendix A

5. Development of supportive legislation

Advocate for the development and implementation of supportive legislation to facilitate the transition away from SUPs, providing a legal framework for change and promoting sustainable practices at all levels.

Refer to section 6.3

6. Capacity building in material science, standards, and certificates

Implement capacity-building initiatives in material science, standards, and certification processes for plastics, bio-based plastics, and non-plastic substitutes. This includes education, training, knowledge sharing, skill development, and institutional strengthening efforts.

Refer to section 2.5

7. Consumer behaviour change campaigns

Implement targeted campaigns and interventions to promote shifts in consumer behaviour towards more sustainable consumption patterns and choices. Educate consumers about the environmental impact of SUPs, and empower them to make informed decisions.

Refer to sections 3.1, 3.2

8. Stakeholder engagement and collaboration

Emphasise the importance of engaging diverse stakeholders, including government agencies, businesses, civil society organisations, academic institutions, and local communities, in the development and implementation of sustainable solutions. Foster collaboration and partnerships to harness resources, expertise, and support for collective action.

Refer to section 6.5

9. Waste management infrastructure

Invest in the development and improvement of waste management infrastructure, including composting facilities and waste collection systems, to support the proper disposal and management of both biodegradable and non-biodegradable waste. Promote the establishment of community-based initiatives and decentralised solutions to address waste management challenges in remote or underserved areas.

Refer to section 3.1

10. Level the playing field for the private sector within the region

Uptake of SUP alternatives can be enhanced through comparable costing, tax exemptions or subsidies, and clear sources of substitutes. Consistency in legislation across the region will enhance the region's collective power to source materials by creating economies of scale. Regional procurement could be considered in collaboration with the private sector.

Refer to sections 2.3, 3.1, 6.5

11. Testing, quality control, and compliance

Establish and enforce mandatory minimum standard and rigorous testing protocols with SOPs to verify the quality of plastic substitutes and alternatives. Conduct regular random testing to prevent the influx of banned and fake items. Harmonize regional standards to facilitate consistent quality control across borders. Additionally, comprehensive investigations should be conducted before procurement to help avoid problems with falsely advertised, non-biodegradable products.

Refer to sections 3.1, 4.2, 7.1, 7.2

12. Data collection and analysis

Standardize waste data collection, and collect waste data from various sectors within the Pacific to inform strategies for reducing SUPs. Comprehensive data analysis will enable targeted actions and policies to address waste management challenges effectively.

Refer to section 7

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Appendix A: Biodegradable substitutes and alternatives to conventional plastics

a. Bio-based substitutes

Natural biodegradable materials have been used by humans since the dawn of civilisation. Their traditional and artisanal production and numerous applications have a long history and remain very common in SIDS, providing a strong foundation for replacing SUPs that have, on the other hand, been around only for a few decades or less. Apart from the traditional production, adopting modern and innovative concepts of manufacturing non-plastic substitutes through processes such as compression moulding, injection moulding, and hot pressing could bring multiple benefits to the SIDS. The ongoing development of new substitutes presents an opportunity for the production of entirely new products based on the existing country-specific raw materials, supporting more holistic circular economies (UNCTAD, 2023). Examples of bio-based renewable substitute materials are given in Table 11. Very often these substitute materials include waste products of agricultural processes that are upcycled from waste and residues to valuable new products.

Table 11: An illustrative list of bio-based renewable materials (UNCTAD, 2023)

Plant fibres and materials	banana leaves, stem or fibres, areca leaves, pineapple leaves, bamboo wood, cork, hemp, jute, sisal, palm, flax husk, sugarcane bagasse, corn husk, cornstalk, rice husk, wheat husk, straw, coconut husk, shell, vegetable oil, cacao pod husk, calabash shell, wood bark, pulp and chip, food market and household organic waste (i.e. fruit and vegetable food waste), peels and seeds, roots and tubers (e.g. cassava, taro, potato), okra, tofu waste, seaweed
Fungal fibres and materials	mushrooms & mycelium material
Animal fibres and materials	silk, fish skin or residues, leather various animal wools (alpaca, angora, cashmere, sheep, etc.)

Sugarcane bagasse clam

Bagasse cups & lids

Bamboo

Coconut cup

Areca leaves

Acacia wood

Jute bag

Palm leaf

Mycelium foam packaging

Cotton

Sheep wool

Some of the most common substitute materials include plant leaves, sugarcane bagasse, coconut husk, rice husk, bamboo, jute and hemp. **Sugarcane bagasse** is particularly versatile and has found numerous applications in disposable service ware, such as containers, plates, trays and bowls, as well as bagasse paper, textiles, biofuels and furniture. This fibrous residue of sugarcane stalks left after juice extraction represents a significant agricultural waste in small island developing countries, such as Fiji. To avoid its disposal, incineration or use as biomass for sugar mills, bagasse is repurposed into various products, giving it new life as a raw material (UNCTAD, 2023). Being a non-edible waste material of agricultural production, bagasse is a highly valuable renewable resource, especially as an alternative to paper. By replacing materials like cardboard, plywood, particleboard, and Styrofoam (i.e. expanded polystyrene, EPS), bagasse could reduce wood consumption by over 52%. Some of its qualities include resistance to high temperatures (up to 93°C), grease and water resistance, durability, freezer and microwave compatibility, superior insulation properties, and prolonged shelf life. Its highly porous nature enables effective moisture absorption, promoting breathability and a drier environment for perishables. In summary, bagasse is renewable, biodegradable, and compostable (UNCTAD, 2023).

Some bio-based materials perform better in combination with other materials, creating so-called **biocomposites**. For example, coconut husk has been used in combination with other bio-based materials, often in production of bio-based foam that aims to replace expanded polystyrene. Pongsa et al. (2023) successfully created a biodegradable foam composite by converting coconut waste into coconut residue flour and adding it as a reinforcing material in foam-type material made of cassava starch. Another group has produced biofoam cup from sugarcane bagasse, coconut fibre, soybean flour, and commercial fungus Rhizopus sp. (Indarti et al., 2020).

Since ancient times, various plant-based fibres have been used in production of textiles, and more recently, some of them have also been used as substitutes for plastic bags, nappies, sanitary pads, and tampons. Cotton is still the most prevalent natural fibre (Townsend, 2020); however, bamboo and hemp have also experienced increased demand and production (Zimniewska 2022; Tahir et al., 2023).

Exploration of mycelium-based biomaterials is also gaining momentum. Saravana et al. (2023) succeeded in producing mycelium of the oyster mushroom (*Pleurotus ostreatus*), obtaining different material properties that depended on the substrate for the mycelium growth. Mycelium-based materials have demonstrated versatility and minimal environmental impacts (Alemu et al., 2022).

b. Bio-based and biodegradable plastic alternatives

Bio-based plastic alternatives have also become increasingly relevant in global SUP management efforts. Unlike conventional petrochemical (fossil fuel-based) plastics, these polymers are derived from biomass – plant and animal-based materials. The main difference between the bio-based substitutes and the bio-based plastic alternatives is that the final product of the latter considerably differs chemically from the raw material used for bioplastic production. The new material is a type of biogenic polymer obtained through various processes of polymer synthesis.

Not all bio-based plastics are designed to be biodegradable. Meanwhile, the ones that are biodegradable are compostable on either small-scale at home or large-scale in a composting facility (i.e. industrial composting). The relationship between the biodegradability and renewability of resources of the bio-based biodegradable and non-biodegradable, and conventional biodegradable and non-biodegradable plastics is provided in the diagram below. In this report, recommendations will include only bio-based (i.e. renewable) biodegradable plastics (upper right corner).

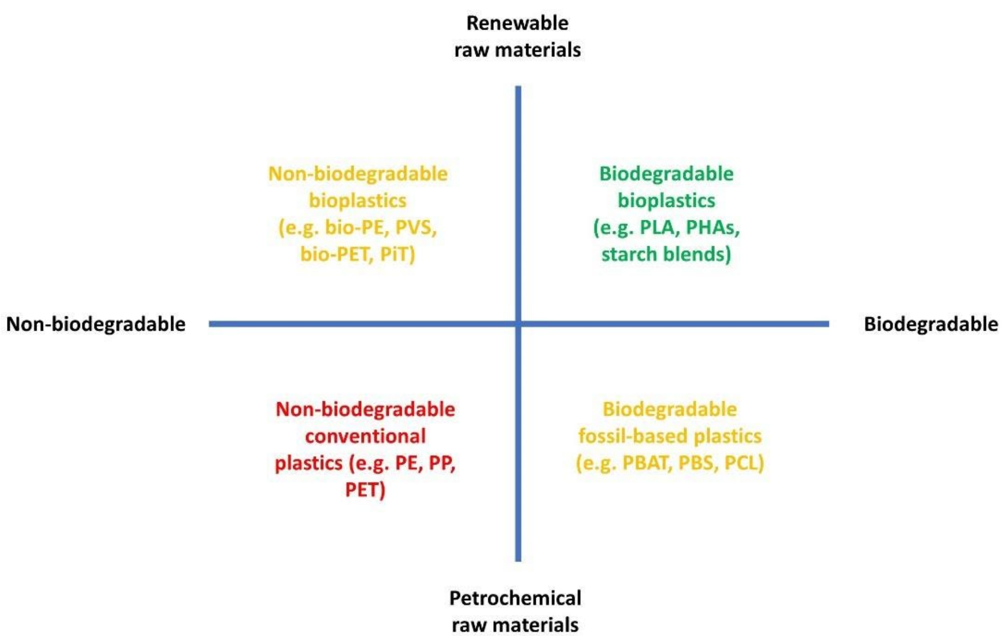

Figure 13: Conventional plastics and bioplastics and their biodegradability (adopted from Lackner, 2015). Red represents undesirable materials, green acceptable and the acceptability of yellow colour depends on the application

With respect to raw materials (biomass) used in the production of bio-based plastics and the resulting polymers, there is a plethora of combinations. Biomass used for production includes sugar-based polymers, starch-based polymers, cellulose-based polymers, lignin-based polymers, protein-based polymers, algae-based polymers, mycelium-based polymers, and microbial polymers. Raw materials for each of these categories can be obtained from various sources, such as corn, wheat, potatoes, cassava, and food waste (See more detail in Chapter 3.3.3.). The resulting bio-based polymers most commonly discussed in academic literature are polylactic acid (PLA), thermoplastic starch (TPS), polyhydroxyalkanoates (PHAs) (polyester), polybutylene succinate (PBS), and polybutylene adipate terephthalate (PBAT).

Many of these bio-based materials can be produced as composite plastics or **biocomposites** – blends of two or more compounds (note: composite does not mean it is compostable). The blends can be made entirely from bio-based and/or biodegradable polymers, but also in combination with petrochemical polymers. Often bamboo, wheat or hemp plastic are actually composites of plant fibres and polyethylene, polypropylene or melamine-formaldehyde (for example, as mentioned in Bari et al., 2019), and this should be taken into consideration when dealing with bio-based plastics. Biocomposites that are entirely based on renewable biopolymers can include combinations of PLA, PHAs, PSB, TPS, cocoa, cassava, coconut, and bamboo (Sunarti et al., 2015; Versino et al., 2015; Fazita et al., 2016; Su et al., 2019; Jiang et al., 2020, Jullanun and Yoksan, 2020; Meereboer et al., 2020; Garcia-Brand et al., 2021, Rafiqah et al., 2021).

Table 12: Some common bio-based plastics

Polymer	Description
PLA	**PLA** is currently one of the most common bio-based plastics replacing SUPs in the market. PLA is usually synthesised from corn starch, but starch can also be sourced from other starch-rich plants such as roots and tubers. The properties of PLA require appropriate sorting and composting facilities for its end-of-life management, as it is not a home compostable material. Without industrial composting, PLA is likely to end up in landfill where its fate is similar to conventional plastics. If not sorted properly, PLA can also contaminate recyclable plastics streams.
TPS	**TPS** is also a biodegradable polymer derived from starch, but the production process is different from the synthesis of PLA. It is a thermoplastic material that can be moulded or shaped when heated and solidifies upon cooling. TPS is biodegradable and home compostable.
PHAs	**PHAs** are a group of biodegradable polymers produced by microorganisms, primarily bacteria, of which polyhydroxybutyrate (**PHB**) is the most well-known and studied. The polymers are synthesised within the cells of microorganisms under nutrient stress, serving them as energy and carbon storage. Given that PHAs can be made from food waste and are generally home compostable, they are considered to be particularly environment-friendly polymers.
PBS	**PBS** is a type of biodegradable polyester polymer. PBS is usually synthesised via polycondensation of succinic acid (or dimethyl succinate) and 1,4-butanediol (BDO). The monomers can be derived from fossil-based or renewable resources (e.g. plant glucose). PBS is biodegradable and home compostable.
PBAT	**PBAT** is also a biodegradable home-compostable polymer in the polyester family from biomass-derived sugars, fatty acids, and plant oils.

c. Feedstock for bio-based materials and plastics

Raw materials or **feedstocks** for bio-based materials and plastics, derived from plant and animal sources, encompass a diverse array of materials, including corn, potato, wheat, cassava, wood pulp, sugarcane, vegetable oil, jute, hemp, collagen, gelatine, algae, among others. Feedstocks can be classified into three generations (Wellenreuther and Wolf, 2020) (Table 6):

- **first generation feedstock** – products that can be used as food or animal feed,
- **second generation feedstock** – non-food biomass or waste materials from the first-generation feedstock, and
- **third generation feedstock** – innovative feedstock (e.g. algae biomass).

First-generation feedstocks are highly efficient but, being of value as food or animal feed, there is now more focus on developing and using second and third generation feedstocks. Similar materials and the same polymer types can be obtained from various types of feedstocks. For example, bio-based plastic polymer PLA is produced from lactic acid obtained through fermentation of starch sourced from crops like corn, sugar beet, potatoes, wheat, maize, and tapioca (cassava). On the other hand, some products, such as food and beverage tableware, can also be made directly from plant material (either first or second generation). For example, plates and trays have been successfully made from waste banana and areca leaves by applying a heated mould to shape the leaves. Drinking cups can be made from bamboo, and bowls from coconut shells.

Table 13: Materials used as feedstock for bio-based materials and plastics

	Type of feedstock
First generation	Grasses (sugarcane, bamboo, corn, rice, wheat, oat, barley, rye, proso millet)
	Roots (cassava, taro, potato, sugar beet)
	Legumes (beans, soybeans, chickpeas, etc.)
	Vegetable oil
Second generation	Wood pulp, timber waste and sawdust, bamboo waste
	Palm leaves (banana, areca)
	Husk and straw from various grains
	Bagasse (by-product of sugarcane)
	Hemp, flax, sisal
	Coconut byproducts, coffee byproducts, wine byproducts
	Tofu industry byproducts
	Other agro-industrial residues (cassava, potato, banana peels, corn stover)
	Market waste
	Waste paper and cardboard
Third generation	Algae biomass (agar)

	Municipal waste
	Food industry waste (sludge)

Appendix B: Suitability Criteria Details

Table 14: Suitability criteria for introducing bio-based and biodegradable non-plastic substitutes and plastic alternatives to SUPs in PICs, or expanding existing local production.

Criteria	Description
Environmental Impact	**Biodegradability**: Substitute materials should be biodegradable and compostable in home composting conditions, especially if there is no industrial composting facility.
	Life cycle analysis: Overall environmental footprint of the material throughout its life cycle, including production, use and disposal, should be much lower than that of conventional plastics, and generally minimal.
Human health safety	**Toxicity**: Substitute materials must not contain compounds harmful to human health, including additives, especially in products designed as food contact materials.
Market accessibility	**Supply chain**: Continuous availability and accessibility of quality raw materials is necessary for production within the Pacific Islands or through reliable import channels.
	Distribution channels: Existing distribution channels and logistical capabilities for delivering the substitute materials to different islands and remote communities are important.
	Cost-effectiveness: The cost of production and distribution should be comparable to the conventional single-use plastics, considering factors such as transportation/shipping costs and economies of scale.
Technical feasibility	**Durability**: The durability and performance of the material should be suitable for various applications to ensure it meets the requirements for single-use products.
	Standards & labelling: Materials and products must have clear and reliable labels, easily visible, concerning material composition, recyclability, degradability, and compostability standards.
	Compatibility: If locally produced, the production of the replacing material should ideally be compatible with existing manufacturing processes, equipment, and infrastructure available in PICs.
Financial viability	**Investment requirements**: For local production, the initial investment is needed for setting up production facilities or transitioning existing facilities to produce bio-based materials.
	Return on investment: Profitability and long-term sustainability of producing and selling bio-based substitutes is critical, considering market demand and pricing dynamics.

Criteria	Description
Circular bio-economy considerations	**Resource efficiency**: Ideally, waste streams from agriculture, forestry or other industries should be used as feedstock for bio-based material production.
	Recycling and reuse: There should be options available for recycling or reusing bio-based materials at the end of their life cycle to promote circularity and minimise waste.
Products' end-of-life options and waste management	**Infrastructure**: If locally produced or imported materials require industrial composting or mechanical recycling to satisfy resource efficiency criterion, prior to production or import, measures should be taken to ensure proper infrastructure is available.
Community engagement and acceptance	**Cultural sensitivity**: Cultural attitudes and preferences regarding materials and packaging are important. Community support is vital for the adoption of new materials and products.
	Community engagement: Education and involvement of local communities in the decision-making process is necessary.
Regulatory compliance	**Legal framework**: Introduction and use of bio-based materials must comply with existing regulations and standards related to environmental protection, waste management, and product safety.
	Policy support: Advocate for supportive policies and regulations at the national and regional levels to incentivise the adoption of bio-based substitutes and facilitate their market penetration through tariffs and tax reduction.

Appendix C: Summary of SUP related legislation

Table 15: Summary of legislation in SUPs by item

B: Banned E: Enforcement supported by legislation NE: Not Enforced (only where status is known) SE: Special Exemption NA: Not Applied LY: Levied CDL: Container Deposit Levy

	Key Plastic Items	Details	Kiribati [14]	Tuvalu [15]	Niue [16]	Nauru [17]	RMI [18]	FSM [19]	Palau [20]	Solomon Islands [21]	Samoa [22]	Tonga [23]	Timor Leste [24]	Fiji [25]	PNG [26]	Cook Islands [27]	Vanuatu [28]
1.	1.1. Cups (cold and hot serve)	Plastics	NA	BE	NA	NA	BE	BE	NA	BE	NA	NA	NA	BE	NA	NA	BE
		Styrofoam	NA	BE	NA	NA	BE	BE	NA	BE	BE	NA	NA	BE	NA	NA	BE
	1.2. Straws	Straws alone	NA	BE	NA	NA	NA	BE	NA	BE	BE	NA	NA	BE	NA	NA	BE
		Drinks with straws	NA	SE/NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1.3. Takeaway food container	Plastic	NA	BE	NA	NA	BE	BE	NA	BE	NA	LY	NA	BE	NA	NA	BE
		Styrofoam	NA	BE	NA	NA	BE	BE	NA	BE	BE	LY	NA	BE		NA	BE

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i.[14].https://www.sprep.org/news/sprep-to-provide-support-to-kiribatis-single-use-plastic-reduction-priorities/ ***Customs Act 2019 (Act No.8 of 2019)***

15 *Waste Management (Prohibition on the Importation of Single Use Plastics) Regulation 2019.*

16 *https://tvniue.com/2020/03/niue-bans-importation-of-plastic-shopping-bags/*

17 *Environmental Management and Climate Change (Ban on Single Use Plastic Shopping Bags) Regulations 2021*

18 *Styrofoam Cups and Plates, and Plastic Products Prohibition and Container Deposit Act 2016.*

19 *Prohibition on the importation 4 of one-time-use disposable Styrofoam and plastic food service 5 items and plastic shopping bags.*

20 *Plastic Bag Use Reduction Act 2017 (RPPL No. 10-14).*

21 *Environment (Single Use Plastic Ban) Regulations 2023*

22 *Waste Management (Plastic Ban) Regulation 2018*

23 *Waste Management (Plastic Levy) Regulations 2013*

24 *https://library.sprep.org/sites/default/files/2023-05/plastic-pollution-laws-legislation-timor-leste.pdf*

25 *Environment Management (Amendment) Act 2020.*

26 *https://www.postcourier.com.pg/total-ban-on-plastic-bags-to-come-into-effect-jan-2020/*

27 *Prohibition on Importation of Plastic Shopping Bags Regulation 2012.*

28 *Order 15 (Waste Management Regulations), issued under the Waste Management Act No. 24 of 2014,*

	Key Plastic Items	Details	Kiribati [14]	Tuvalu [15]	Niue [16]	Nauru [17]	RMI[18]	FSM[19]	Palau [20]	Solomon Islands [21]	Samoa[22]	Tonga [23]	Timor Leste [24]	Fiji[25]	PNG[26]	Cook Islands [27]	Vanuatu [28]
	1.4. Food trays / plates	Plastic	NA	BE	NA	NA	BE	BE	NA	BE	NA	NA	NA	BE	NA	NA	BE
		Styrofoam	NA	BE	NA	NA	BE	BE	NA	BE	BE	NA	NA	BE	NA	NA	BE
	1.5. Cutlery	Spoons, Knives, Forks,	NA NA NA	BE BE BE	NA NA NA	NA NA NA	NA NA NA	BE BE BE	NA NA NA	BE BE BE	NA NA NA	NA NA NA	NA NA NA	BE BE BE	NA NA NA	NA NA NA	BE BE BE
		Chopsticks	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Stirrers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	BE
2.	2.1. Shopping	Plastic	BE	BE	BE	BE[29]	BE	BE[30]	BE[31]	BE	BE	LY	BNE	BE[32]	BNE	BE[33]	BE[34]
		Nylon net	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA	NA	NA	BE
	.2. Packing for food safety	Agriculture products	NA	SE	NA	NA	NA	SE/NA	NA	NA	SE/NA	SE/NA	NA	SE/NA	NA	NA	BE
		Bakery products	NA	SE	NA	NA	NA	SE/NA	NA	NA	SE/NA	SE/NA	NA	SE/NA	NA	NA	SE/NA
		Freezer goods	NA	SE	NA	NA	NA	SE/NA	NA	NA	SE/NA	SE/NA	NA	SE/NA	NA	NA	SE/NA
		Ice blocks	BE	BE	NA	NA	NA	NA	NA	NA	SE/NA	SE/NA	NA	SE/NA	NA	NA	NA
		Local chips	NA	SE	NA	NA	NA	NA	NA	NA	SE/NA	SE/NA	NA	SE/NA	NA	NA	NA
		Sugar, salt, flour, etc.	NA	SE	NA	NA	NA	NA	NA	NA	SE/NA	SE/NA	NA	SE/NA	NA	NA	NA

29 *Reusable, degradable and compostable bags are exempted and allowed.*

30 *Below 35microns are banned. Recyclable and reusable bags above 35microns thickness are exempted, including compostable bags.*

31 *Compostable and Biodegradable Bags are exempted and allowed to import.*

32 *Below the 35 microns thickness are banned.*

33 *Only biodegradable shopping bags allowed based on set specifications.*

34 *Below the 35 microns thickness are banned.*

	Key Plastic Items	Details	Kiribati [14]	Tuvalu [15]	Niue [16]	Nauru [17]	RMI [18]	FSM [19]	Palau [20]	Solomon Islands [21]	Samoa [22]	Tonga [23]	Timor Leste [24]	Fiji [25]	PNG [26]	Cook Islands [27]	Vanuatu [28]
	2.3. Waste Care	Rubbish bags	NA	SE	NA	NA	NA	NA	NA	NA	SE/NA	NA	NA	SE/NA	NA	NA	NA
	2.4. Health care	Specific bags	NA	NA	NA	NA	NA	NA	NA	NA	SE/NA	NA	NA	NA	NA	NA	NA
OTHER	3.1. General protection cover	Food wrapping	NA	BE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Construction purposes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Furniture cover	NA	BE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PRODUCTS	4.1 Personal care & use	Nappies	BNE	LY	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Pads	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Tampons	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Cotton buds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Wet wipes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Flags	NA	BE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Artificial flower	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	BE
		Water & beverages	CDL	CDL/BE [35]	NA	NA	CDL	CDL	CDL	BE [36]	NA	LY	NA	NA	NA	NA	NA

[35] *Water and drinks come in less than 1.5L plastic bottles are banned. All imported bottles pay a 10cent waste levy deposit.*

[36] *Water and drinks less than 1.5L are banned.*

Appendix D: Detailed list of biodegradable plastics

Base	Polymer	Common feedstock/ raw material	Home compostability	Description
Sugar-based	Polymers made of sugar-rich crops such as sugarcane or sugar beets			
	Polyethylene Furanoate (PEF)	Fructose from sugarcane, corn, or other biomass	No	PEF is a biopolymer made from plant-based sources, and it is considered a potential alternative to traditional PET (polyethylene terephthalate) in beverage bottles. The biodegradability of PEF depends on specific conditions and the presence of suitable microorganisms. In industrial composting facilities with controlled conditions, PEF may undergo biodegradation more readily than in natural environments. However, in traditional waste disposal environments, such as landfills or the natural environment, PEF may persist for a long time, similar to PET.
Starch-based	Polymers derived from crops like corn, potatoes, or cassava			
	Polylactic Acid (PLA)	Corn, sugar beet, potatoes, wheat, maize and tapioca	No	PLA is derived from renewable resources such as corn starch or sugarcane. It is commonly used in packaging materials, disposable cutlery, and compostable bags. PLA is suitable for home composting under certain conditions.
	Thermoplastic Starch (TPS)		Yes	TPS is a biodegradable polymer made by plasticizing starch, often with the addition of plasticizers or other biodegradable polymers.
Cellulose-Based Polymers	Obtained from cellulose, which is the main component of plant cell walls			
	Paper and Cardboard		Yes	Paper and cardboard are natural and home compostable materials. They are widely used for packaging and disposable items.
	Bamboo Fiber		Yes	Products made from bamboo fibers, such as plates, cups, and utensils, are often marketed as biodegradable and can be suitable for home composting.
	Sugarcane Bagasse		Yes	Bagasse, the fibrous residue left after extracting juice from sugarcane, is used to make biodegradable plates, bowls, and containers. These products are often compostable in home compost systems. It is primarily made of cellulose, but contains hemicellulose and lignin.
	Cotton and Linen		Yes	Natural fibers like cotton and linen can be composted at home. Compostable cotton and linen items include towels, napkins, and certain types of clothing.
	Cellulose acetate		No	Biodegradable polymer used in certain films and coatings.
Lignin-Based Polymers	Derived from lignin, a complex polymer found in the cell walls of plants			
	Lignin-based polyurethane		n/a	Lignin-based polyurethanes are synthesized by combining lignin with diisocyanates and polyols. The lignin component is typically derived from lignocellulosic biomass, such as wood or agricultural residues. The resulting polymer can exhibit biodegradable properties, making it environmentally friendly compared to traditional petroleum-based plastics.

Base	Polymer	Common feedstock/ raw material	Home compostability	Description
Protein-Based Polymers	Derived from proteins found in plants or animals			
	Zein			protein found in corn, can be used to produce biodegradable films
	Soy Protein-Based Polymers			Soy protein, derived from soybeans, has been investigated for its potential use in biodegradable materials. It can be processed into films, coatings, and other forms to create biodegradable packaging materials. Soy protein-based polymers are renewable and can contribute to reducing the environmental impact of packaging waste.
	Wheat Gluten-Based Polymers			Wheat gluten, a protein obtained from wheat, is another example of a protein-based polymer. It has been used in the development of biodegradable plastics and packaging materials. Wheat gluten-based polymers can be processed to form films and coatings, offering a sustainable alternative to conventional plastics.
	Casein-Based Polymers			Casein is a protein found in milk, and it has been explored for the production of biodegradable materials. Casein-based polymers can be used to create films and coatings that are edible, making them suitable for food packaging applications. These materials are not only biodegradable but also offer the potential for reduced food waste by providing edible and protective coatings for perishable goods.
Algae-Based Polymers	Derived from algae, which are photosynthetic microorganisms			
	Algae-Derived Polysaccharides			Algae, particularly certain types of seaweed, contain polysaccharides that can be extracted and processed into biodegradable materials. Alginate, for example, is a polysaccharide found in brown algae and has been investigated for its potential use in various applications, including biodegradable packaging.
	Algae-Based Polyhydroxyalkanoates (PHA)			Some types of microalgae have been researched for their ability to accumulate polyhydroxyalkanoates (PHA), which are biodegradable polyesters. PHA can be extracted from the algae and processed into biodegradable plastics. Algae-derived PHA has the advantage of being produced using photosynthesis, making it a renewable and potentially sustainable feedstock.
Microbial polymers	Microbially synthesized polymers			
	Polyhydroxyalkanoate (PHA) (polyester)			PHA is a family of biodegradable polymers produced by microorganisms. These polymers can be derived from renewable resources and have applications in packaging, disposable items, and agricultural films. Products made from PHA, like compostable food containers and utensils, can be home compostable.
	Polyhydroxybutyrate (PHB)			PHB is a type of biopolymer that belongs to the family of polyhydroxyalkanoates (PHAs). PHB is produced by certain bacteria as a storage material when they are in conditions of nutrient imbalance, particularly when there is an excess of carbon and a limitation of other nutrients like nitrogen or phosphorus.
	Polybutylene Succinate (PBS)			PBS is a biodegradable polyester that can be derived from renewable resources like succinic acid and 1,4-butanediol. It is used in packaging, agricultural films, and other disposable items.

Base	Polymer	Common feedstock/ raw material	Home compostability	Description
Mycelium-based	Made of mycelium, which is the root structure of fungi. Specifically, the mycelium of certain fungi, such as mushrooms, can be grown and cultivated to form a network of tiny threads. This mycelium network can be combined with agricultural waste, such as corn stalks or husks, to create a composite material.			
	Mycelium-based composites	agricultural waste, such as corn stalks or husks		The process generally involves inoculating the agricultural waste with fungal spores and providing the right conditions for the mycelium to grow and bind the material together. Over time, the mycelium consumes and transforms the waste into a durable and biodegradable material that can be molded into various shapes to serve as a sustainable alternative to traditional plastics.
Vegetable Oils & Fats-Based Polymer	Derived from natural oils and fats, often from crops like soybean, palm, or canola.			
	Polyurethane from vegetable oil polyols			
BLENDS	Mix of 2 or more materials			
	Starch-Polyvinyl Alcohol (PVA) Blends			Blending starch with PVA can create materials with improved biodegradability. PVA is water-soluble and can enhance the overall performance of the blend.
	Polybutylene adipate terephthalate (PBAT)	plant-derived sugars or other biomass		PBAT) is a type of biodegradable polyester that is commonly used in the production of biodegradable plastics. PBAT is a copolymer, meaning it is composed of different monomers. In the case of PBAT, the main monomers are 1,4-Butanediol (B), Adipic Acid (A) and Terephthalic Acid (T).
	Starch-Polyethylene Blends			Blending starch with traditional polyethylene can result in materials with improved biodegradability compared to pure polyethylene.
	Algae-Blended Bioplastics			Algal biomass or extracts can be blended with other biodegradable polymers to enhance their properties and biodegradability. For example, blending algae-derived components with traditional biopolymers like polylactic acid (PLA) or polyhydroxyalkanoates (PHA) may result in biodegradable materials with improved performance and reduced environmental impact
Other (various)				
	Polyglycolic Acid (PGA) (polyester)	glycolic acid molecules from various feedstock		PGA is a biodegradable polymer often used in medical applications such as absorbable sutures. It can be derived from renewable resources like glycolic acid
	Polycaprolactone (PCL) (polyester)	ε-caprolactone from various feedstock		PCL is a biodegradable polyester that can break down in home composting conditions. It is used in applications like compostable cutlery and packaging.
	Polyvinyl Alcohol (PVA) (polyvinyl ester)			PVA is a water-soluble polymer that is often used in applications like water-soluble films and packaging. It can be biodegradable under certain conditions.

Appendix E: A list of standards relevant to bio-based materials and plastics.

Standard	Description	Organisation
	BIOPLASTICS AND GENERAL	
Biobased content		
EN 16640	Biobased products – Determination of the biobased carbon content of products using the radiocarbon method. It describes how to measure the carbon isotope 14C (radiocarbon method).	CEN
EN 16785-1	Biobased products – Biobased content – Part 1: Determination of the biobased content using the radiocarbon analysis and elemental analysis. It accounts for other biobased elements in a polymer through elemental analysis.	CEN
EN 16785-2	Biobased products – Biobased content – Part 2: Determination of the biobased content using the material balance method", describes a material balance method to determine the renewable content of a biobased product.	CEN
Sustainability and Life Cycle Assessment (LCA)		
ISO 14040	Environmental management - Life cycle assessment - Principles and framework	ISO
ISO 14044	Environmental management - Life cycle assessment - Requirements and guidelines	ISO
ISO 14067	Carbon Footprint of Products", providing detailed information on how to measure and report the carbon footprint of products	ISO
ISO 22526	Carbon and environmental footprint of biobased plastics	ISO
EN 16760	Biobased products - Life Cycle Assessment, provides specific LCA requirements and guidance for biobased products based on the ISO 14040 series.	CEN
	BIODEGRADABLE PLASTICS	
Industrial composting and anaerobic digestion		
ISO 18606	Packaging and the environment – Organic Recycling	ISO
ISO 17088	Specifications for compostable plastics	ISO
ISO 15985	International standard for products suitable for anaerobic biodegradation	ISO
AS 4736-2006	Biodegradable plastics suitable for composting and other microbial treatment	AS
ASTM D5511-18	Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under High-Solids Anaerobic-Digestion Conditions	ASTM
ASTM D5526-18	Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under Accelerated Landfill Conditions	ASTM
ASTM D6400-21	Standard Specification for Labeling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities	ASTM
ASTM D6868	Standard Specification for Labeling of End Items that Incorporate Plastics and Polymers as Coatings or Additives with Paper and Other	ASTM

Standard	Description	Organisation
	Substrates Designed to be Aerobically Composted in Municipal or Industrial Facilities	
EN 13432: 2000	Packaging: requirements for packaging recoverable through composting and biodegradation	CEN
EN 14995	This standard describes the same requirements and tests as EN 13432, while applying not only to packaging but plastics in general	CEN
DIN V 54900-1	Testing of compostability - Determination of disintegration of plastics under simulated composting conditions in a laboratory-scale test (industrial composting)	DIN
Home composting		
ISO 17088:2021	Plastics — Organic recycling — Specifications for compostable plastics	ISO
AS 5810	Biodegradable plastics – biodegradable plastics suitable for home composting	AS
ASTM WK35342	Specification for Home Composting of Biodegradable Plastics	ASTM
EN 17427	Packaging - Requirements and test scheme for carrier bags suitable for treatment in well-managed home composting installations	CEN
OK compost home	Certification scheme that requires at least 90% degradation in 12 months at ambient temperature	TÜV AUSTRIA, Belgium
NF T51-800	“Plastics — Specifications for plastics suitable for home composting	AFNOR
Biodegradability in aqueous environments		
ISO 16221	Water quality – Guidance for determination of biodegradability in the marine environment	ISO
ISO 18830:2016	Determination of aerobic biodegradation of non-floating plastic materials in a seawater/sandy sediment interface. Method by measuring the oxygen demand in closed respirometer	ISO
ISO 19679:2020	Determination of aerobic biodegradation of non-floating plastic materials in a seawater/sediment interface. Method by analysis of evolved carbon dioxide	ISO
ISO 22766	Standard for the disintegration test of plastic materials in marine habitats under real field conditions	ISO
ISO 22403	Standard that includes test methods and requirements of the inherent aerobic biodegradability and environmental safety.	ISO
ISO 14851: 2019	Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium. Method by measuring the oxygen demand in a closed respirometer	ISO
ASTM D7081	Standard Specification for Non-Floating Biodegradable Plastics in the Marine Environment” has been withdrawn in 2014 without replacement	ASTM
ASTM D6691	Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials in the Marine Environment by a Defined Microbial Consortium or Natural Sea Water Inoculum	ASTM
ASTM D6692	Standard Test method for Determining the Biodegradability of Radiolabelled Polymeric Plastic Materials in Seawater	ASTM
ASTM D7473	Standard Test Method for Weight Attrition of Plastic Materials in the Marine Environment by Open System Aquarium Incubations	ASTM
OECD 306	Biodegradability in sea water	OECD

Standard	Description	Organisation
Biodegradability in soil		
ASTM WK29802	New Specification for Aerobically Biodegradable Plastics in Soil Environment.	ASTM
EN 17033	Biodegradable mulch films for use in agriculture and horticulture – Requirements and test methods. It specifies the requirements for biodegradable films, manufactured from thermoplastic materials, to be used for mulching applications in agriculture and horticulture, which are not intended to be removed from the field. A degradation of at least 90% in two years at preferably 25°C is required.	CEN
OK biodegradable SOIL	The certification scheme "Bio products – degradation in soil" is based on EN13432/EN14995 (Standards for the industrial composting of packaging/plastics) and adapted for the degradation in soil. The test demands at least 90% biodegradation in two years at ambient temperatures.	TÜV AUSTRIA Belgium