SMEP

Sustainable Manufacturing and Environmental Pollution Programme

OPPORTUNITIES FOR PLASTIC SUBSTITUTION IN CRITICAL ECONOMIC SECTORS OF DEVELOPING COUNTRIES

Summary and recommendations

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Lia Tostes designed the report, and Lahiru Iddamalgoda, whose photo is featured on Unsplash, took the cover photo.

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1.

Introduction

Plastic pollution poses significant threats not only to environmental health but also to human well-being and economic stability. For instance, emerging research has detected microplastics in **human blood and brain tissues**, raising concerns about potential long-term health effects. In marine ecosystems, **plastic debris endangers wildlife** and incurs substantial costs for pollution management, with **global ecosystem damage estimated at approximately US$2.2 trillion annually**. Despite numerous international initiatives **to govern plastic materials**, critical issues persist, mainly due to the expanding production of plastics, prevalent single-use packaging, and low recycling and recovery rates in most countries. These challenges underscore the urgent need for a **transition to circular economy** practices anchored in waste hierarchy principles, as well as the **adoption of sustainable materials**.

This is a summary of a longer report exploring **potential alternatives to conventional plastics** in three sectors central to the economies of many developing nations: **food export packaging, fishing gear**, and **agricultural applications**. Through **case studies in Ghana**, **Nigeria**, **Fiji**, and **Kenya**, this analysis identifies **promising substitutes and alternatives**, from natural fibres to biobased polymers, which may offer **reduced environmental impact** while supporting **economic growth and diversification** in these regions. However, the adoption of these substitutes or alternatives is **hindered** by **infrastructural limitations** and the **lack of standardised definitions and material standards**. **Recommendations** emphasise sector-specific interventions to promote the **shift away from plastic reliance**, grounded especially in **local resources and innovations**.

↓ Image 1. A pallet of goods in boxes, prepared for export, and wrapped in plastic film, in a warehouse

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↓ Image 2. Compacted secondary packaging cardboard boxes, 2017

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2.

Packaging for food exports

The widespread adoption of plastics has dramatically transformed the food packaging industry, improving food safety, distribution efficiency, and product longevity. This transformation has facilitated **long-range trade of food products**, allowing goods to reach global markets and meet growing consumer demand. Plastic packaging has become a critical component in the food sector by **shielding products from contamination and spoilage** throughout the supply chain.

Packaging serves multiple purposes, from **preserving product quality** to **ensuring accessibility** for consumers with varying needs. **Sustainable packaging**, however, must prioritise **material efficiency, hazard elimination, and recyclability**, aligning with goals of **environmental conservation and public health**. Achieving these aims in developing economies requires a careful balance between **efficiency and environmental stewardship**. This also involves drawing on a **broader array of approaches, including traditional and Indigenous knowledge systems**, to enhance food protection and reduce waste in a contextually relevant manner.

Understanding the different levels of packaging — primary, secondary, and tertiary — is essential for designing sustainable supply chains. Each level of packaging has a distinct function, with **primary packaging** focusing on direct **product preservation**, while **secondary and tertiary packaging** support **transportation and storage**, minimising waste and preserving food quality from environment stressors and physical damage along the logistics chain. **Adopting a life cycle** perspective ensures that packaging solutions are sustainable and do not inadvertently harm the environment. This comprehensive view is particularly important as developing economies integrate **best practices in sustainable packaging**.

2.1. An example of cocoa in Ghana and Nigeria

Plastic packaging presents both opportunities and challenges in **Ghana and Nigeria**, two key players in the **global cocoa market**. Both countries face **socioeconomic challenges**, such as high poverty rates and inadequate waste management infrastructure, which affect the sustainability of their cocoa export packaging. For instance, **raw cocoa beans** are typically transported in **jute bags lined with plastic for added protection**. In contrast, **processed cocoa products** like butter and powder rely heavily on plastic packaging to maintain quality during transport.

A range of **sustainable packaging** alternatives are being explored to address these challenges. **Biodegradable liners for jute bags, recyclable aluminium containers, compostable sacks, and moulded pulp containers** offer viable substitutes for conventional plastics in those applications. Additionally, innovative materials such as **seaweed-based bioplastics, mushroom-based packaging, and biodegradable options** derived from **areca, banana leaves, hemp, and bamboo** show promise for **reducing the environmental impact of cocoa packaging**.

Circular economy policies, such as **Extended Producer Responsibility (EPR) legislation** and **government incentives** for biodegradable packaging, can further encourage sustainable practices. Furthermore, **South-South collaborations**, particularly with traditional natural fibre producers like **Bangladesh**, hold the potential to foster **jute-based biopolymer development** and **active packaging solutions**. These partnerships could be crucial in transitioning to **more sustainable packaging solutions** tailored to developing countries' specific needs and resources.

3.

Fishing nets and fishing gear

↑ Image 3. Abandoned, lost, or discarded fishing gear is a major source of plastic debris in the oceans

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The use of plastics in fishing nets and gear has substantially enhanced durability and efficiency within the fishing industry, yet it has also contributed significantly to marine pollution. Abandoned, lost, or discarded fishing gear, often termed "ghost gear," is a major source of **plastic debris** in the oceans, endangering marine ecosystems and biodiversity. For regions with an economy that heavily relies on **fishing and tourism**, the impact of plastic pollution on marine environments is particularly acute.

Historically, **fishing gear was crafted from natural fibers** like sisal, hemp, wood, and cork. However, with the advent of **synthetic plastics**, the industry shifted to materials that provided **greater durability and efficiency** but came with **environmental drawbacks**. Today, **biodegradable alternatives for fishing gear** are emerging, though challenges remain, particularly the need to **align costs and degradation rates** with practical operational requirements in the marine environment. These solutions aim to ensure both **ecological safety** and **operational efficiency** in fishing operations.

To achieve meaningful progress, **establishing biodegradation standards** that reflect the specific conditions of the fishing industry is essential. This would not only support the adoption of biodegradable materials but also help reduce environmental harm. Furthermore, emphasis should be put on the importance of **tracking and documenting gear loss** through s**ystematic collection efforts**, which could foster a culture of **environmental stewardship and responsibility** within the fishing industry.

3.1. An example from Fiji and the South Pacific

Recent **waste audits** from the **South Pacific Regional Environment Programme (SPREP)** and the **International Union for Conservation of Nature (IUCN)** reveal an urgent need for **improved waste management infrastructure** and robust **recycling schemes** in Fiji to mitigate these escalating challenges. **Introducing policies** that promote **community waste accountability** and global cooperation to reduce marine debris could play a pivotal role in curbing plastic waste in marine environments.

Promising material innovations for sustainable fishing gear include **biodegradable polymers and bioblends**, which can decompose safely within marine environments without harming wildlife. Efforts to **recycle abandoned fishing nets** and **promote local innovations**, such as bioblend research at universities, could further support Fiji's **blue economy ambitions, aligned with its environmental goals**. Additionally, **integrating tracking mechanisms** like **GPS** and **gear marking** could enhance gear management and minimise losses, contributing to reduced marine pollution.

To advance these sustainable practices, **transparent partnerships and collaborative efforts** will be needed to address technical, intellectual property, and cost barriers. By implementing **maintenance and reporting systems** for gear, and supporting **biodegradability standards** tailored to local contexts, Fiji and similar regions can significantly **reduce the negative impacts of plastic fishing gear** while supporting sustainable fishing operations.

4.

Agricultural mulch and seedling tubes

↑ Image 4. A plantation supported by SMEP project FreshPPact utilizes biodegradable mulch film

© FreshPPact

Plastic mulch films have become essential in agriculture for enhancing crop productivity through improved soil water retention, temperature control, and weed suppression. However, their disposal poses significant challenges. When left in fields, these films can fragment into microplastics, contributing to persistent soil pollution and potentially contaminating underground water sources. Retrieval is costly, often resulting in these films being landfilled, incinerated, or left to degrade in the soil.

Potential substitutes for plastic mulches include **organic mulching practices** and **biodegradable mulch films (BDMs)**. Organic mulching, utilising crop residues, is plastic-free and supports climate-smart agricultural practices, while BDMs offer a biodegradable option that removes the need for retrieval. However, BDMs come with trade-offs:

- Advantages: BDMs reduce labour and disposal costs by decomposing naturally, offering a lower-impact alternative to conventional plastic.
- Drawbacks: BDMs degrade at variable rates depending on soil, climate, and crop type, which can sometimes result in incomplete decomposition and microplastic buildup in the soil. In some cases, BDMs may also release chemicals like traditional plastics.

4.1. An example from Kenya' agricultural sector

In Kenya, agriculture contributes substantially to the economy, representing a third of the GDP and 60% of export earnings. Both commercial and small-scale farmers increasingly use plastic mulch and seedling tubes, particularly in horticulture, which accelerates land degradation and threatens long-term soil health.

Kenya's **abundance of crop residues** provides an **opportunity to transition to organic mulching**, improving soil health and enhancing carbon sequestration. This approach considers crop residue availability, existing uses, and local production capacity. While BDMs offer a secondary option to organic mulch, establishing clear agriplastic standards is essential to ensure their safety and effectiveness in sustainable farming.

Additionally, **cellulose-based products and crop residues are viable substitutes for plastic seedling tubes**. These alternatives are essential for reforestation efforts and help mitigate the environmental impact of plastic seedling bags when improperly discarded.

5.

Key findings

A. Packaging for food exports

The global market for **plastic substitutes** is maturing, valued at $388 billion in 2020. However, challenges persist, particularly in Africa, where plastic waste remains a significant issue due to weak enforcement and limited alternatives. Efforts such as **plastic bag bans** in Nigeria and Ghana during the mid-2010s demonstrate regional actions to reduce pollution from packaging, yet more comprehensive policies are needed. **Extended Producer Responsibility (EPR)** and **Deposit Return Schemes (DRS)** offer promising strategies, urging businesses to take greater responsibility for managing the life cycles of product packaging.

In Ghana, the cocoa supply chain has the potential to utilise **cocoa waste** as a sustainable packaging material, aligning with global sustainability goals and potentially offering a competitive edge as markets impose stricter controls on plastic use. Such initiatives illustrate how **local agricultural residues** can serve as **viable feedstock for non-plastic substitutes**, offering dual benefits of waste reduction and sustainable packaging innovation.

B. Fishing nets and fishing gear

Several regions' reliance on both **fisheries and tourism** highlights the urgency for sustainable practices in marine industries. With the fisheries sector facing downturns due to COVID-19, including reduced fishing and tourism activities, the need for innovative, sustainable solutions has become more pressing in the sector. Indirect measures like **GPS tracking, gear marking**, and **waste collection programs** could help reduce marine pollution by minimising gear loss.

Developing **biodegradable fishing gear** that meets local biodegradability standards can also help and align with conservation goals and support economic development in countries such as Fiji. Additionally, promoting r**ecycling initiatives for abandoned nets** and expanding **seaweed cultivation** in coastal areas could stimulate local economies. Supporting **research** into bioblend materials and enhancing recycling facilities are key actions for transitioning toward sustainable fishing practices.

C. Agricultural mulch and seedling tubes

Substitutes for plastic mulch, such as **organic mulching** and **BDMs**, offer practical options for reducing plastic use in agriculture. Organic mulching, using crop residues, improves soil health and supports carbon sequestration.

Kenya's abundant agricultural residues make organic mulching a viable alternative, yet improved **waste management policies** and infrastructure are needed to maximise their use. Examples of effective policies include **incentives for crop residue collection** and **subsidies for composting infrastructure** to promote better recovery and utilisation of these materials.

For seedling tubes, **cellulose-based products** and agricultural waste can serve as low-impact alternatives, reducing reliance on plastic in reforestation efforts. New business models, such as those utilising **agrimats from organic waste materials**, present promising pathways to meet conservation and sustainable agriculture goals in countries such as Kenya.

6.

Recommendations

Considering these findings, key recommendations include:

- Promoting organic mulching practices that leverage locally available crop residues.
- Supporting the development of standards for biodegradable and compostable plastics to guide sustainable agricultural practices.
- Encouraging the adoption of EPR and DRS for food packaging to ensure accountability in the supply chain.
- Enhancing recycling and transformation infrastructure and offering incentives for recovering and repurposing agricultural residues.
- Facilitating local production of mulch substitutes and seedling container alternatives to reduce plastic dependency in agroforestry sectors.

These approaches emphasise localised solutions, regulatory support, and cross-sector collaborations, each essential for building sustainable practices in key economic sectors common to many developing countries, supporting and promoting synergies between economic and environmental goals.