Sustainable Manufacturing and Environmental Pollution Programme

BEYOND PLASTICS

A review of trade-related policy measures on non-plastics substitutes

April **2024**

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This study is a product of the Sustainable Manufacturing and Environmental Pollution (SMEP) Programme. It also benefitted from inputs by the UNCTAD Oceans Economy and Fisheries Programme. It was prepared by Lorenzo Formenti, David Vivas-Eugui, Henrique Pacini and Glen Wilson (UNCTAD), under the supervision and guidance of Chantal Line Carpentier, Head of the Trade, Environment, Climate Change and Sustainable Development Branch, UNCTAD. This paper benefitted from comments from Glen Wilson, Daniel Ramos (WTO), Mahesh Sugathan (Forum on Trade, Environment, & the SDG (TESS) and Ieva Baršauskaite (International Institute for Sustainable Development (IISD). The authors are grateful to Nicole Unger, Life Cycle Assessment Expert, for technical input provided in the writing of section 3.

The SMEP Programme is funded by the United Kingdom's Foreign, Commonwealth & Development Office (FCDO) and the Oceans Economy Programme receives support from the Government of Portugal. Desktop formatting was done by Rafe Dent and Lia Tostes, UNCTAD. Cover art was prepared by Lana Barcellos.

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Abbreviations

EPR	Extended product responsibility
EPS	Expanded polystyrene
EPRC	European Paper Recycling Council
FMCGs	Fast moving consumer goods
GHG	Green House Gas
HDPE	High-density polyethylene
IISD	International Institute for Sustainable Development
INC	Intergovernmental Negotiating Committee on Plastic Pollution
ITC	International Trade Centre
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LDPE	Low-density polyethylene
LDC	Least Developed Country
LCA	Life Cycle Assessment
MSMEs	Micro, small and medium-sized enterprises
OECD	Organisation for Economic Co-operation and Development
PET	Polyethylene Terephthalate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonic acid
SMEP	Sustainable Manufacturing and Environmental Pollution Programme
TESS	Forum on Trade, Environment, & the SDG
TrPMs	Trade-related policy measures
WTO	World Trade Organization
WTO DPP	WTO Dialogue on Plastics Pollution and Environmentally SustainaOrganisation for Economic Co-operation and Development
WTO EDB	WTO Environmental Database
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme

Executive Summary

Trade-related policy measures targeting non-plastic substitutes have proliferated in recent years, impacting international trade. These measures encompass rules and support mechanisms, reflecting increased regulatory focus on sustainability and health aspects. Members of the World Trade Organization (WTO) have reported various measures aimed at non-plastic substitutes, including materials like paper, glass, and natural fibres (such as bamboo, cotton, jute, and wool). These policies establish regulations throughout the life cycle, from raw material supply to end-of-life, and target products and by-products with high substitution potential.

While notifications related to non-plastic substitutes have grown exponentially between 2009 and 2021, they remain slower than plastic-related notifications but faster than those with environmental objectives. Measures span environmental requirements, technical standards, and market-based support, with developing countries emphasizing technical standards and developed economies favoring active support measures like tax concessions and grants.

In multilateral United Nations and WTO discussions on plastic pollution, the "sustainability, safety, and efficacy" of non-plastic substitutes are actively debated. The notification texts do not contain specifications that allow the sustainability, safety, and effectiveness of non-plastic substitutes to be assessed from a technical point of view. However, the objectives and descriptions of the measures, which in some cases are provided by the notifying parties in standard formats, give precise indications of the rationale and ambition of certain measures.

Environmental requirements are the most common type of measures, accounting for 86 per cent of the notified policies. Technical standards or specifications are more common in developing countries, which tend to regulate substitution trade more defensively. In contrast, active support measures such as tax concessions and grants are more common in developed economies.

Material functionality aspects of non-plastic and Life Cycle Analysis (LCA) considerations are rarely mentioned WTO in notifications. However, more than half of the notified measures contain environmental sustainability, health, and safety objectives.

While there are many non-plastic substitutes with high substitution potential, none are intrinsically better or worse than plastics. Substitution is context specific and depends on a number of interrelated socio-economic and environmental factors. These include the end use of a product, material properties, efficiency and substitution ratios, location and proximity between production and consumption, end-of-life scenarios (e.g. regulations, infrastructure, etc.), and producer and consumer responsibility.

There are several tools that aim at facilitating the broad applicability of LCA analysis and findings based on available data. For instance, UNCTAD has developed a Trade and Pollution Dashboard, which enables comparative LCA of plastics, plastic alternatives, and non-plastic substitutes. It facilitates decision-making on the different environmental impacts of exports by region or country, by material, by product or by type of impact.

Finally, while trade-related policy measures notified serve as binding legal instruments shaping standards and market development for non-plastic substitutes, their diversity generates regulatory fragmentation challenges to multilateral efforts for a transition away from plastics. Simplification and harmonization of rules should be prioritized in discussions within forums like the United Nations Intergovernmental Negotiating Committee on Plastic Pollution (INC), WTO Dialogue on Plastics Pollution and Environmentally Sustainable Plastics Trade (WTO DPP) and UNCTAD's Trade and Environment Expert meetings.

1.

Introduction

Plastics is omnipresent in the global economy and value chains, having become a fundamental enabler of human economic activity. Their relatively low cost and versatile properties such as durability, lightweight and mouldability have contributed to their widespread adoption across all regions, with applications ranging from packaging for fast moving consumer goods (FMCGs) to essential product components. It is now hard to imagine a world without plastics and in the absence of sound policies, plastics use is projected to triple by 2060 (OECD, 2022).

Unsurprisingly, global trade in plastics, including raw materials, plastic end-products, and waste, has soared in recent years, reaching unprecedented levels. Its value is estimated to have doubled in the last 15 years, from US$600 billion in 2006 to US$1.2 trillion in 2021; an amount only slightly less than the value of China's merchandise exports. Volume growth has followed a similar but slower path, rising from 232 million tonnes in 2005 to 369 million tonnes in 2021 (UNCTAD, 2023a).

With plastics trade accounting for over 5 per cent of global merchandise trade in 2021, plastics are an important determinant of socio-economic development. While a few countries, such as China, the United States, Germany, Thailand and South Korea dominate plastics exports, several economies rely on plastics as a means of accessing global supply chains and adding value domestically (Barrowclough, Deere Birkbeck and Christen, 2020, UNCTAD, 2023a,).

While plastics have become a key enabler of human economic activity, they have also raised environmental and health concerns due to the challenges associated with their disposal. Plastics are difficult to break down and, in the absence of sound waste management, persist in the environment causing system-wide pollution problems that are now well known. Examples include but are not limited to municipal solid waste consisting of food packaging and plastic bottles and the contamination of oceans (and blood streams) by microplastics such as those embedded in textiles and cosmetics. It is estimated that even with immediate and concerted action, vast amounts of plastic waste will keep entering aquatic and terrestrial ecosystems in 2040 (Winnie, Lau et al., 2020).

Against this backdrop, countries are being urged to move towards a “smart plastics economy” that reduces the excessive and polluting use of plastics and focuses on sustainable material with properties that made plastic omnipresent. This involves, inter-alia, managing domestic production and use in a way to maximize socio-economic benefits while reducing environmental and health externalities. However, with low recycling rates and end-of-life systems and infrastructure not keeping pace with material innovation, the transition is not automatic and poses unprecedented challenges (WEF, 2016).

Non-plastic substitutes are any natural materials of mineral, plant, animal, marine or forestry origin that have similar properties to plastics - excluding fossil fuel-based or synthetic polymers - bioplastics, and biodegradable plastics. They can play an important role in the global materials system, if conditions of biodegradability, suitability for reuse, recycling and disposal are met (UNCTAD, 2023b). They can also be important drivers of socio-economic development and sustainability transitions in many developing countries, including in sub-Saharan Africa and South Asia (UNCTAD, 2022a).

International trade can help reduce plastic pollution through access to substitute goods and innovative technologies and by supporting the harmonization of rules that underpin a smart plastics economy. As plastic pollution becomes one of the most important environmental issues of the modern era, non-plastic substitutes are moving up the trade and environment agenda (Sugathan and Deere Birkbeck, 2023; UNCTAD, 2022b). Key multilateral initiatives, such as the WTO DPP and INC, are increasingly including substitution needs in programmatic documents and negotiating texts.

To realize the full potential of non-plastic substitutes, a significant shift in investment is needed away from fossil fuel-based technologies for the production and conversion of virgin plastics towards substitution-driven business models (The Pew Charitable Trusts and SYSTEMIQ, 2020; UNCTAD, 2023b). This shift will require rapid and globally coordinated policy actions to set new standards and provide incentives that maximize new socio-economic benefits and minimize environmental trade-offs in nascent green industries.

In this context, a sound understanding of the plethora of standards, technical requirements and policy incentives currently affecting trade in non-plastic substitutes is paramount.

To fill this gap, this study analyses trade-related policy measures that currently apply to a relevant set of non-plastic substitutes that can replace plastics in various functions. These include, but are not limited to, wood pulp and paper, aluminium, glass, and natural fibres such as cotton and bamboo. The study builds on UNCTAD's mapping of trade-related policy measures on plastics (UNCTAD, 2020). It also complements findings of the survey of trade-related measures relevant to plastic pollution conducted by the coordinators of the WTO DPP (WTO, 2023) and an IISD study "Trade-Related Policy Measures to Reduce Plastic Pollution: Building on the State of Play" (IISD, 2023). To do so, this study uses the WTO Environmental Database (WTO EDB) as its primary source of data, since its contents reflect environment-related measures which carry potential impact on trade, notified by members to the World Trade Organization (WTO).

By looking in-depth at policies regulating sustainability aspects of plastic substitutes, such as environmental and health risks, the study addresses three main objectives:

1. improve our understanding of how key material substitutes are regulated and promoted globally through national measures that affect international trade (section 2 and 3);

2. examine the extent to which policies incorporate the sustainability principles and criteria discussed in the WTO DPP and INC, with a view to developing an international legally binding instrument on plastic pollution (section 2 and 3); And

3. discuss the multi-dimensional trade-offs these substitutes imply, such as those of replacing plastic with paper, introducing LCA as a means of informing trade policymaking (section 4).

2.

Notifications of Trade-related Policy Measures to WTO

2.1. Study scope and methodology

This study covers non-plastic **substitutes** as defined in UNCTAD (2023b), i.e. natural materials from mineral, plant, animal, marine or forestry origin that have similar properties to plastics, excluding fossil fuel-based or synthetic polymers and plastic alternatives i.e. bioplastics and biodegradable plastics. These non-plastic substitutes are limited to (in alphabetical order): Agricultural residues, aluminium, ceramics, glass, natural fibers (bamboo, cotton, jute, wool), paper, seaweed and wood cellulose and pulp from 282 potential material and product substitutes to plastics identified by UNCTAD (UNCTAD, 2023b). This subset was selected as it can be analyzed qualitatively and was identified by industry practitioners as more common substitution options (e.g. paper) or frontier/promising options (e.g. seaweed, agricultural residues). All substitutes in scope are potentially relevant for socio-economic development and sustainability transitions in developing countries.

A keyword strategy for extracting data on these potential substitutes from the WTO EDB was elaborated, resulting in the identification of **201 notifications targeting non-plastic substitutes** submitted to the WTO in the period 2009-21. Manual data cleansing was then carried out to:

- map notifications containing more than one measure. Notifications containing, for instance, technical regulations or specifications and underlying conformity assessment procedures or risk assessments are a case in point. A total of **243 measures** were considered in this way;
- classify notifications or underlying measures by commodity/material, as some of them cover multiple products; and
- remove duplicates, i.e. measures notified at more than one time and not explicitly coded in the data.

Some of the analyses presented in this section look at the 201 notifications, while others look at the 243 measures within them at a more detailed level.

2.2. Notification trends (2009-21)

Trade-related policy measures affecting both plastic and non-plastic substitutes are on the rise, indicating increasing regulatory attention devoted to sustainability and health aspects of materials (figure 1). This trend also shows the important impacts that domestic measures have on international trade in plastics and their substitutes.

Measures applied on plastics and non-plastic substitutes have both experienced an upward trend over the period 2009-2021 (figure 1a). Notifications with environmental objectives, which correspond to all notifications available in the WTO EDB, have roughly doubled in the reference period – from 480 in 2009 to 931 in 2021; despite high inter-annual variability, non-plastic substitutes and plastic notifications have both grown at a higher rate[1]. Non-plastic substitutes notifications have been growing at an annual average rate of 13 per cent, more than twice as fast as all environment-related notifications (CAGR = 6 per cent). Growing by 28 per cent annually on average, plastics related notifications have experienced the fastest growth (figure 1b).

1 Inter-annual variability, such as in 2015-17, may be related to different notification obligations under different WTO agreements and the resulting notification cycles. By removing the inter-annual variability, a 3-year moving average helps to illustrate this trend.

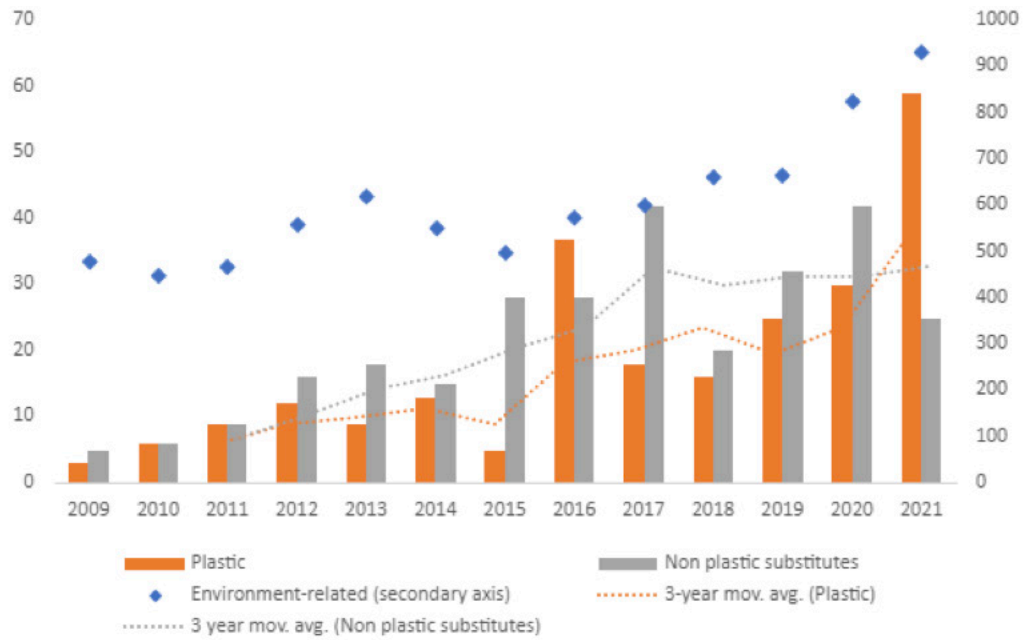
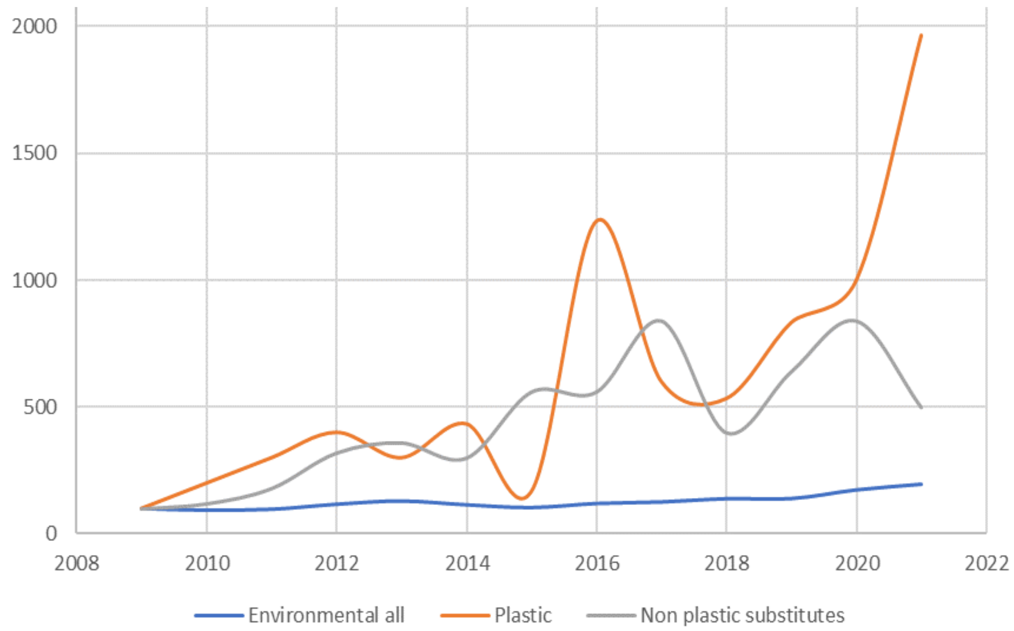


Figure 1. Trade-related policy measures on non-plastic substitutes, plastic and environment-related (2009-21)

a. Measure count and 3-year moving average



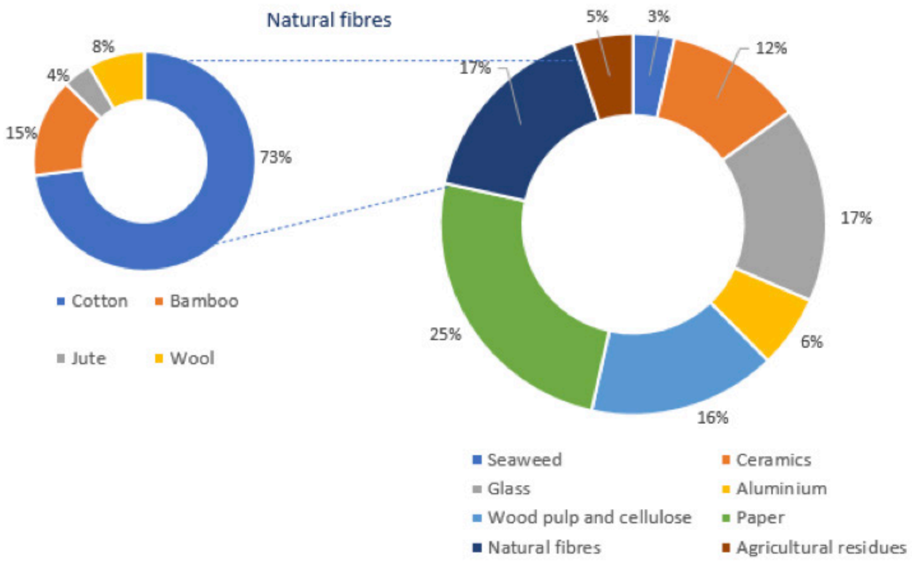
b. Indexed count (Base year:2009=100)

Source: UNCTAD analysis based on data WTO Environmental Database. Last accessed November 2023.

2.3. Commodities and materials targeted by notified measures

Trade-related measures notified to WTO cover a wide array of materials that can act as non-plastic substitutes across their life cycles, from input supplies to end-of-life disposal, including aspects related to manufacturing or harvesting. [2]Paper (25 per cent), natural fibres (17 per cent) and glass (17 per cent) are the substitutes that are most targeted by measures covered in this study (figure 2). Looking at notifications targeting natural fibres, almost three out of four notifications concern cotton (73 per cent) while bamboo, jute and wool are targeted in only 27 per cent of cases. There is no evidence of measures explicitly targeting an emerging yet relevant group of commodities, such as hemp, banana, pineapple, palm or areca leaves. This may be due to their low trade value and their more recent consideration as marketable materials.

2 Policies apply to both the materials and the value-added products made from them. Product mapping is available to a further level of detail e.g., cotton, bamboo, hemp, jute, and wool for "natural fibres".



← Figure 2. Trade-related policy measures on non-plastic substitutes, by commodity/type of material (2009-21)

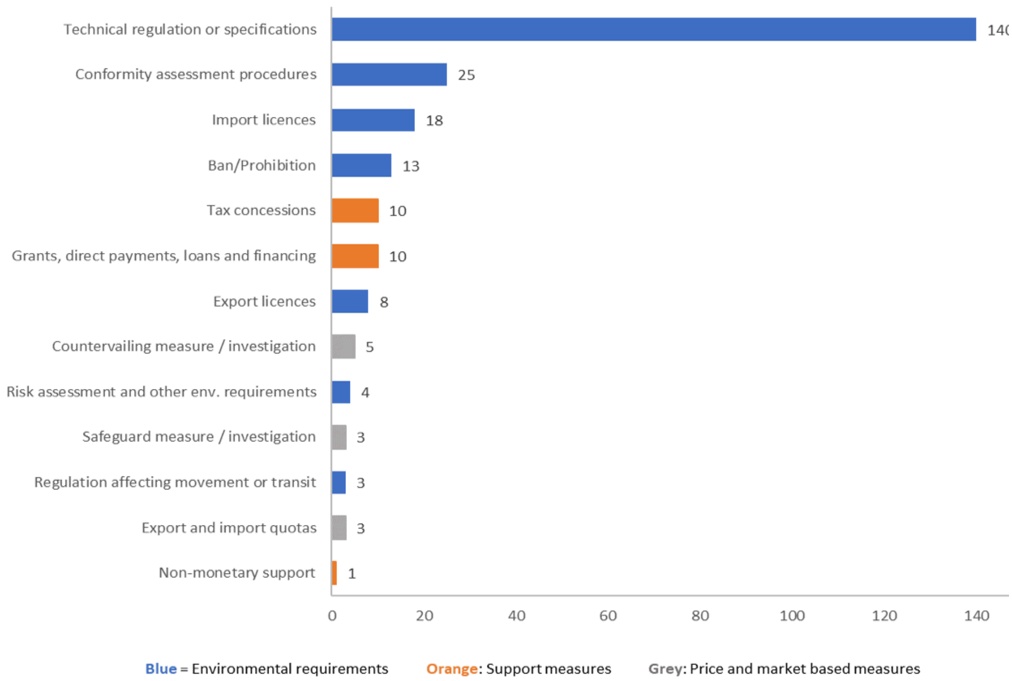
Source: UNCTAD (2023). Analysis based on data WTO Environmental Database. Last accessed November 2023.

Note: Notifications cover, in some instances, more than one material substitute and thus may be double counted. Totals may not add up to 100 due to rounding.

2.4. Types of measures and notifying members

Members notify the WTO of a wide range of measures related to non-plastic substitutes. Measures range from environmental specifications and standards to instruments for price and market-based support. They include but are not limited to technical specifications for materials with food contacts such as aluminium foil, grading schemes for recyclability of non-plastic packaging and permits/licenses for import of packing materials made of cotton, jute, and bamboo.

Environmental requirements, which account for 86 per cent of notified measures, are the most common type of measures (figure 3). Among them, technical regulations, or specifications represent the majority, with 58 per cent of all notifications (140 notifications)[3]. Conversely, while being instrumental in supporting strategic and emerging industries globally, **support measures**



← Figure 3. Harmonized type of measures on non-plastic substitutes, by cluster (2009-21)

Source: UNCTAD (2023). Analysis based on data from WTO Environmental Database. Last accessed November 2023.

Note: In some instances, notifications cover multiple measures such as technical regulations and conformity assessment procedures. These measures are counted separately in this analysis making the total count > 201. For the sake of simplicity, measures are grouped into Harmonised Types of Measures as defined by the WTO. "Environmental requirements" cover a wide range of standards and regulations, not all of which are purely environmental.

3 The relatively high weight of environmental requirements in the sample may be due to disclosure obligations foreseen by certain WTO agreements, which do not apply the same standards to the disclosures of other measures.

↓ Source: UNCTAD (2023). Analysis based on data from the WTO Environmental Database. Last accessed November 2023.

Note: In some instances, notifications cover multiple measures such as technical regulations and conformity assessment procedures. These measures are counted separately in this analysis making the total count > 201. The European Union is a WTO member. Accordingly, notifications submitted by the EU are counted as a whole and not allocated to individual European Union Member States. For this reason, the figures for developed countries may be conservative.

such as tax concessions, grants and loans account for only 8 per cent of all notifications (20 notifications). Among **price and market-based measures**, export and import quotas make up a negligible share of about 1 per cent (only 3 notifications). This suggests a low preference for quantitative restrictions when pursuing environmental objectives through non-plastic substitutes (11 notifications).

Breaking down measures by the development status of notifying WTO member reveals different policy approaches in support of non-plastic substitutes and related industries in developed countries, developing countries and least developed countries (LDCs) (table 1). Technical standards or specifications and underlying conformity assessment procedures are more prominent in developing countries than in developed countries (60 per cent vs. 43 per cent and 12 per cent vs. 0 per cent of notified measures, respectively). Together with a relatively high use of bans/prohibitions and import licensing, they profile a "defensive" policy approach, where WTO members seek to prevent adverse environmental impacts originating from certain types of trade, such as the export of hazardous waste from developed countries. Similarly, LDCs entirely rely on technical standards or specifications and conformity assessment procedures.

Active support measures such as tax concessions and grants and direct payments are more common in developed countries than in developing countries (9 per cent vs. 2 per cent and 11 per cent vs. 1 per cent of notified measures, respectively). This may be due, inter-alia, to more

Table 1. Harmonized types of measures on non-plastic substitutes, by development status of notifying member (2009-21), total and percentages

Type of measures	Developed	Developing	LDCs	Total	Developed	Developing	LDCs	Total
Environmental requirements / command-and-control								
Technical regulation or specifications	32	78	30	140	43%	60%	77%	58%
Conformity assessment procedures	–	16	9	25	0%	12%	23%	10%
Import licenses	7	11	–	18	9%	8%	0%	7%
Ban/Prohibition	5	8	–	13	7%	6%	0%	5%
Export licenses	5	3	–	8	7%	2%	0%	3%
Risk assessment	1	2	–	3	1%	2%	0%	1%
Regulation affecting movement or transit	2	1	–	3	3%	1%	0%	1%
Technical regulation or specifications	–	1	–	1	0%	1%	0%	0%
Price and market based measures								
Countervailing measure / investigation	5	–	–	5	7%	0%	0%	2%
Safeguard measure / investigation	–	3	–	3	0%	2%	0%	1%
Import quotas	1	1	–	2	1%	1%	0%	1%
Export quotas	–	1	–	1	0%	1%	0%	0%
Price and market based measures								
Tax concessions	7	3	–	10	9%	2%	0%	4%
Grants and direct payments	8	1	–	9	11%	1%	0%	4%
Non-monetary support	–	1	–	1	0%	1%	0%	0%
Loans and financing	1	–	–	1	1%	0%	0%	0%
Price and market based measures	**74**	**130**	**39**	**243**	**100%**	**100%**	**100%**	**100%**

mature and competitive industries and higher budgets to finance policies. Overall, developed countries tend to support non-plastic substitutes and related industries more actively, implying that upscaling non-plastic substitutes are generally left to market forces alone in developing and least developed countries, ironically where greater comparative advantages often exist.

3.

Content and coverage of Trade-related Policy measures

3.1. Environmental sustainability, health, and safety objectives

There are lively discussions ongoing in key multilateral fora such as the WTO DPP and the INC about the sustainability, safety, and effectiveness of non-plastic substitutes. Discussions centred on specific concerns, particularly on whether non-plastics are "better" materials than plastics, particularly when the latter are reused, repurposed, or recycled and to what extent they are safer for human consumption and for the environment.

For these reasons, basic criteria have been put forward in programmatic documents and negotiating drafts. In their latest contributions, the WTO DPP refers to "environmentally sound, safe, and effective" and the INC to "safe, environmentally sound, and sustainable" non-plastic substitutes.[4]

The issue has also been discussed by the scientific and academic communities, such as the Scientists' Coalition for an Effective Plastics Treaty, which proposes four criteria of "safety, sustainability, essentiality, and traceability" for both plastic alternatives and non-plastic substitutes.[5]The Coalition's proposal has the limitation that it applies to materials (natural or not) and by-products, which are completely different regardless of their level of recyclability, compostability and erodibility. In addition, plastic alternatives and non-plastic substitutes can have very different life-cycle environmental impacts depending on their composition, use or end of life.

Notification texts do not contain specifications that allow assessment of sustainability, safety, and effectiveness of non-plastic substitutes from a technical standpoint. They measure objectives and descriptions which, in some instances, are provided by notifying parties in standard formats and give precise hints as to the rationale and ambition of certain measures. They allow assessment, to a certain extent, of the level of regulatory maturity pertaining to safety, health, and environmental aspects.

While it does not provide information regarding effectiveness, the analysis of notification texts reveals a relatively high coverage of aspects of environmental sustainability, health, and safety of non-plastic substitutes (figure 4). More specifically, over half of notified measures explicitly state environmental sustainability and health and safety objectives or, in their absence, contain elements or references to support them (126 notifications). Among 148 measures aiming to protect human, animal and plant health (126+22), more than 90 per cent aim to protect human health (135 notifications) with animal and plant health being less prominent aspects (13 notifications). About 31 per cent of all notifications have pure environmental motives (75 notifications).

4 See the https://docs.wto.org/dol2fe/Pages/SS/directdoc.aspx?filename=q:/INF/TEIDP/W10R2.pdf&Open=True of the WTO DPP for the 13th WTO Ministerial Conference (MC13) (19 January 2023) and the Revised Draft of the International Legally Binding Instrument on Plastic Pollution put forth for the 4rd Session of the INC (28 December 2023).

5 See the Coalition's Factsheet on Plastic Alternatives and Substitutes: https://ikhapp.org/wp-content/uploads/2023/11/Fact_Sheet_Plastics-Alternatives-and-Substitutes-101.pdf

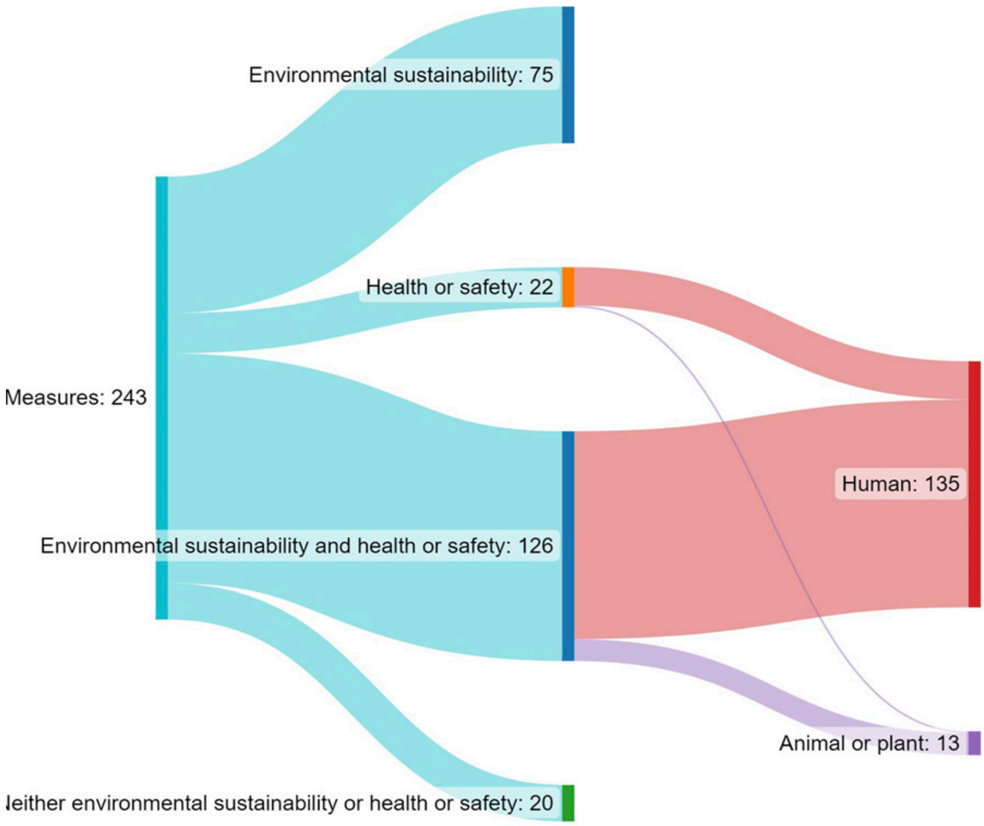


Figure 4. Objectives of non-plastic substitute measures notified to WTO (2009-21)

Source: UNCTAD (2013) based on data from the WTO Environmental Database 2023. Last accessed November 2023.

Note: Notifications either explicitly list objectives of protection of the environment, human, animal, or plant health or contain elements and references that implicitly corroborate them. Expert judgement was used where the former criteria did not apply.

While environmental sustainability, health and safety aspects are widely addressed by measures and provide a strong background for life cycle assessment (LCA) considerations, no notifications explicitly mention LCA and related aspects or set requirements in this area. This may be due to the relative newness and low maturity of this subject in trade and domestic policy making.

Trade-related policies measures are binding legal instruments in respective countries and can cover all stages of the life cycle of non-plastic substitutes. They can in turn contribute to establishing standards and developing markets for safe, sustainable, and effective substitutes. Measures contribute to the preservation of human, animal and plant life and the protection of the environment in different ways, some of which are interrelated with each other. Examples include but are not limited to the regulation of hazardous substances used in the production of paper and aluminium and phytosanitary standards establishing maximum residue limits for pesticides applied to cotton.

3.2. Insight into policy measures by commodity/material

A qualitative analysis of the notifications helps to extract various insights into the content and coverage of trade-related policy measures.[6] Sections 3.2.1 to 3.2.6. present the main findings of this analysis with the aim of identifying common policy-making practices as well as distinctive features of the regulatory landscape of different non-plastic substitutes.

Notified measures target a wide range of products and by-products covering all stages of their life cycles. They establish a plethora of standards, ranging from material specifications for greenhouse gas (GHG) emissions controls through labelling requirements. While most measures pursue environmental objectives explicitly, only a few of them explicitly promote the use of products and by-products as replacements for plastic. Overall, these measures promote substitution only

6 The wording used in the analyses contained in this section reflects as much as possible the wording used in the texts of notifications and measures.

↓ Source: UNCTAD (2023). Analysis based on data from the WTO Environmental Database. Last accessed November 2023.

Note: In some instances, notifications cover multiple measures such as technical regulations and conformity assessment procedures. These measures are counted separately in this analysis making the total count > 201. The European Union is a WTO member. Accordingly, notifications submitted by the EU are counted as a whole and not allocated to individual European Union Member States. For this reason, the figures for developed countries may be conservative.

indirectly by contributing to a policy environment that is conducive to plastic substitution. At the same time, measures can result in high compliance costs for companies, especially micro, small, and medium-sized enterprises (MSMEs) in developing countries, where regulations and standards may act as technical barriers to trade (ITC, 2022 and 2021a).

3.2.1. Wood cellulose, pulp and paper

While frequently referred to interchangeably, wood cellulose and pulp are different materials. Cellulose is a biodegradable polysaccharide that is the main structural component of the cell wall of green plants. Pulp, which is obtained by chemically or mechanically separating cellulose fibres from wood or wastepaper, is a lignocellulosic fibrous material. Pulp is the major raw material used in the production of packaging and paper where it is mixed with other additives such as chemicals. Both cellulose and pulp are abundantly mentioned in the notifications targeting paper and paper products. Together, they make up over 40 per cent of all notified measures considered in the study.

The measures targeted at cellulose, pulp and paper products cover all stages of the life cycle, from the supply of raw materials to the end of life. Many of these measures target packaging materials, such as cardboard and paper bags, and set standards for functionality, quality, and safety (table 2). These materials are used in combination with, or as an alternative or in substitution to, plastics in the development of packaging solutions for finished goods traded in global supply chains.

Table 2. Technical requirements applicable to packaging materials made of paper, pulp and cellulose

Area	Requirements	Materials	Sustainability objectives and elements
Functionality and performance	Properties of materials and components e.g., grammage, porosity, moisture content etc.; Dimensions; Methods of manufacturing and testing; Conformity assessment procedures.	Paper bags for packaging of cement and gypsum; Paper used for wrapping items such as gifts; Tapes used in packaging including cellulose based.	Protect the environment; Reduce use of excess material; Prohibition of environmentally harmful specifications (e.g., plastic bag thickness less than 30 micron).
Quality	Requirements of compliance with national and international standards (e.g., ISO FSC, PEFC); Normative references (e.g. ISO 536:2019).	Coated paperboard; Corrugated fibreboard boxes for general packaging.	Protect the environment.
Safety	Prohibited substances and materials; Permissible limits of heavy metals, e.g., lead, chromium, mercury; Overall migration limits (OMLs) for non-volatile substances; Provisions to minimize transfer, e.g., requirement to use a functional barrier.	Food packaging material in contact with food, e.g., waxed paper for bread wrap.	Minimize risks to human health.
Marking and labelling	Miscellaneous - name of manufacturer or packer, type of material, material properties, country of origin etc.	Cellulose wadding or webs of cellulose fibre; Sacks of paper and paperboard.	Environmental labelling, e.g., "Recyclable" and circularity such as "Prioritize use of reusable bags";

Area	Requirements	Materials	Sustainability objectives and elements
Import and export	Exemptions to import bans/prohibitions on single use plastic products or equivalents made of fibre; Obligation of notification of export and import;	Paper, paper pulp, kraft paper, cellulose; Unbleached kraft paper or paperboard;	Reduction of plastic pollution; Conservation of exhaustible natural resources (Article XX(g) of GATT);

With recycling rates as high as 70 per cent and fibres recycled on average 2.5 times, paper is one of the most recycled materials in the world (European Paper Recycling Council, 2022). Since paper can be recycled up to 5-7 times, recycling not only extends the life cycle of materials and significantly reduces waste, but also saves resources used in the production of virgin fibre such as water and energy. From an environmental standpoint, this makes paper an attractive substitute to plastics, 50 per cent of which is landfilled and only 9 per cent recycled (OECD, 2022).[7] Against this background, it is not surprising that a number of measures specifically target recycling activities through direct support to enterprises (table 3). These are mainly reported by developed countries and include tax exemptions and rebates, as well as direct grants to finance strategic investment projects.

Table 3. Support measures promoting closed-loop recycling of pulp and paper

Notifying member	Measure name	Coverage	Description
Australia	Queensland: Waste levy exemptions and discounts - G/SCM/N/372/AUS (2021)	Miscellaneous activities, including paper and cardboard recycling	Levy imposed on paper and cardboard delivered to leviable waste disposal sites is discounted
	Australian Paper Maryvale Pulp and Paper Mill Assistance Grant - G/SCM/N/284/AUS (2016)	Paper manufacturing and recycling	Direct grant to establish a de-inked pulp facility diverting wastepaper into de-inked pulp used to manufacture recycled white paper
United States of America	Michigan: Forest Products Processing Renaissance Zones (FPPRZ) - G/SCM/N/372/USA (2021)	Facilities or operations that transform, package, sort, recycle, or grade forest or paper products	Tax exemption for companies (e.g., real property, local income)
China	Preferential tax treatment for products produced with integrated utilization of resources - G/SCM/N/315/CHN (2018)	Miscellaneous products recycled or made from waste, including recycled pulp	50 per cent VAT tax refund applied to producers

↑ Source: UNCTAD analysis based on notifications to the WTO Environmental Database. Last accessed November 2023.

Paper production generates negative externalities that pose direct risks to human health and the environment. Not only does it involve processes such as bleaching and drying that are energy and water intensive; it also uses a number of hazardous substances, such as caustic soda, chlorine, and carbon dioxide, which can be released into the environment and come into contact with people. Therefore, technical regulations aim to set standards for the use and trade of these substances (Table 4). These include technical requirements to improve quality and prevent overuse, as well as bans on production, use and imports. In some cases, the latter refers to obligations under international treaties such as the Stockholm Convention on Persistent Organic Pollutants.

7 However, it is important to note that recycling rates for different types of plastic vary widely. In the United States, they range from 1 per cent for polystyrene and expanded polystyrene (EPS) to 15 per cent for polyethylene terephthalate (PET) (Milbrandt et al., 2022).

In addition to packaging materials, notified measures also cover a wide array of manufactured products with weak links to plastic substitution. They range from construction materials such as cement to automotive components through to textbooks and copy paper as per the word cloud

Table 4. **Measures regulating hazardous chemical substances used in paper production**

Notifying member	Measure name	Coverage	Description
India	Caustic Soda Quality Control Order - G/TBT/N/IND/69 (2017)	Caustic soda, (mercury impurity of)	Quality standard (IS-252:2013) applied to domestic producers and imports of caustic soda to reduce the consumption of inferior grade soda with mercury impurity
	Sodium Tripolyphosphate Quality Control Order - G/TBT/N/IND/144 (2020)	Sodium Tripolyphosphate Anhydrous	Quality standard (IS-6100:1984) applied to locally manufactured or imported Sodium Tripolyphosphate, which shall bear the standard mark under license from the Bureau of Indian Standards (BIS)
Japan	Revision of the Cabinet Order of the Chemical Substances Control Law - G/TBT/N/JPN/307 (2009)	Perfluorooctane sulfonic acid (PFOS) and its salts, Tetrabromodiphenyl ether or Pentabromodiphenyl ether	Prohibition on the import of products that contain the designated substances, including printing paper
New Zealand	New chemicals under the Stockholm Convention on Persistent Organic Pollutants - G/TBT/N/NZL/98 (2020)	Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds"	Prohibition of use and production of PFOA, its salts and PFOA related compounds to meet the obligations of the Stockholm Convention
United Republic of Tanzania	Sodium hydroxide Specification - G/TBT/N/TZA/118 (2017)	Sodium hydroxide	Prohibition of use and production of PFOA, its salts and PFOA related compounds to meet the obligations of the Stockholm Convention

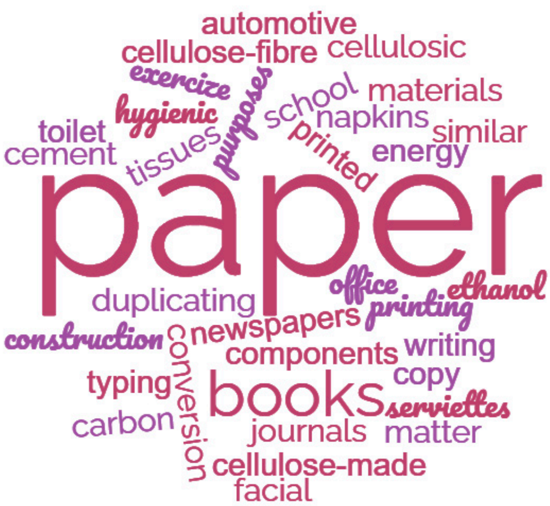
↑ Source: UNCTAD analysis based on notifications to the WTO Environmental Database. Last accessed November 2023.

below (figure 5). Although not directly relevant for the purpose of this study, such measures help to understand the relatively high maturity of regulations for cellulose, pulp and paper substitutes when compared to other non-plastic substitutes.

A detailed examination of all these standards is beyond the scope of this study, but would help practitioners assess their effectiveness, safety, and sustainability as non-plastic substitutes.

Figure 5. The selected key relevant actors (direct, indirect, and potential) involved in the ULABs in Bangladesh →

Source: UNCTAD analysis based on notifications to the WTO Environmental Database. Last accessed November 2023.



3.2.2. Aluminium

Measures targeting aluminium are driven by broad GHG emissions, environmental, health and safety concerns. These include bans/prohibitions or licensing schemes for the import and export of aluminium scrap, technical specifications for aluminium products such as wires and conductors, and regulations for hazardous substances contained in certain aluminium alloys such as lead.

Due to unique properties such as high oxygen and light insulation, aluminium coating is extensively used in packaging in combination with or for replacement of plastics, particularly for foods and other perishable products. Not surprisingly, a number of measures define technical standards for aluminium foil and containers with a focus on food contact materials (Table 5). Standards, which are established by notifying members via technical regulations, include quality specifications, release limits and labelling rules for recycling. In some instances, measures cover both aluminium and plastic materials such as polyethylene terephthalate (PET) due to common use in packaging.

Table 5. Examples of measures regulating sustainability aspects of food contact materials of aluminium

Notifying member	Measure name	Type of measure (WTO harmonized)	Content and coverage
India	Aluminium Foil (Quality Control) Order - G/TBT/N/IND/76/REV.1 (2019)	Quality and labelling standard (Technical regulation)	Goods or articles of aluminium foil shall conform to the Indian Standard on Aluminium and Aluminium Alloy Bare Foil for Food Packaging and bear its standard mark
Japan	Ministerial Ordinance on Standards for Labeling of the Steel or Aluminium beverage cans - G/TBT/N/JPN/651 (2020)	Labelling standard (Technical regulation)	Manufacturers of steel or aluminium beverage cans are required to include specific marks indicating waste separation practices with a view to reduce waste and encourage recycling
Turkey	Regulation Amending Turkish Food Codex Regulation on Materials and Articles in Contact with Food - G/SPS/N/TUR/34 (2014)	Safety and labelling standard (Technical regulation)	Set a release limit and labelling rules for aluminium materials and articles that are in contact with food.

↑ Source: UNCTAD analysis based on notifications to the WTO Environmental Database. Last accessed November 2023.

3.2.3. Ceramics

The vast majority of measures targeting ceramics are environmental, health and safety requirements applied to goods with weak links to plastic substitution. These include ceramic sanitary ware and construction materials as well as materials with scientific applications such as resistors and capacitors.

While not explicitly promoting plastic substitution, one measure notified by Rwanda set technical requirements as well as sampling and test methods for handmade ceramic products. Requirements include maximum permissible levels of contaminants such as lead and cadmium as well as characteristics of labelling and packaging.[8] Standards of this type are particularly relevant in developing countries, where the availability of plastic food containers may be low and handmade ceramic products extensively used for food conservation and food serving.

8 Notification n. G/TBT/N/RWA/301

3.2.4. Glass

Measures targeting glass regulate hazardous substances used in its production (e.g., barium carbonate, lead and cadmium) and set technical specifications for manufactured products (e.g., safety glass, glass sheets). None of these measures explicitly promote plastic substitution. Several measures set up restrictions on the trade of scrap glass and glass waste, including import and export licenses as well as bans and prohibitions. Bans, prohibitions, and licenses cover a wide range of scrap and waste, ranging from manufacturing residues to glass embedded in e-waste (Table 6).

Table 6. Restrictions to trade in scrap glass and glass waste

Type of measures	Targeted products	Notifying members
Ban/prohibition	Dust of glass production containing beryllium and its compounds; Glass from cathode-ray tubes and other activated glasses; Glass from other contaminated glass; Waste of glass fibres; Waste of contaminated packages and containers, including of glass;	Kazakhstan Russian Federation Thailand
Import license	Imported glass scrap; Glass from cathode-ray tubes and other glass with an active coat, or contaminated with cadmium, mercury, lead, polychlorinated biphenyls; Glass waste;	Israel Kazakhstan Vietnam
Export licence	Waste and scrap of glass processed into furnace-ready fines and/or cullet; Glass from cathode-ray tubes and other glass with an active coat, or contaminated with cadmium, mercury, lead, polychlorinated biphenyls;	Australia Russian Federation

↑ Source: UNCTAD (2923). Analysis on data from the WTO Environmental Database. Last accessed November 2023.

Unlike paper, glass is 100 per cent recyclable and can be recycled endlessly without loss of quality. Due to non-porous, non-toxic and impermeable properties, it is widely used in the packaging of fast-moving consumer goods (e.g., carbonated drinks and sauces) as a viable alternative to plastic. These features are largely reflected in the regulatory landscape. Several notified measures covering glass are technical regulations specifying requirements and methods of sampling and testing for glass bottles. Taking a multi-product approach that equates non-plastic substitutes to plastics, a few of them aim at establishing legal frameworks to promote closed-loop recycling (Table 7).

Table 7. Technical regulations promoting closed-loop recycling of packaging of glass and other materials

Notifying member	Measure name	Coverage	Description
France	Decree on consumer information symbols indicating the sorting rule for waste resulting from products subject to the principle of extended producer responsibility - G/TBT/N/FRA/204 (2020)	Packaging used to market products is subject to extended product responsibility (EPRs) when consumed or used by households (e.g., household glass drinks packaging)	Labelling symbol informing consumers that the product is subject to a sorting rule and with information specifying the methods for sorting or bringing in waste resulting from the product.

Notifying member	Measure name	Coverage	Description
Chile	Preliminary draft Supreme Decree establishing collection and recovery targets and other obligations relating to packaging - G/TBT/N/CHL/507 (2019)	Packaging of carton, metal, paper, plastic, liquid packaging carton (Tetra Pak) or glass	Establish collection and recovery targets and other obligations relating to packaging in order to prevent waste generation and to promote reuse and recovery.
Republic of Korea	Sub Act on the Promotion of Saving and Recycling of Resources - G/TBT/N/KOR/857 (2019)	Packaging as paper packs, glass bottles, cans, plastics	Materials and structures of packaging are graded and evaluated according to their recyclability. Grades are then marked on product labels with a view to promote the production of easily recyclable packaging
Lithuania	Draft law of the Republic of Lithuania amending and supplementing the Law on the management of packaging and packaging waste - G/TBT/N/LTU/22 (2013)	Beverage products packed into disposable glass, plastic or metal packaging with a volume between 0.1 litres and 3.0 litres	Establish a legal regulatory framework for implementing a mandatory deposit system for disposable packaging to increase the amount of collected good-quality disposable packaging waste which is suitable for recycling

↑ Source: UNCTAD (2023). Analysis based on data from the WTO Environmental Database. Last accessed November 2023.

Note: Wording reflects to the largest extent possible that used in notification and measure texts.

3.2.5. Agricultural residues, seaweed and algae

Agricultural residues such as husks and straws are the subject of support measures for the effective management and use of agricultural waste with environmental objectives other than plastic substitution. These include the production of renewable energy and biofuels. They include, but are not limited to, grants and cash transfers to and tax benefits (credits, exemptions, refunds) for businesses. While few of these measures are aimed at promoting residue-based substitutes for plastics, they shed light on non-standard applications that can be further replicated (Table 8). Conversely, seaweed and algae are mainly covered by import/export licensing schemes that address, among other things, plant protection and food safety. None of these contain references to material substitution.

Source: UNCTAD (2023). Analysis based on data from the WTO Environmental Database. ↓ Last accessed November 2023.

Table 8. Support measures seeking promotion of plastic substitutes made of agricultural residues or waste

Notifying member	Measure name	Coverage	Description
China	Preferential tax treatment for products produced with integrated utilization of resources - G/SCM/N/315/CHN (2018)	Miscellaneous products, recycled or made from waste, including: • recycled polyester products which are made from waste natural fibres	50 per cent VAT tax refund applied to producers
	Preferential VAT on comprehensively utilized products with agricultural surplus and forestry residues as raw materials - G/SCM/N/220/CHN; G/SCM/N/253/CHN; G/SCM/N/284/CHN (2015)	Miscellaneous products made from agriculture and forestry residues, including: • Paper products made of bagasse • Fibreboard made of tree remains and crop straw	100 per cent VAT tax refund applied to producers

3.2.6. Natural fibres (cotton, bamboo, jute, wool)

Source: UNCTAD (2023). Analysis based on data from the WTO Environmental Database. Last accessed November 2023.

Note: Wording reflects to the largest extent possible that used in notification and measure texts. The life cycle stages are adapted from WTO (2023).

Natural fibres such as jute and bamboo are increasingly seen as viable substitutes for plastics in packaging and everyday products such as cutlery, bags and stationery. However, substitution involves complex environmental trade-offs. This complexity is reflected in the policy landscape, where notifications cover a wide range of measures for natural fibres throughout their life cycle, from the supply of agricultural inputs to end-of-life (Table 9). Similarly to plastics (WTO, 2023), most measures target middle stages of the life cycle such as finished goods and manufacturing while no measures cover consumptions and end use. While the majority of measures set environmental requirements such as those for certification, quality and labelling, direct support measures are provided in the form of tax concessions and grants. They targets companies active in primary production (e.g., sheep farming for wool), processing (e.g., paper products made of bagasse) and recycling (e.g., fibre waste-based manufactures). Waste and scrap including transboundary movements are regulated via import bans/prohibitions applied selectively to individual products (e.g., cotton buds) or in combination with other hazardous wastes (e.g. plastic).

Table 9. Environmental requirements and support measures applied to natural fibres

Life cycle stage	Requirements and support measures	Products
Input supplies	Certification standards; Quality standards, including risk assessment and conformity assessment procedures; Import permits and licenses;	Cotton (seeds and planting material)
Agricultural production and harvesting	Classification, quality, marking and labelling requirements, sampling procedures, method of presentation; Maximum residue levels and safety security periods of pesticides; Phytosanitary requirements for import, including risk assessment and conformity assessment procedures; Grants/direct payments to farms	Bamboo Bagasse Cotton (uncarded or uncombed fibre) Wool
Processed goods and manufacturing	Technical requirements, tolerance levels e.g., fibre composition, vegetable impurities etc.; Exemption to import bans/prohibitions on single use plastic products for equivalents made of natural fibre; Phytosanitary requirements for import; Tax exemption for producers i.e., refund of VAT;	Cotton (combed and carded fibre, yarn, weaving, textiles of, cotton buds) Bagasse (pulp, paper products made of) Rattan (articles of) Bamboo (articles of e.g. stakes and poles) Palm (articles of)
Packaging materials	Import permits;	Bamboo (packing materials) Jute (packing materials)
Waste and scrap (including transboundary)	Import bans and prohibitions; Phytosanitary requirements for import;	Cotton gin (waste of) Cotton comber (waste of) Wool (waste of)
Recycling	Tax exemption for producers i.e., refund of VAT	Natural fibre (recycled polyester products made from waste of)

A small number of measures can have a pronounced impact on non-plastic substitution. For instance, import bans/prohibitions aimed at phasing out single-use plastics explicitly exclude fibre-based products (e.g., bagasse, bamboo, and palm), or list exceptions in cases where alternatives are "viable and available".[9] Similarly, one import licensing scheme includes permits for the import of packing materials made from jute and bamboo.[10] This shows how non-plastics substitutes are increasingly recognized as viable options by policy makers in certain jurisdictions.

4. The multi-dimensional trade-offs of substitution

4.1. Environmental impacts across the material life cycle

Non-plastic substitutes have characteristics that make them substantially different from each other. These relate not only to material properties (e.g., volume, weight), functionality and environmental performance (e.g., biodegradability), but also to production, market and socio-economic factors. This can be seen, for example, when comparing plastics with paper as complementary and substitute materials used in packaging solutions in global supply chains of e-commerce (Table 10). While paper is considered to be better than plastic for the environment, this is not true in all contexts. For example, consider a situation where a government provides grants or tax breaks to packaging companies to fund research and development promoting the replacement of plastic coatings with paper equivalents in flexible packaging. From an environmental perspective, this may only make sense if the country has access to large managed forests and water resources, suitable facilities for paper production and recycling, and a favourable regulatory environment. Conversely, wastepaper would be disposed of in landfills or dumpsites, which can cause significant GHG emissions. These activities have a carbon footprint that can be as high as the emissions reduction achieved by producing less plastic.

Source: UNCTAD (2023). Analysis based on European Paper Recycling Council (2022), OECD (2022), Bell and Cave (2011), Environment Agency of the United Kingdom (2006) and expert knowledge.

Note: Non-exhaustive, high-level comparison of paper and plastic without contextual considerations. Green, yellow and red dots are assigned for explanatory purposes (traffic lights) and indicate better, worse or similar performance of materials, other things being equal.

Table 10. Environmental requirements and support measures applied to natural fibres

Life cycle stage	Key attributes	Paper		Plastic	
Functionality	Barrier (i.e. insulation from light, moisture)	Low, with no coating or functional barries	red	High	green
	Durability, reusability	Depends on product characteristiscs (e.g. design) and context	yellow	Depends on product characteristiscs (e.g. design) and context	yellow
	Weight	High, thus generating higher amounts of solid waste	red	High, thus generating higher amounts of solid waste	green
	Volume	High, thus generating higher amounts of solid waste	red	High, thus generating higher amounts of solid waste	green
Environment	Compostability, biodegradability	High, with no coating, lamination, etc.	green	Low, with possible toxins leaching	red

9 Notifications n. G/SCM/N/220/CHN, G/SCM/N/253/CHN, G/SCM/N/284/CHN and G/SCM/N/315/CHN

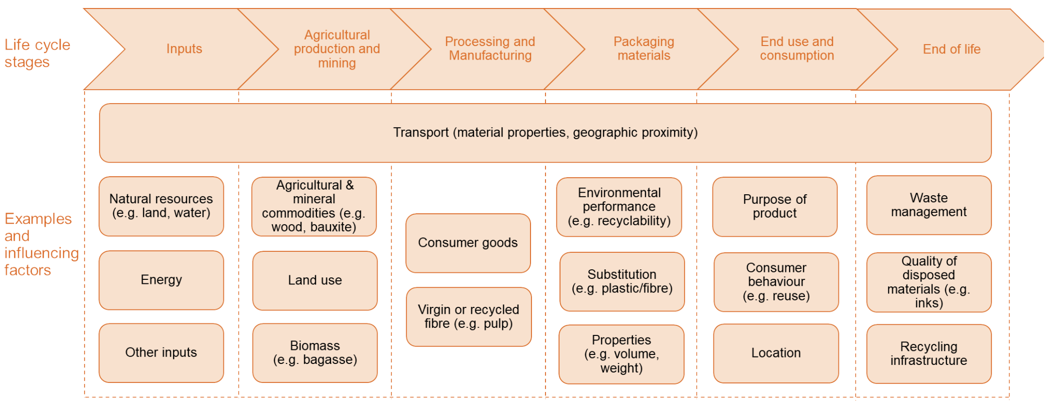
10 Notification n. G/LIC/N/3/MYS/14

Life cycle stage	Key attributes	Paper	Plastic
Environment	Recyclability	High, 73% in Europe and 60% globally (European Paper Recycling Council, 2022)	Low, 9% globally (OECD, 2022)
	Energy in manufacturing	High, but most of it is clean energy e.g. from feedstock	Low
	Fossil fuels in manufacturing	Relatively low, due to the use of biomass e.g. from feedstock	High, petrochemical inputs
	Water in manufacturing	Relatively low, due to the use of biomass e.g. pulp liquor, wood waste	Low, up to 4 times less than paper in the case of grocery bags (Bell and Cave, 2011)
	Renewability	High	Low
	Toxicity	Potentially high, from coating e.g. Per-and polyfluoroalkyl substances	Potentially high, e.g. microplastics and toxins leaching
Market	Regulatory pressure	Low	High
	Demand	High, particularly for recycled paper and green solutions	High, but may decline due to phase out calls (consumers, regulation, etc.)
	Costs	Relatively high, e.g. transport, energy	Low
	Socio-economic gains	Context specific, yet potential for value addition from forestry	Context specific, technology may not be available locally

Environmental impacts, including GHG emissions, are often interlinked, creating complex trade-offs of substitution that span across the production system of different materials. At the same time, impacts are generated at different life cycle stages depending on business and policy choices. These aspects cannot be overlooked and must be carefully evaluated based on their opportunity costs in any decisions involving the phase out or replacement of plastics.

Figure 6 shows examples and influencing factors of environmental impact throughout the life cycle, which create trade-offs and opportunity costs. Examples and influencing factors of emissions are also mapped. These can be used to make basic, non-exhaustive considerations when dealing with the plastic vs. substitute dilemma.

Figure 6. Examples and influencing factors of environmental impact across the life cycle →



Source: UNCTAD 2023. Analysis based on WTO (2023) and technical input provided by subject matter experts.

Note: The life cycle diagram is adapted from WTO (2023). It is not exhaustive as it only shows selected examples and influencing factors of environmental impact. Some stages such as "Packaging materials" are added for illustrative purpose and are not part of the standard life cycle process chain (Figure 7).

In theory, there are high environmental costs associated with setting up agricultural production and mining systems for the raw materials needed to replace plastics. These costs are commodity- and location-specific but range from high water use and pesticide run-off to deforestation. Climate risks can also play a significant role (ITC, 2021b). From this perspective, replacing plastics with natural fibres other than wood may only make sense where **excess biomass** is available as agricultural waste or in the natural environment. Examples include sugarcane bagasse and banana leaves, or algae, which are abundant in the oceans and can be harvested at very low cost.

When considering replacing plastics with non-plastic substitutes, it is important to consider the ultimate **purpose of a product**, whether the substitute is suitable to fulfil it and, if so, how many grams of the substitute would be required to fulfil it as well as plastic. This boils down to the **environmental performance** of materials and affects the overall carbon footprint. In the case of bottled drinks, for example, the performance of PET bottles, which are shatterproof and have a high strength-to-weight ratio, may be difficult to match with alternative materials unless they are used in large quantities. Similarly, functionality also determines paper's viability as an alternative to plastic.

It follows that, in addition to the end use, the relative **efficiency** of non-plastic substitutes must be considered by looking at their **substitution ratios**. Although aluminium has relatively high GHG emission factors due, inter-alia, to the energy intensity of the smelting process, it is an efficient material that delivers high performance from very small quantities. In other words, aluminium has a low substitution ratio with plastics. Consider, for example, the unique barrier properties of aluminium coating in food packaging, which prevents food from coming into contact with external agents such as oxygen, moisture, and light, thus preserving its freshness and quality. The same could be achieved by using a greater amount of plastic and an even greater amount of paper, which may be inefficient from an environmental standpoint.

Certain **material properties**, such as **volume** and **weight**, can have a significant impact on air, water, and land **transport** due to space and cargo capacity constraints. Most importantly, increased cargo weight increases fuel consumption during transport and thus pushes emissions up. While final conclusions can only be drawn when all material properties are considered, non-plastic substitutes considered in this study tend to be heavier than plastic. When looking at grocery carrier bags, low-density polyethylene (LDPE) bags are almost twice as light as kraft paper bags and up to 10 times lighter than organic cotton bags (Danish Environmental Protection Agency, 2018).

Similarly, **location**, and in particular **proximity** between the points of production and consumption, is a key determinant of a product's environmental footprint. Transporting biomass to processing facilities, packaging materials to manufacturing sites and waste to recycling facilities all generate GHG emissions. The greater the distance goods must travel, the greater the emissions. A detailed analysis and mapping of the supply chain can help decision-makers understand the extent to which these factors play a role in choosing one material over another. For example, manufacturers located near sugar cane plantations could explore the possibility of producing takeaway meal boxes and trays from bagasse instead of importing polymers to make polypropylene.

End-of-life scenarios must not be overlooked. It only makes sense to market recyclable products if they can be recycled relatively close to the point of disposal. This is particularly true for FMCGs, which are often not designed for recycling. In many cases, their low disposable value does not justify transporting them over long distances. Similarly, paper-based packaging, although potentially made from renewable resources and recyclable, can be an environmentally inferior solution if certain conditions at end of life are not met. For example, in a non-recycling scenario where paper is landfilled together with other waste and not exposed to light and air, it can take as long as plastic to decompose, that is, between 400 and 1000 years. This also contributes to GHG emissions as methane is released when materials biodegrade anaerobically (Bell and Cave, 2011). In the case of paper, this is estimated to account for about one third of total life cycle emissions, with improvements in landfill practices providing greater emission reductions than waste recovery (Van Ewijk, Stegemann and Ekins, 2021). For this reason, the availability of **recycling infrastructure**, i.e. facilities and technologies, as well as incentive systems for **waste management**, must be considered.

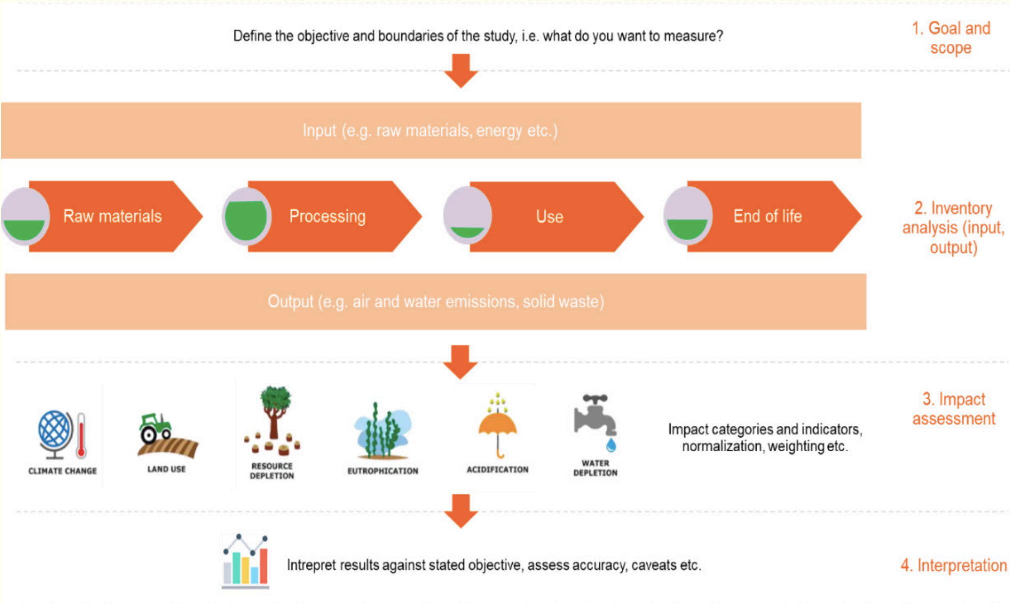
In the case of packaging, end-of-life considerations are also important and lie at the intersection of **producer** and **consumer responsibility**. Components and additives such as laminates, coatings, inks, varnishes, and adhesives are known to make paper less recyclable and should not exceed 10 per cent of the weight of the package (Confederation of Paper Industries, 2022). At the same time, the **quality of disposed materials** is influenced by consumer behaviour as increased awareness of environmental issues does not always translate into concrete action. This is critical to the success of circular strategies and behavioural insights should be integrated into LCA (Corona, Tunn and van den Broek, 2024).

4.2. Managing complexity with Life Cycle Assessment (LCA)

The multidimensional trade-offs described in section 3.1 illustrate typical situations faced by business leaders and policy makers when making business decisions that maximize not only profit but also the triple bottom line (people, planet, profit). Adding to the complexity, decisions made on one trade-off affect the other, potentially altering opportunity costs and returns. Therefore, impact hotspots across the life cycle need to be assessed simultaneously. This is far from straightforward and requires working with sound tools and reasonable assumptions that help to model reality as closely as possible. LCA is a well-established method for conducting environmental impact assessments and is becoming increasingly popular with business leaders and policy makers (Box 1).

Box 1. Life Cycle Assessment (LCA)

LCA is a systematic and comprehensive method for assessing the environmental impacts of a product, process, or service throughout its life cycle, from raw material extraction to disposal or recycling. LCA considers all stages, including manufacturing, transport, use and end-of-life considerations. By looking at all stages simultaneously and applying the same assumptions across them, LCA helps to quantify and evaluate the environmental footprint of a product or system. It typically involves four main steps (figure 7).



←Figure 7. The four steps of Life Cycle Assessment (LCA)

Source: UNCTAD analysis based on ISO (2006a, 2006b), UNEP (2021) and expert knowledge

Box 1. Life Cycle Assessment (LCA) (cont.)

1. Goal and scope definition: This involves clearly defining the goals and boundaries of the assessment. It includes specifying the purpose of the study, the system boundaries (what is included and excluded), the functional unit (the unit of measurement for comparing different products or services), and the intended audience of the results. For instance, cradle-to-gate and cradle-to-grave approaches look at different parts of the life cycle.

2. Life cycle inventory (LCI): After conducting preparatory work, a comprehensive inventory of all inputs and outputs associated with the product or system is compiled. This involves identifying and quantifying the raw materials, energy, and emissions at life cycle stages that lie within the system boundaries. The data collected during the LCI stage is often organized into a LCI database.

3. Life cycle impact assessment (LCIA): The data collected in the LCI is then used to assess the potential environmental impacts. This step involves grouping the various inputs and outputs and combining them into indicators such as climate change, eutrophication, and resource depletion. The LCIA helps in understanding how the inputs and outputs identified in the LCI contribute to different environmental impacts.

4. Life cycle interpretation: The final step is to interpret the results of the LCIA. This involves drawing conclusions from the data collected and analyzing the environmental significance of the identified impacts, placing them in the context of the goal and scope of the assessment. The results are then communicated to stakeholders and decisions or recommendations may be made based on the findings.

LCA is widely used to compare scenarios where plastics and non-plastic substitutes are used in products to fulfil specific functions. Companies are conducting their own LCA both to meet regulatory requirements and to inform customers' business decisions.[11] When comparing plastics with non-plastic substitutes, assessments typically look at resource depletion and environmental degradation associated with raw material extraction, energy consumption, emissions and waste generated during manufacturing, transportation (e.g., methods, distances, and modes) and use. In the case of packaging materials, the evaluation of disposal and end-of-life scenarios, including the impact of waste management options such as landfill or incineration, is also considered. This includes an assessment of the recyclability, compostability, or potential for reuse of the materials.[12] LCA might also extend the impact assessment to aspects of human health protection, the natural environment and issues related to the use of natural resources.

4.3. LCA and trade in non-plastic substitutes: UNCTAD SMEP Trade and Pollution Dashboard

Thanks to LCA, the body of knowledge at the interface of materials science and environmental sustainability is growing. Yet, using results of LCAs outside the context where they are conducted, such as for comparing the environmental footprint of merchandise exports can be challenging due to several factors. These challenges primarily arise from differences in methodologies and assumptions used to assess similar products in different locations.

While there are guidelines and standards for conducting LCA (e.g., ISO 14040 and ISO 14044), interpretation and application can still vary. For example, different LCAs may use different data sources, and variability in data quality and availability can affect the accuracy and reliability of the assessment. The definition of system boundaries may also vary between LCAs. Differences in scope, functional units and the inclusion or exclusion of certain life cycle stages can have a

11 See, for example, a independent, company-led life cycle assessment comparing conventional plastic stretch film for pallet wrapping with a paper-based alternative.

12 Note that these aspects are not part of the LCA framework as such but rather background information needed to define the system being assessed.

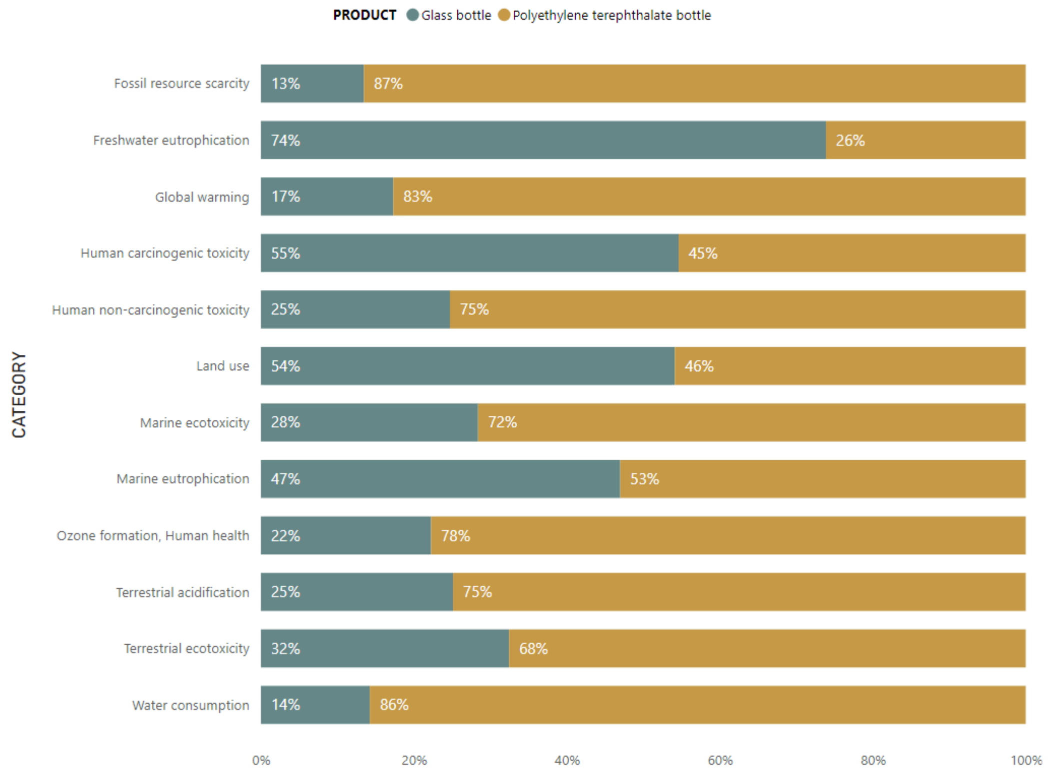
significant impact on the results. Environmental impacts may also vary over time and between geographical regions. LCAs may not always take these variations into account, making it difficult to compare assessments for products with different life spans or produced in different locations.

To overcome these challenges and to extend the benefits of LCA from specific business situations to international trade, UNCTAD's Sustainable Manufacturing and Environmental Pollution (SMEP) programme has developed a Trade and Pollution Dashboard, which enables comparative LCA of plastics, plastic alternatives, and non-plastic substitutes. [13]

The dashboard, produced in collaboration with Instituto 17, combines economic, trade and product life-cycle analysis to provide governments and industry stakeholders with key data on export pollution for key manufacturing sectors in 13 countries in sub-Saharan Africa and South Asia. It also facilitates decision-making on the different environmental impacts of exports by region or country, by material, by product or by type of impact, such as damage to freshwater or marine ecosystems.

For trade in non-plastic substitutes, the Dashboard allows basic comparisons to be made between traditional plastic packaging and natural fibre substitutes, modelling time-bound reuse cycles in key trade hubs in sub-Saharan Africa an South Asia.

Figure 8. illustrates a product-based LCA comparing a PET bottle with a substitute glass bottle, assuming both are single-use items. It is striking to observe how the interplay of environmental impacts discussed in this section comes into play when configuring real sustainability trade-offs.



Functional unit	Plastic product	Substitute product	Uses
"Holding 1 l of liquid consumed in one year's shopping (52 purchases) from the factory to the supermarket and then to the home"	52 Polyethylene terephthalate bottles	2,6 glass bottles	Reuse of substitute product (1-year)

← Figure 8. Comparative life cycle assessment of a glass versus PET bottles.

Source: UNCTAD (2024). Analysis based on data UNCTAD SMEP Trade and Pollution Dashboard. Values on horizontal axis represent per centage of total impact on LCA category (i.e. fossil fuel scarcity, freshwater eutrophication, etc). Under the SMEP dashboard, when comparing two products for life cycle analysis purposes, the higher is the percentage, the larger is the impact of the over the listed category.

Note: Modelled in Zambia in a single use scenario. Results change based on different modelling assumptions, such as the number of use cycles.

13 See https://smepprogramme.org/resources-1/dashboard-shows-environmental-impacts-of-exports-from-african-and-south-asian-countries/

Compared to the PET bottle, the substitute glass bottle has a particularly positive impact in terms of its environmental footprint, including lack of fossil fuel use, global warming, non-toxicity, and carcinogenic impact on humans, as well as marine ecotoxicity and terrestrial acidification. On the other hand, the PET bottle performs better in terms of impacts on freshwater eutrophication.

In all cases, when considering multiple uses, the glass bottle outperforms the PET bottle due to its significant durability and high recyclability rates.

5.

The way forward

This study goes a long way towards demonstrating that supply chain stakeholders and policymakers need to move beyond thinking about a plastic-free world and join forces to pursue a smart plastics economy. Plastics should be phased out where possible and used where appropriate, taking into account the overall efficiency of materials (e.g. substitution ratios) and complementarities between plastics and substitute materials (e.g. between plastics and paper in packaging).

The analysis shows that no material is a priori better than another as a substitute for plastic and the answer depends on multi-dimensional trade-offs in substitution. These are rather complex and result from the interaction of socio-economic and environmental factors. For these reasons, business and policy decisions need to be based on thorough contextual analysis.

Against this background, there is an urgent need to share knowledge and experience across industries and geographies to better understand non-plastic substitutes from both a technical and policy perspective. Governments, the private sector, and civil society should join forces in this effort to unleash new business models focused on substitution that will help develop products and packaging solutions that are both high performing and truly circular.

Learnings from trade related policy measures adopted by WTO members can play a prominent role in shaping this transition, both by establishing building blocks for broader policy frameworks for the production, trade, use and disposal of non-plastic substitutes, and by fostering nascent green industries that can contribute to the fight against plastic pollution.

To unlock this potential, policymakers need to engage in a concerted multilateral dialogue to ensure that the plethora of regulations, standards and technical requirements act as drivers for regulatory harmonization rather than technical barriers to trade in non-plastic substitutes. The negotiations for an international legally binding instrument on plastic pollution and the renewed interest on plastic pollution in WTO plurilateral initiatives such as the WTO DPP provide an unprecedented opportunity to align agendas and work towards real harmonization of rules, thus reducing complexity and fragmentation.

Opportunities for policy innovation in support of plastic pollution reduction are also opening and should be considered. One example is the introduction of life-cycle considerations into multilateral discussions on trade and the environment. This needs to be supported in concrete ways, such as the development of common guidelines on LCA for negotiators and the inclusion of technical annexes to negotiating texts. By promoting life-cycle thinking and enhancing data accessibility, intergovernmental initiatives and tools such as the United Nations Environment Programme (UNEP) Life Cycle Initiative's Global LCA Data Access Network (GLAD) and UNCTAD SMEP's Trade and Pollution Dashboard will help translate guidance into concrete policy actions at the national level.

The study also shows that material substitution alone will not be enough to successfully tackle plastic pollution. For example, the environmental benefits of commercializing fully recyclable paper-based food packaging may not be realized in the absence of renewable energy sources such as biomass, good household waste sorting practices and modern recycling infrastructure. Comprehensive policy approaches are needed that combine standard private sector incentives and regulatory requirements for plastic substitution with policies to support extended producer responsibility, consumer awareness, infrastructure development and biodiversity conservation, among others.

Against this background, a number of avenues for future research can be identified with a view to informing policies that truly support plastics substitution. These include, but are not limited to, mapping the policy space and intersections of plastics substitution (e.g. consumer and producer policies), identifying best practices in policy making with a focus on emerging issues such as LCA (e.g. through in-depth analysis of trade related policy measures), conducting technical deep dives and analyses on priority sectors or high potential substitutes (e.g. packaging, sugarcane bagasse), conducting surveys with exporting and export-ready companies and raw material producers to better understand the challenges, opportunities and limits of plastics substitution.

In all these streams, strong public-private collaboration is needed to support the cross-fertilization of knowledge and to ensure that private sector needs and priorities, as well as best practices, are successfully integrated into policy making. Research findings will not only inform policy development, but also help identify gaps and support the development of capacity building modules for businesses and government officials.

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